Practice Parameters for the Treatment of Sigmoid Diverticulitis

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The American Society of Colon and Rectal Surgeons 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 Guideline 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. This is accompanied by developing Clinical Practice Guidelines based on the best available evidence. These guidelines are inclusive, and not prescriptive. Their purpose is to provide information on which decisions can be made, rather than 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.

It should be recognized that these guidelines should not be deemed inclusive of all proper methods of care or exclusive of methods of care reasonably directed to 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 built on the last Practice Parameter for the Treatment of Sigmoid Diverticulitis published by the American Society of Colon and Rectal Surgeons.[1] An organized search of MEDLINE, PubMed, EMBASE, and the Cochrane Database of Collected Reviews was performed through August 2013. Key-word combinations using the mesh terms included "diverticulitis," "diverticulosis," "diverticular," "lavage," "abscess," "fistula," "leak," "complicated," "uncomplicated," "stents," "ureter," "bowel preparation," "Hinchey," "CT," "MRI," "ultrasound," "antibiotics," "resection," "percutaneous drainage," "laparoscopic," and "colectomy." Directed searches of the embedded references from the primary articles were also performed in selected circumstances. Although not intended to be exclusionary, the authors primarily focused on English language manuscripts and studies in adults. Recommendations were formulated by the primary authors and reviewed by the entire Clinical Practice Guideline Committee. The final grade of recommendation was performed by using the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) system (Table 1).[2]

STATEMENT OF THE PROBLEM

The prevalence of diverticulosis in the United States has increased dramatically over the past century, and it increases substantially with age. It is generally estimated that approximately 20% of patients with diverticulosis develop diverticulitis over the course of their lifetime.[3] Diverticular disease accounts for approximately 300,000 hospitalizations per year in the United States, resulting in 1.5 million days of inpatient care.[4] Additionally, roughly 1.5 million outpatient visits each year are due to diverticular disease.[5] Over the past several years, research describing the natural biology of diverticulitis has been incorporated into the management recommendations for this challenging disease. The continuously evolving diagnostic and treatment options for diverticulitis are reflected in this updated review. Although diverticulitis may affect any location in the colon, this parameter will focus on left-sided disease.

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, a complete blood count, urinalysis, and abdominal radiographs in selected clinical scenarios. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

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TABLE 1. The GRADE system-grading recommendations

	Description	*Benefit vs 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. Used with permission.

The diagnosis of acute diverticulitis can often be made following a focused history and physical examination, especially in patients with recurrent diverticulitis whose diagnosis has been previously confirmed. The constellation of left lower quadrant tenderness with or without other peritoneal findings, fever, and leukocytosis is suggestive of sigmoid diverticulitis. The presence of fecaluria, pneumaturia, or pyuria raises the suspicion for a colovesical fistula. Urinalysis and plain abdominal radiographs are helpful in excluding diagnoses in the differential including urinary tract infections, kidney stones, and bowel obstruction. Other diagnoses that can mimic the presentation of acute diverticulitis include irritable bowel syndrome, appendicitis, IBD, ischemic bowel, neoplasia, and gynecologic disorders. In an effort to reduce the misdiagnosis rate among patients with diverticulitis, clinical scoring systems have been proposed that rely on history, physical examination, and blood work.[6]

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 aid in the diagnosis and Hinchey staging of patients with suspected diverticulitis, to assess disease severity, and to help plan treatment. In the appropriate setting, multislice CT imaging with intravenous and luminal contrast has excellent sensitivity and specificity, reported as high as 98% and 99%.[7,8] In cases of early or mild diverticulitis, CT may not be as diagnostic. Computed tomography findings associated with diverticulitis most commonly include diverticulosis with associated colon wall thickening, fat stranding, phlegmon, extraluminal gas, abscess, stricture, and fistula. Importantly, cross-sectional imaging can accurately diagnose other disease processes that may mimic the presentation of diverticulitis. The considerable

overlap of CT findings seen in patients with diverticulitis and colon cancer requires colonoscopy (once the acute inflammatory process has resolved) to make a definitive diagnosis.[9] Immunocompromised patients who may not mount a normal or significant inflammatory response may have only extraluminal gas on CT without other typical radiographic findings of diverticulitis.[9] The utility of CT imaging goes beyond 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.[10–12]

3. Ultrasound and MRI can be useful alternatives in the initial evaluation of a patient with suspected acute diverticulitis. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Transabdominal, high-resolution ultrasound is an alternative imaging modality that may be useful in patients with relative contraindications to CT scanning (pregnancy, renal insufficiency, and contrast allergy). Ultrasound has a diagnostic accuracy as high as 97%, but has several drawbacks compared with cross-sectional imaging; it is more operator-dependent, it is less effective in confirming alternative diagnoses, and it may not be practical in patients with abdominal tenderness because the transducer probe requires compression.[13] Also, the utility of ultrasound may be diminished in obese patients.[14] Magnetic resonance imaging, which is not constrained by the limitations of ultrasound, has sensitivity and specificity as high as 94% and 92%.[15] As ultrasound transducer technology and MRI colonography techniques improve, these imaging modalities may be used more frequently and will limit patient exposure to ionizing radiation.[16]

Medical Treatment of Acute Diverticulitis

1. Nonoperative treatment typically includes oral or intravenous antibiotics and diet modification. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

The pathophysiologic mechanism underlying diverticulitis is not well understood. The long-held belief that diverticulitis is caused by microperforation and bacterial infection has been challenged by the concept that diverticulitis may be a primary inflammatory process.[17] Results from the AVOD (Swedish acronym standing for "antibiotics in uncomplicated diverticulitis") study group support this alternative pathogenesis. Their multicenter trial randomly treated 623 inpatients with CT-confirmed uncomplicated left-sided diverticulitis with intravenous fluids or intravenous fluids and antibiotics. They found that antibiotic therapy did not prevent complications, accelerate recovery, or prevent recurrences.[18] This study, the only randomized trial to evaluate the need for antibiotics in uncomplicated diverticulitis, did not accrue all eligible patients over the interval and did not address whether or not hospitalization is necessary or if outpatient treatment without antibiotics is appropriate. A recent Cochrane review including 3 randomized trials similarly found no significant difference between antibiotics and no antibiotics for the treatment of uncomplicated diverticulitis.[19] Newer evidence suggesting that a family history of diverticulitis may predict recurrence supports this alternative pathogenesis.[20] Further research is required before adopting an antibiotic-free treatment strategy.

Before the AVOD and Cochrane reports, antibiotics were considered the unchallenged cornerstone of treatment for patients with diverticulitis. In general, clinically stable, reliable patients with uncomplicated disease who can tolerate oral antibiotics can be treated initially as outpatients.[21] The vast majority of patients diagnosed with diverticulitis who are treated with oral antibiotics are successfully treated as outpatients.[22] Patients with complicated disease (ie free perforation, larger abscesses, fistula, or stricture), who cannot tolerate oral hydration, with relevant comorbidities, or who do not have adequate support at home, require hospital admission and, typically, intravenous antibiotics and bowel rest. Antibiotics should cover Gram-negatives and anaerobes. Multidisciplinary, nonoperative management of inpatients with acute diverticulitis is successful in as many as 91% of patients.[23]

After the resolution of an episode of diverticulitis, a variety of agents may be effective in preventing future attacks. Supplemental fiber, rifaximin, antispasmodics, mesalamine, and probiotics have been studied in randomized, controlled trials as well as in less rigorous studies that included heterogeneous patients and poorly characterized the history of diverticulitis in the study subjects. Although some of the literature suggests a protective benefit for these agents, their role in prevention of diverticulitis remains to be defined.[24]

2. Image-guided percutaneous drainage is usually the most appropriate treatment for stable patients with large diverticular abscesses. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

Abscess formation, probably the result of a contained perforation, is a common complication of acute diverticulitis and occurs in 15% to 20% of patients.[25] Since the 1980s, percutaneous drainage has been extensively used in the treatment of these patients. According to a statewide hospital discharge database, the odds of percutaneous diverticular abscess drainage in Washington increased 7% a year between 1987 and 2001, whereas the rate of emergency colectomy decreased 2% a year.[26] Literature supports the concept that percutaneous drainage allows a major-

ity of patients (52%–74%) to avoid urgent operation and undergo interval elective, 1-stage colectomy.[27–31]

Deciding which patients with diverticular abscesses require percutaneous drainage rather than medical management, and which patients should undergo definitive surgery after successful abscess treatment (with or without percutaneous drainage), remains controversial. Several studies support medical treatment without percutaneous drainage for clinically stable patients with small abscesses up to 3 to 4 cm in the largest dimension, recognizing that many of these abscesses will resolve without a drainage procedure.[23,28,29] However, patients who do not clinically improve without drainage should undergo percutaneous drain placement.

A retrospective review of 114 patients with abdominal abscesses from a variety of underlying causes advocates initial medical therapy for all patients, with percutaneous drainage attempted only after 48 to 72 hours for those with continuing fever, leukocytosis, unresolved abdominal pain or tenderness, or intolerance of oral diet.[32] Sixty-one patients (54%) were successfully treated medically and did not undergo drainage. Medical therapy without percutaneous drainage was more likely to fail in patients with fever >101.2°F on presentation or abscesses of >6.5 cm.

A prospective study of 73 patients with diverticular abscesses used a similar treatment algorithm with the use of selective percutaneous drainage only for patients who did not improve after 48 hours of medical therapy.[30] Predictors of undergoing a drainage procedure were pelvic abscess (rather than mesocolic or abdominal location) and abscess size of ≥5 cm. Medical therapy with or without percutaneous drainage was successful in 75% of patients, whereas 25% of patients underwent colectomy during the initial hospitalization because of continuing or worsening infection. With a median 43 months of follow up, an additional 34% of patients underwent nonemergent colectomy for diverticulitis and the remaining 41% never underwent surgery.

The high rate of success with medical therapy (with or without percutaneous drainage) has also been shown in a retrospective, single-institution study of 99 patients; 77% of patients were successfully treated with medical therapy.[31] None of the 15 patients who underwent successful drainage required nonelective operation. Of the 61 patients whose abscesses resolved with medical therapy (with or without percutaneous drainage) and who did not undergo subsequent elective resection, 14 patients (23%) had recurrent diverticulitis in the follow-up period (follow-up interval not available). Patients with previous pelvic abscesses had a higher rate of recurrence compared with patients with pericolic abscesses.

The literature, albeit mostly retrospective, supports the use of percutaneous drainage for accessible, larger abscesses in patients who do not improve with medical therapy. The majority of patients who undergo percutaneous drainage resolve the acute diverticulitis, and a majority of those go on to elective single-stage colectomy.[23] Patients without an adequate radiographic window to permit safe percutaneous drainage may be candidates for operative drainage that is typically accomplished laparoscopically.

Evaluation After Recovery From Acute Diverticulitis

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

Patients with abdominal pain and colonic wall thickening on CT should have the lumen of the colon evaluated, ideally, after the acute symptoms resolve. The purpose of the investigation is to exclude diagnoses other than diverticulitis, because patients with simple thickening on imaging may be found to have ischemia, IBD, or neoplasia.[33] Although the discovery of a mass lesion associated with colon wall thickening is highly suggestive of an underlying neoplasm, the absence of a mass on CT does not preclude neoplasia.[34,35] When fat stranding is more severe than expected for the degree of bowel wall thickening, an inflammatory condition such as diverticulitis is most likely.[36] Patients with presumed diverticulitis who have not had a recent colon evaluation should undergo colonoscopy, typically within 6 to 8 weeks following resolution of the acute episode (although data supporting this time interval is lacking). The absence of neoplasia on colonoscopy may confirm the diagnosis of diverticulitis suspected on CT.[37] Alternatively, CT colonography may be used in this setting.[38]

Elective Surgery for Acute Diverticulitis

1. 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.

One of the more controversial points in the management of diverticulitis involves the appropriate selection of patients for elective sigmoid colectomy after recovery from an uncomplicated episode. Based on large retrospective series, it is estimated that, after an initial attack, approximately one-third of patients will have a recurrent episode, and that one-third of those patients are expected to have yet another recurrence.[39,40] The accuracy of these recurrence rates has been questioned because the source literature predates the routine use of cross-sectional imaging. More recent studies examining the natural biology of uncomplicated diverticulitis treated nonoperatively report lower recurrence rates ranging from 13% to 23% and low rates of subsequent complicated disease or need

for emergency operation (<6%).[20,41–44] 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.[39] According to this, 18 patients would need to undergo elective colectomy to prevent 1 emergency surgery for recurrent diverticulitis.[42] The practice of recommending elective colectomy to prevent a future recurrence requiring stoma formation is not supported by this literature and should be discouraged.

Despite previous emphasis on the number of attacks dictating the need for surgery, the literature demonstrates that patients with more than 2 episodes are not at an increased risk for morbidity and mortality in comparison with patients who have had fewer episodes, signifying that diverticulitis is not a progressive disease.[45] Rather, most patients who present with complicated diverticulitis do so at the time of their first attack.[42,46] A decision analysis model has also demonstrated that elective resection following the fourth episode is not associated with an increased colostomy or mortality rate compared with the performance of surgery after the first episode.[47] Research evaluating the impact of the decline in elective surgery for diverticulitis demonstrated an increase in abscess formation, but no concomitant rise in the rate of emergency colectomy.[48] Similarly, a recent population-based study found that posthysterectomy patients with an increasing number of readmissions for diverticulitis had an increased rate of pelvic fistula formation.[49] Future prospective research regarding CT-confirmed recurrent diverticulitis with extended patient follow-up evaluating the long-term consequences of nonoperative treatment may influence the evolving recommendations for elective resection after acute uncomplicated diverticulitis.

Transplant patients and patients maintained on chronic corticosteroid therapy with acute diverticulitis are a unique subgroup in which medical management is more likely to fail and that has a high mortality rate with medical therapy alone.[50] Immunosuppressed patients and patients with chronic renal failure or collagen-vascular disease have a significantly greater risk of recurrent, complicated diverticulitis requiring emergency surgery.[51] Surgeons should maintain a low threshold to recommend operative intervention as definitive treatment during the first hospitalization for acute diverticulitis in these patients. Elective colectomy in anticipation of transplant remains controversial.

The decision to recommend elective surgery should be individualized to each patient and should consider the risks of operative therapy, the overall medical condition of the patient, and other factors such as the effects on lifestyle (professional and personal) imposed by recurrent attacks, inability to exclude carcinoma, severity of the attacks, as well as chronic or lingering symptoms that may constitute "smoldering" disease.[52] Potential poor functional outcomes and persistent abdominal symptoms after elective sigmoid colectomy for diverticulitis should be considered as well.[53,54]

2. Elective colectomy should typically be considered after the patient recovers from an episode of complicated diverticulitis. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

Complicated diverticulitis includes those episodes associated with free perforation, abscess, fistula, obstruction, or stricture. Free perforation resulting in generalized peritonitis requires urgent operative intervention and is reviewed elsewhere (see "Emergency surgery for acute diverticulitis," recommendation 1, below). Neither phlegmon nor extraluminal gas alone seen on imaging is considered complicated disease, and these findings should not dictate a specific therapy. Rather, the clinician should consider these findings together with the clinical scenario, physiologic status, physical examination, and response to ongoing therapy when deciding on operative intervention. Following successful medical treatment of mesocolic abscesses of ≥5 cm or pelvic abscesses with or without percutaneous drainage, elective colectomy should typically be advised, because retrospective data (albeit with small patient numbers) has shown recurrence rates as high as 40%.[11,31] Although expectant, nonoperative management in this scenario has been supported by other reports, large-scale prospective data are lacking.[30,43,55,56] Future research is needed to better determine the resection criteria in this group of patients. In situations where diverticulitis is complicated by stricture or fistula formation, elective or semielective resection is generally necessary to provide symptomatic relief.[51]

3. Routine elective resection based on young age (<50 years) is no longer recommended. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Diverticulitis among young patients has historically been associated with worse clinical outcomes, and young age has therefore been used as an indication for elective surgery following recovery after an acute episode of even uncomplicated diverticulitis. Conflicting data remain regarding the risks for recurrence or complications for younger (age <50 years) versus older patients, although more recent data suggest that age <50 years does not increase the risk for worse clinical outcomes.[39,55,57] Older reports had suggested that young age at the time of the initial attack was associated with having more severe disease as well as a higher risk for recurrent diverticulitis. Much of this earlier literature suffered from poor methodology, selection bias, and high rates of misdiagnosis and delayed diagnosis.[58] However, more recent studies have shown similar virulence of disease in younger and older patient groups, including comparable rates of the need for resection at the initial hospitalization and rates of stoma formation during subsequent attacks.[59,60] Review

of a statewide administrative database demonstrated that, although young patients had a higher risk of recurrence of diverticulitis compared with older patients, the overall rate of recurrence remained relatively low, with 27% of young patients developing a recurrence. Furthermore, following recovery from the initial episode of acute diverticulitis, only 7.5% of young patients required subsequent emergency surgery.[42] Other retrospective data collected on young patients with CT-confirmed initial episodes of diverticulitis demonstrated a low 2.1% rate of emergency surgery at subsequent attacks.[61]

There is emerging data highlighting the biology of the disease in older patients. Review of a large Medicare database including patients over age 66 years (mean age, 77) without previous episodes of diverticulitis demonstrated that 14% of patients had surgery during their first hospitalization for diverticulitis and that 97% of patients who were initially managed nonoperatively did not go on to have surgery in the follow-up period.[62] Analysis of this database also associated increasing age with morbidity, mortality, and stoma formation in the setting of elective surgery.[63]

Emergency Surgery for Acute Diverticulitis

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

Although the majority of patients hospitalized for diverticulitis respond to nonoperative treatment, up to 25% require urgent operative intervention.[64] Patients with multiquadrant peritonitis or overwhelming infection due to purulent or feculent peritonitis are typically acutely ill or appear toxic and require expedited fluid resuscitation, antibiotic administration, and operation without delay.

A subset of patients in whom nonoperative management fails do not present as dramatically; rather, these patients simply do not improve clinically and continue with abdominal pain or the inability to tolerate enteral nutrition owing to infection-related ileus or bowel obstruction. Although repeat imaging to evaluate possible abscess formation or to otherwise guide management of antibiotic coverage and parenteral nutrition may be useful, clinical judgment determines the need for definitive surgical treatment.

Whereas small series have demonstrated successful initial nonoperative management of patients with acute complicated diverticulitis with perforation, even in the face of pneumoperitoneum, this strategy is reserved for highly selected stable patients without diffuse peritoneal findings with the goal of converting an emergent or urgent situation to one where an elective, single-stage operation can be performed.[23]

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

Once the diseased colon is resected, the surgeon may complete the operation by performing a colorectal anastomosis with or without a diverting colostomy or ileostomy, or by constructing an end-colostomy. The surgical literature is replete with nonrandomized studies supporting the idea that primary anastomosis, in comparison with end-colostomy, is not associated with worse morbidity and mortality and may be associated with significantly improved morbidity and mortality rates.[64–67] Nearly all of this literature is retrospective and suffers from an indeterminate degree of selection bias. One of the largest single-institution retrospective reviews described a "diverticulitis disease propensity score" estimating the likelihood of patients undergoing primary anastomosis versus end-colostomy and found that strong predictors of nonrestorative surgery included urgent or emergent cases, BMI $\geq$ 30, Mannheim peritonitis index $\geq$ 10, immunosuppression, and Hinchey grade 3 or 4.[68] These patient factors are frequently recognized in the literature as predictors of end-colostomy formation.[69] In one of the few prospective studies addressing the issue of primary anastomosis, patients with a higher Mannheim peritonitis index were much more likely to undergo end-colostomy.[70]

Because of the shortcomings of the literature, the clinician must weigh the risks associated with anastomotic failure and of prolonging the operation, while recognizing that end-colostomies created under these circumstances are often permanent. Parameters generally favoring proximal diversion include patient and intraoperative factors like hemodynamic instability, acidosis, acute organ failure, and comorbidities such as diabetes mellitus, chronic organ failure, and immunosuppression as well as surgeon preference and experience.[71]

The influence of disease severity on the type of operation performed has been investigated over the years. Meta-analysis of studies comparing resection with primary anastomosis versus Hartmann procedure in patients with Hinchey >2 peritonitis demonstrated comparable mortality.[66] Although the literature supports the fact that select patients with peritonitis are candidates for anastomosis, the significant patient selection bias in this literature limits the ability to make broad treatment recommendations. To address this issue, a small, randomized controlled study was performed comparing Hinchey III and IV patients who underwent resection with end-colostomy creation and subsequent stoma reversal with patients who underwent resection with primary anastomosis and ileostomy creation and subsequent stoma reversal. Accrual to the study was stopped early because of an interim safety analysis that found that Hartmann reversal had significantly more serious complications (20% versus 0%) compared with ileostomy reversal.[72]

The study also demonstrated that Hartmann patients were significantly less likely to undergo stoma reversal compared with ileostomy patients (reversal rate, 57% versus 90%).

Primary anastomosis with proximal diversion may be the optimal strategy for selected patients with Hinchey 3 or 4 disease.[69] The decision to create an anastomosis in the setting of peritonitis should be individualized to each patient based on the factors described above. Intraoperative colonic lavage may be used at the discretion of the surgeon to evacuate the column of stool proximal to the anastomosis.

3. In patients with purulent or feculent peritonitis, operative therapy without resection is generally not an appropriate alternative to colectomy. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Laparoscopic lavage has emerged as a possible surgical alternative for patients in whom medical therapy has failed or who were not candidates for medical therapy to begin with. In theory, lavage is an attractive treatment modality because it avoids much of the morbidity and mortality associated with standard resection-based therapy. The main criticism of lavage is that, by leaving the septic focus in place, patients risk continuing or recurrent infection.

The lavage literature through 2011 includes approximately 300 patients, is almost entirely retrospective, and reports on relatively small numbers of patients over protracted time intervals.[73] Almost none of the patients are described with the use of validated disease severity index scores. This literature calls into question the actual utility of lavage because 24% of reported patients had Hinchey 1 or 2 disease and 75% of patients who had ASA scores reported were ASA 1 or 2. It is unclear how many of these patients would have resolved their diverticulitis with continued nonoperative management.

A large retrospective population study from 2012, using an Irish national database, compared 427 patients who underwent laparoscopic lavage with 2028 patients who underwent resection or diversion over a 14-year interval.[74] The lavage group of patients was younger and had significantly lower Charlson comorbidity indices, less morbidity and mortality, and a shortened length of stay compared with patients who underwent resection. Although this study is notable because of its size, it is limited by its methodology. The poor quality of the existing lavage literature in aggregate and the inherent selection bias in the literature (surgeons offered certain patients lavage and others resection) are major obstacles in advocating the widespread adoption of lavage.

The safety of lavage for purulent or fecal peritonitis has not been proven or disproven by the published studies to date. European randomized controlled trials are underway that may clarify the role of lavage in the management of patients with diverticulitis. At present, in patients with purulent or fecal peritonitis, lavage is not an appropriate alternative to colectomy.

Diversion proximal to the inflamed segment without resection is another possible alternative to colectomy in the nonelective setting. Historically, this was the first stage of the 3-stage approach, since abandoned in favor of single or 2-stage procedures. The most recent randomized, controlled trial addressing this approach was published in 2000 and compared resection with suture colorrhaphy and proximal colostomy.[75] Although only 2% of the patients undergoing colectomy developed postoperative peritonitis, 21% of patients without resection developed peritonitis ($p < 0.01$). Other nonrandomized literature published in the 1980s also supports resection over proximal diversion in this setting. At present, diversion without resection should be reserved for the rare situation where the inflamed operative field is too hostile to permit resection at that time.

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 extent of elective resection is determined intraoperatively based on the anatomy and the quality of the tissues. The distal margin is an important determinant in minimizing the recurrence of diverticulitis and must extend to the proximal rectum to enable a colorectal anastomosis, because a colo-colonic anastomosis significantly increases the risk of recurrence.[76,77] Patients in whom the proximal rectum is secondarily inflamed may require more extensive rectal resection with a lower rectal anastomosis. The proximal extent of resection in the descending colon is chosen by the absence of thickened, hypertrophic tissue and inflammation. Although it is not necessary to remove all diverticula-bearing colon, care should be taken to avoid incorporating any false diverticula in the proximal side of the anastomosis, because this will increase the risk of leak.

2. When expertise is available, the laparoscopic approach to elective colectomy for diverticulitis is preferred. Grade of Recommendation: Strong recommendation based on high-quality evidence, 1A.

Randomized controlled trials demonstrate that laparoscopic colectomy by experienced surgeons is safe and results in better short-term outcomes compared with open surgery. Specifically, laparoscopy is associated with decreased operative blood loss, less pain, shorter hospitalization, reduced duration of ileus, reduced complication rates, and improved quality of life.[78,79] Meta-analysis of 25 randomized controlled trials comparing open and laparoscopic colorectal resection for any indication also documents superior short-term outcomes associated with the laparoscopic approach.[80] National Inpatient Sample data also strongly support laparoscopy over open elective colectomy for diverticulitis.[81] Although the majority of published reports included patients with uncomplicated disease, the

surgical literature supports the laparoscopic approach to complicated diverticulitis as well.[82–84] Hand-assisted laparoscopic colectomy may be particularly useful in this setting.[85]

Long-term follow-up data from a previously published open versus laparoscopic randomized controlled trial with a median follow-up of 30 months reported comparable Gastrointestinal Quality of Life Index scores and comparable diverticulitis recurrence rates after surgery.[86] In addition, the hernia rate in patients who had laparoscopic resection was one-third of the hernia rate in patients who had open or converted operations.

Laparoscopic sigmoid resection for diverticulitis is technically challenging and requires training and adequate experience. The open approach to diverticulitis should be performed at the discretion of the surgeon as determined by unique patient factors and the individual surgeon's judgment and experience.

3. A leak test of the colorectal anastomosis should be performed during surgery for sigmoid diverticulitis. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Intraoperative leak testing identifies suboptimal anastomoses that can be repaired, re-created before completing the operation or diverted proximally. Routine testing of colorectal anastomoses reduces the postoperative leak rate.[87,88]

4. Ureteral stents are used at the discretion of the surgeon. Grade of Recommendation: Weak recommendation based on low-quality evidence, 2C.

Routine use of ureteral stents is not indicated, because ureteral injury during elective colectomy for diverticulitis occurs in well under 1% of cases.[81,89] The regular use of stents would result in longer operative times and added costs and risks stent-related complications. Stenting may facilitate dissection in selected complicated cases such as patients who are morbidly obese, patients who have been irradiated, patients undergoing reoperation, and patients whose preoperative imaging suggests abnormal anatomy.[90]

5. Oral mechanical bowel preparation is not required; however, the use of oral antibiotics may decrease surgical site infections after elective colon resection. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

Oral mechanical bowel preparation before elective, open colon surgery for any indication, studied in randomized fashion and by meta-analysis, does not appear to influence the rates of wound infection or anastomotic failure.[91,92] The available literature does not break the data into a diverticulitis subgroup, so the utility of bowel preparation must be inferred for this group of patients.[93] Literature is lacking regarding the role of bowel preparation in the setting of laparoscopic colectomy.

The use of nonabsorbable oral antibiotics (ie, erythromycin, neomycin, flagyl, and/or clindamycin) may reduce surgical site complications.[94,95] Oral antibiotics given before elective colon resection have been shown in observational studies to decrease overall surgical site infections (4.5% vs 11.8%; $p = 0.0001$), organ space infections (1.8% vs 4.2%, $p = 0.044$), superficial surgical site infections (2.6% vs 7.6%; $p = 0.001$), and ileus (3.9% vs 8.6%, $p = 0.011$), in comparison with mechanical preparation alone.[96] *Clostridium difficile* colitis is not increased by the addition of oral antibiotics (1.3% vs 1.8%, $p = 0.58$).[96,97] In a Veterans Affairs cohort of almost 10,000 patients, rates of surgical site infection with no bowel preparation (18.1%) or mechanical bowel preparation only (20%) were significantly increased in comparison with patients receiving oral antibiotics alone (8.3%) or in addition to a mechanical bowel preparation (9.2%).[98] A separate study found that oral antibiotic use with or without mechanical bowel preparation was associated with decreased surgical site infections, shorter length of stay, and lower rates of readmission (no preparation, 6.1%; mechanical bowel preparation, 5.4%; antibiotic bowel preparation, 3.9%; $p = 0.001$).[99] A recent meta-analysis found that the use of oral nonabsorbable antibiotics, in addition to intravenous antibiotics, led to lower rates of superficial surgical site infection (relative risk, 0.57; 95% CI, 0.43–0.76), but no difference in deep organ space infections or anastomotic leak.[100] Further study is needed to clarify the optimal regimen.

6. Elective colectomy for diverticulitis may be performed by sparing the superior hemorrhoidal artery or according to cancer surgery principles. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

In theory, preservation of the superior hemorrhoidal blood supply to the rectum may improve blood flow to the distal side of the colorectal anastomosis and may reduce the risk of anastomotic failure. A retrospective review of 130 patients who underwent elective sigmoidectomy for diverticulitis did not support this theory.[101] A randomized controlled study of patients undergoing resection for complicated diverticulitis found a decreased leak rate in patients with preserved superior hemorrhoidal arteries, although the authors used a liberal definition of leak that may have influenced the results.[102] Further randomized study is needed to address this issue. Patients with stricturing disease or who, for whatever reason, have not had neoplasia excluded preoperatively should undergo a cancer-type operation.

APPENDIX A: CONTRIBUTING MEMBERS OF THE ASCRS STANDARDS COMMITTEE

Patricia Roberts, Council Representative; George Chang; Dan Herzig; John Monson; Scott Strong; Kirsten Wilkins;

Marty Weiser; Samantha Hendron; Ian Paquette; Emily Finlayson; William Harb; Jennifer Irani; James McClane; James McCormick; Genevieve Melton-Meaux; David Stewart, Sr.; Charles Ternant; Madhulika Varma; P. Terry Phang; Howard Ross.

REFERENCES

1. Rafferty J, Shellito P, Hyman NH, Buie WD. Practice parameters for sigmoid diverticulitis. *Dis Colon Rectum.* 2006;49:939–944.
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. Heise CP. Epidemiology and pathogenesis of diverticular disease. *J Gastrointest Surg.* 2008;12:1309–1311.
4. Kozak LJ, DeFrances CJ, Hall MJ. National hospital survey: 2004 annual summary with detailed diagnosis and procedure data. National Center for Health Statistics. *Vital Health Stat.* 2006;13:162.
5. Shaheen NJ, Hansen RA, Morgan DR, et al. The burden of gastrointestinal and liver diseases, 2006. *Am J Gastroenterol.* 2006;101:2128–2138.
6. Andeweg CS, Knobben L, Hendriks JC, Bleichrodt RP, van Goor H. How to diagnose acute left-sided colonic diverticulitis: proposal for a clinical scoring system. *Ann Surg.* 2011;253:940–946.
7. Laméris W, van Randen A, Bossuyt PMM, et al. Graded compression ultrasonography and computed tomography in acute colonic diverticulitis: meta-analysis of test accuracy. *Eur Radiol.* 2008;18:2498–2511.
8. Ambrosetti P, Jenny A, Becker C, Terrier TF, Morel P. Acute left colonic diverticulitis–compared performance of computed tomography and water-soluble contrast enema: prospective evaluation of 420 patients. *Dis Colon Rectum.* 2000;43:1363–1367.
9. Baker ME. Imaging and interventional techniques in acute left-sided diverticulitis. *J Gastrointest Surg.* 2008;12:1314–1317.
10. 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.
11. 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.
12. Bordeianou L, Hodin R. Controversies in the surgical management of sigmoid diverticulitis. *J Gastrointest Surg.* 2007;11:542–548.
13. Sarma D, Longo WE; NDSG. Diagnostic imaging for diverticulitis. *J Clin Gastroenterol.* 2008;42:1139–1141.
14. van Randen A, Laméris W, van Es HW, et al; OPTIMA Study Group. A comparison of the accuracy of ultrasound and computed tomography in common diagnoses causing acute abdominal pain. *Eur Radiol.* 2011;21:1535–1545.
15. Destigter KK, Keating DP. Imaging update: acute colonic diverticulitis. *Clin Colon Rectal Surg.* 2009;22:147–155.
16. Heverhagen JT, Sitter H, Zielke A, Klose KJ. Prospective evaluation of the value of magnetic resonance imaging in suspected acute sigmoid diverticulitis. *Dis Colon Rectum.* 2008;51:1810–1815.
17. de Korte N, Ünlü Ç, Boermeester MA, Cuesta MA, Vrouenreats BC, Stockmann HB. Use of antibiotics in uncomplicated diverticulitis. *Br J Surg.* 2011;98:761–767.
18. 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.
19. Shabanzadeh DM, Wille-Jørgensen P. Antibiotics for uncomplicated diverticulitis. *Cochrane Database Syst Rev.* 2012;11:CD009092.
20. 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.
21. Alonso S, Pera M, Parés D, et al. Outpatient treatment of patients with uncomplicated acute diverticulitis. *Colorectal Dis.* 2010;12:278–282.
22. Etzioni DA, Chiu VY, Cannom RR, et al. Outpatient treatment of acute diverticulitis: rates and predictors of failure. *Dis Colon Rectum.* 2010;53: 861–865.
23. 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.
24. Maconi G, Barbara G, Bosetti C, Cuomo R, Annibale B. Treatment of diverticular disease of the colon and prevention of acute diverticulitis: a systematic review. *Dis Colon Rectum.* 2011;54:1326–1338.
25. Beckham H, Whitlow CB. The medical and nonoperative treatment of diverticulitis. *Clin Colon Rectal Surg.* 2009;22:156–160.
26. Salem L, Anaya DA, Flum DR. Temporal changes in the management of diverticulitis. *J Surg Res.* 2005;124:318–323.
27. 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.
28. Siewert B, Tye G, Kruskal J, Sosna J, Opelka F. Impact of CT-guided drainage in the treatment of diverticular abscess: size matters. *AJR Am J Roentgenol.* 2006;186:680–686.
29. Brandt D, Gervaz P, Durmishi Y, et al. Percutaneous CT scan-guided drainage versus antibiotherapy alone for Hinchey II diverticulitis: a case-control study. *Dis Colon Rectum.* 2006;49:1533–1538.
30. Ambrosetti P, Chautems R, Soravia C, Peiris-Waser N, Terrier F. Long-term outcome of mesocolic and pelvic diverticular abscesses of the left colon: a prospective study of 73 cases. *Dis Colon Rectum.* 2005;48:787–791.
31. Kaiser AM, Jiang JK, Lake JP, et al. The management of complicated diverticulitis and the role of computed tomography. *Am J Gastroenterol.* 2005;100:910–917.
32. Kumar RR, Kim JT, Haukoos JS, et al. Factors affecting the successful management of intra-abdominal abscesses with antibiotics and the need for percutaneous drainage. *Dis Colon Rectum.* 2006;49:183–189.
33. Wolff JH, Rubin A, Potter JD, et al. Clinical significance of colonoscopic findings associated with colonic thickening on computed tomography: is colonoscopy warranted when thickening is detected? *J Clin Gastroenterol.* 2008;42:472–475.
34. Eskaros S, Ghevariya V, Diamond I, Anand S. Correlation of incidental colorectal wall thickening at CT compared to colonoscopy. *Emerg Radiol.* 2009;16:473–476.
35. Moraitis D, Singh P, Jayadevan R, Cayten CG. Colonic wall thickening on computed tomography scan and clinical correlation. Does it suggest the presence of an underlying neoplasia? *Am Surg.* 2006;72:269–271.
36. Pereira JM, Sirlin CB, Pinto PS, Jeffrey RB, Stella DL, Casola G. Disproportionate fat stranding: a helpful CT sign in pa-

tients with acute abdominal pain. *Radiographics.* 2004;24: 703–715.
37. Lau KC, Spilsbury K, Farooque Y, et al. Is colonoscopy still mandatory after a CT diagnosis of left-sided diverticulitis: can colorectal cancer be confidently excluded? *Dis Colon Rectum.* 2011;54:1265–1270.
38. Hjern F, Jonas E, Holmström B, et al. CT colonography versus colonoscopy in the follow-up of patients after diverticulitis: a prospective, comparative study. *Clin Radiol.* 2007;62:645–650.
39. Janes S, Meagher A, Frizelle FA. Elective surgery after acute diverticulitis. *Br J Surg.* 2005;92:133–142.
40. Stollman N, Raskin JB. Diverticular disease of the colon. *Lancet.* 2004;363:631–639.
41. Eglinton T, Nguyen T, Raniga S, Dixon L, Dobbs B, Frizelle FA. Patterns of recurrence in patients with acute diverticulitis. *Br J Surg.* 2010;97:952–957.
42. Anaya DA, Flum DR. Risk of emergency colectomy and colostomy in patients with diverticular disease. *Arch Surg.* 2005;140:681–685.
43. Broderick-Villa G, Burchette RJ, Collins JC, Abbas MA, Haigh PI. Hospitalization for acute diverticulitis does not mandate routine elective colectomy. *Arch Surg.* 2005;140:576–581.
44. Holmer C, Lehmann KS, Engelmann S, Gröne J, Buhr HJ, Ritz JP. Long-term outcome after conservative and surgical treatment of acute sigmoid diverticulitis. *Langenbecks Arch Surg.* 2011;396:825–832.
45. Chapman JR, Dozois EJ, Wolff BG, Gullerud RE, Larson D. Diverticulitis: a progressive disease? Do multiple recurrences predict less favorable outcomes? *Ann Surg.* 2006;243:876–883.
46. Chapman JR, Davies M, Wolff BG, et al. Complicated diverticulitis: is it time to rethink the rules? *Ann Surg.* 2005;242:270–277.
47. Salem L, Veenstra DL, Sullivan SD, Flum DR. The timing of elective colectomy in diverticulitis: a decision analysis. *J Am Coll Surg.* 2004;199:904–912.
48. 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.
49. Altman D, Forsgren C, Hjern F, Lundholm C, Cnattingius S, Johansson AL. Influence of hysterectomy on fistula formation in women with diverticulitis. *Br J Surg.* 2010;97:251–257.
50. Hwang SS, Cannom RR, Abbas MA, Etzioni D. Diverticulitis in transplant patients and patients on chronic corticosteroid therapy: a systematic review. *Dis Colon Rectum.* 2010;53:1699–1707.
51. 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.
52. Forgione A, Leroy J, Cahill RA, et al. Prospective evaluation of functional outcome after laparoscopic sigmoid colectomy. *Ann Surg.* 2009;249:218–224.
53. Egger B, Peter MK, Candinas D. Persistent symptoms after elective sigmoid resection for diverticulitis. *Dis Colon Rectum.* 2008;51:1044–1048.
54. Levack MM, Savitt LR, Berger DL, et al. Sigmoidectomy syndrome? Patients' perspectives on the functional outcomes following surgery for diverticulitis. *Dis Colon Rectum.* 2012;55:10–17.
55. Nelson RS, Ewing BM, Wengert TJ, Thorson AG. Clinical outcomes of complicated diverticulitis managed nonoperatively. *Am J Surg.* 2008;196:969–974.
56. 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.
57. Kotzampassakis N, Pittet O, Schmidt S, Denys A, Demartines N, Calmes JM. Presentation and treatment outcome of diverticulitis in younger adults: a different disease than in older patients? *Dis Colon Rectum.* 2010;53:333–338.
58. Janes S, Meagher A, Faragher IG, Shedda S, Frizelle FA. The place of elective surgery following acute diverticulitis in young patients: when is surgery indicated? An analysis of the literature. *Dis Colon Rectum.* 2009;52:1008–1016.
59. Guzzo J, Hyman N. Diverticulitis in young patients: is resection after a single attack always warranted? *Dis Colon Rectum.* 2004;47:1187–1190.
60. Hjern F, Josephson T, Altman D, Holmström B, Johansson C. Outcome of younger patients with acute diverticulitis. *Br J Surg.* 2008;95:758–764.
61. Nelson RS, Velasco A, Mukesh BN. Management of diverticulitis in younger patients. *Dis Colon Rectum.* 2006;49:1341–1345.
62. Lidor AO, Segal JB, Wu AW, Yu Q, Feinberg R, Schneider EB. Older patients with diverticulitis have low recurrence rates and rarely need surgery. *Surgery.* 2011;150:146–153.
63. Lidor AO, Schneider E, Segal J, Yu Q, Feinberg R, Wu AW. Elective surgery for diverticulitis is associated with high risk of intestinal diversion and hospital readmission in older adults. *J Gastrointest Surg.* 2010;14:1867–1873.
64. Abbas S. Resection and primary anastomosis in acute complicated diverticulitis, a systematic review of the literature. *Int J Colorectal Dis.* 2007;22:351–357.
65. Constantinides VA, Tekkis PP, Senapati A. Prospective multicentre evaluation of adverse outcomes following treatment for complicated diverticular disease. *Br J Surg.* 2006;93:1503–1513.
66. Constantinides VA, Tekkis PP, Athanasiou T, et al. Primary resection with anastomosis vs. Hartmann's procedure in nonelective surgery for acute colonic diverticulitis: a systematic review. *Dis Colon Rectum.* 2006;49:966–981.
67. Salem L, Flum DR. Primary anastomosis or Hartmann's procedure for patients with diverticular peritonitis? A systematic review. *Dis Colon Rectum.* 2004;47:1953–1964.
68. Aydin HN, Tekkis PP, Remzi FH, Constantinides V, Fazio VW. Evaluation of the risk of a nonrestorative resection for the treatment of diverticular disease: the Cleveland Clinic diverticular disease propensity score. *Dis Colon Rectum.* 2006;49:629–639.
69. Constantinides VA, Heriot A, Remzi F, et al. Operative strategies for diverticular peritonitis: a decision analysis between primary resection and anastomosis versus Hartmann Procedures. *Ann Surg.* 2007;245:94–103.
70. Richter S, Lindemann W, Kollmar O, Pistorius GA, Maurer CA, Schilling MK. One-stage sigmoid colon resection for perforated sigmoid diverticulitis (Hinchey stages III and IV). *World J Surg.* 2006;30:1027–1032.
71. Bauer VP. Emergency management of diverticulitis. *Clin Colon Rectal Surg.* 2009;22:161–168.
72. 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: 819–827.
73. Feingold DL. Laparoscopic lavage for Hinchey grade III sigmoid diverticulitis. *Semin Colon Rectal Surg.* 2011;22:173–179.

74. Rogers AC, Collins D, O'Sullivan GC, Winter DC. Laparoscopic lavage for perforated diverticulitis: a population analysis. *Dis Colon Rectum.* 2012;55:932–938.
75. Zeitoun G, Laurent A, Rouffet F, et al. Multicentre, randomized clinical trial of primary versus secondary sigmoid resection in generalized peritonitis complicating sigmoid diverticulitis. *Br J Surg.* 2000;87:1366–1374.
76. Dozois EJ. Operative treatment of recurrent or complicated diverticulitis. *J Gastrointest Surg.* 2008;12:1321–1323.
77. Thaler K, Baig MK, Berho M, et al. Determinants of recurrence after sigmoid resection for uncomplicated diverticulitis. *Dis Colon Rectum.* 2003;46:385–388.
78. Klarenbeek BR, Veenhof AA, Bergamaschi R, et al. Laparoscopic sigmoid resection for diverticulitis decreases major morbidity rates: a randomized control trial. *Ann Surg.* 2009;249:39–44.
79. Gervaz P, Inan I, Perneger T, Schiffer E, Morel P. A prospective, randomized, single-blind comparison of laparoscopic versus open sigmoid colectomy for diverticulitis. *Ann Surg.* 2010;252:3–8.
80. Schwenk W, Haase O, Neudecker JJ, Müller JM. Short-term benefits for laparoscopic colorectal resection. *Cochrane Database Syst Rev.* 2005:CD003145.
81. 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.
82. Scheidbach H, Schneider C, Rose J, et al. Laparoscopic approach to treatment of sigmoid diverticulitis: changes in the spectrum of indications and results of a prospective, multicenter study on 1,545 patients. *Dis Colon Rectum.* 2004;47:1883–1888.
83. Bartus CM, Lipof T, Sarwar CM, et al. Colovesical fistula: not a contraindication to elective laparoscopic colectomy. *Dis Colon Rectum.* 2005;48:233–236.
84. Jones OM, Stevenson AR, Clark D, Stitz RW, Lumley JW. Laparoscopic resection for diverticular disease: follow-up of 500 consecutive patients. *Ann Surg.* 2008;248:1092–1097.
85. Lee SW, Yoo J, Dujovny N, Sonoda T, Milsom JW. Laparoscopic vs. hand-assisted laparoscopic sigmoidectomy for diverticulitis. *Dis Colon Rectum.* 2006;49:464–469.
86. Gervaz P, Mugnier-Konrad B, Morel P, Huber O, Inan I. Laparoscopic versus open sigmoid resection for diverticulitis: long-term results of a prospective, randomized trial. *Surg Endosc.* 2011;25:3373–3378.
87. Ricciardi R, Roberts PL, Marcello PW, Hall JF, Read TE, Schoetz DJ. Anastomotic leak testing after colorectal resection: what are the data? *Arch Surg.* 2009;144:407–411.
88. Beard JD, Nicholson ML, Sayers RD, Lloyd D, Everson NW. Intraoperative air testing of colorectal anastomoses: a prospective, randomized trial. *Br J Surg.* 1990;77:1095–1097.
89. Guller U, Rosella L, Karanicolas PJ, Adamina M, Hahnloser D. Population-based trend analysis of 2813 patients undergoing laparoscopic sigmoid resection. *Br J Surg.* 2010;97:79–85.
90. Pokala N, Delaney CP, Kiran RP, Bast J, Angermeier K, Fazio VW. A randomized controlled trial comparing simultaneous intra-operative vs sequential prophylactic ureteric catheter insertion in re-operative and complicated colorectal surgery. *Int J Colorectal Dis.* 2007;22:683–687.
91. Jung B, Påhlman L, Nyström PO, Nilsson E. Multicentre randomized clinical trial of mechanical bowel preparation in elective colonic resection. *Br J Surg.* 2007;94:689–695.
92. Güenaga KF, Matos D, Wille-Jørgensen P. Mechanical bowel preparation for elective colorectal surgery. *Cochrane Database Syst Rev.* 2011:CD001544.
93. Contant CM, Hop WCJ, Sant HPV, et al. Mechanical bowel preparation for elective colorectal surgery: a multicentre randomised trial. *Lancet.* 2007;370:2112–2117.
94. Fry DE. Colon preparation and surgical site infection. *Am J Surg.* 2011;202:225–232.
95. Hayashi MS, Wilson SE. Is there a current role for preoperative non-absorbable oral antimicrobial agents for prophylaxis of infection after colorectal surgery? *Surg Infect (Larchmt).* 2009;10:285–288.
96. Englesbe MJ, Brooks L, Kubus J, et al. A statewide assessment of surgical site infection following colectomy: the role of oral antibiotics. *Ann Surg.* 2010;252:514–519.
97. Krapohl GL, Phillips LR, Campbell DA Jr, et al. Bowel preparation for colectomy and risk of Clostridium difficile infection. *Dis Colon Rectum.* 2011;54:810–817.
98. Cannon JA, Altom LK, Deierhoi RJ, et al. Preoperative oral antibiotics reduce surgical site infection following elective colorectal resections. *Dis Colon Rectum.* 2012;55:1160–1166.
99. Toneva GD, Deierhoi RJ, Morris M, et al. Oral antibiotic bowel preparation reduces length of stay and readmissions after colorectal surgery. *J Am Coll Surg.* 2013;216:756–762.
100. Bellows CF, Mills KT, Kelly TN, Gagliardi G. Combination of oral non-absorbable and intravenous antibiotics versus intravenous antibiotics alone in the prevention of surgical site infections after colorectal surgery: a meta-analysis of randomized controlled trials. *Tech Coloproctol.* 2011;15:385–395.
101. 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? *Am J Surg.* 2011;201:623–627.
102. Tocchi A, Mazzoni G, Fornasari V, Miccini M, Daddi G, Tagliacozzo S. Preservation of the inferior mesenteric artery in colorectal resection for complicated diverticular disease. *Am J Surg.* 2001;182:162–167.