Review

Surgery for Diverticulitis in the 21st Century
A Systematic Review

Scott E. Regenbogen, MD, MPH; Karin M. Hardiman, MD, PhD; Samantha Hendren, MD, MPH; Arden M. Morris, MD, MPH

IMPORTANCE Diverticulitis of the sigmoid colon is an increasingly common disease. Patterns of care and management guidelines have significantly evolved in recent years.

OBJECTIVES To review and classify the primary data published since 2000 that are guiding decision making, technical considerations, and the outcomes of surgery for sigmoid diverticulitis.

EVIDENCE REVIEW We searched the National Guideline Clearinghouse, PubMed, and Cochrane databases for studies pertaining to the diagnosis and management of chronic and recurrent diverticulitis from January 1, 2000, to March 31, 2013. We supplemented this automated search with references drawn from included studies and PubMed. We rated the level of evidence according to American College of Cardiology/American Heart Association guidelines.

FINDINGS We identified 68 studies meeting inclusion criteria for final review. The studies were almost exclusively observational and had limited certainty of treatment effect. We found that complicated recurrence after recovery from an uncomplicated episode of diverticulitis is rare (<5%) and that age at onset younger than 50 years and 2 or more recurrences do not increase the risk of complications. Chronic symptoms may persist even after resection in 5% to 22% of patients. Prophylactic surgery is generally not recommended for average-risk patients with diverticulitis, irrespective of the number of episodes of acute, noncomplicated disease. Decisions to proceed with colon resection should be based instead on the patient-reported frequency and severity of diverticulitis symptoms.

CONCLUSIONS AND RELEVANCE The prior standard for proceeding with elective colectomy following 2 episodes of diverticulitis is no longer accepted. Decisions to proceed with colectomy should be made based on consideration of the risks of recurrent diverticulitis, the morbidity of surgery, ongoing symptoms, the complexity of disease, and operative risk. Laparoscopic surgery is preferred to open approaches. Recent evidence suggests that existing guidelines should be updated.

JAMA Surg. 2014;149(3):292-302. doi:10.1001/jamasurg.2013.5477
Published online January 15, 2014.

Related article at jama.com

Supplemental content at jamasurgery.com

Author Affiliations: Division of Colorectal Surgery, Department of Surgery, University of Michigan, Ann Arbor.

Corresponding Author: Arden M. Morris, MD, MPH, Division of Colorectal Surgery, Department of Surgery, University of Michigan, 1500 E Medical Center Dr, TC-2124, Ann Arbor, MI 48109 (ammsurg@med.umich.edu).

Diverticulitis of the sigmoid colon is a common condition, responsible for substantial morbidity and ongoing uncertainty about the optimal strategies for surgical management. The incidence of diverticulitis has increased in the last decade,[1,2] accounting for nearly 300 000 US hospital admissions[3] and $1.8 billion of annual direct medical costs.[4] Also in the last decade, treatment algorithms have evolved in response to improved diagnostic imaging,[5,6] greater understanding of the natural history and disease prognosis,[7,8] and increased application of nonoperative management including percutaneous abscess drainage.[9] Urgent operations for acute diverticulitis are now less common,[2,9] and national guidelines have begun to question the traditional indications for elective resection as well.[10] Still, per capita rates of elective surgery for diverticulitis have continued to increase, especially in patients younger than 65 years.[1,11]

Treatment goals for diverticulitis, whether for the hospitalized patient with an acute episode or a stable patient being treated as an outpatient, are to alleviate symptoms, prevent recurrence, perform elective rather than emergency operations when possible, and maintain intestinal continuity. The high incidence of operative complications, long-term morbidity,[12,13] and persistent symptoms such as pain, bloating, and altered defecatory function after colectomy[14-16] all have imparted new uncertainty about optimal strategies for surgical management.

We performed a systematic review of recent primary reports on the decision making, technical aspects, and outcomes of surgery for acute, recurrent, and chronic sigmoid diverticulitis. The specific research questions were the following: (1) What are the indications for surgical resection? (2) Should a specific surgical approach or technique be recommended? and (3) What are

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

the outcomes of surgical treatment? We consider this evidence in the context of published clinical practice guidelines[10] and current patterns of care.[2,11] A review of the nonoperative aspects of diverticulitis are concurrently published in *JAMA*.[17]

Methods

Search Strategy

We searched the National Guideline Clearinghouse and PubMed between January 1, 2000, and March 31, 2013, for existing clinical practice guidelines addressing surgical management of sigmoid diverticulitis. The only relevant guideline identified was the practice parameter published by the American Society of Colon and Rectal Surgeons in 2006 (which was based on literature up to 2005).[10] With this guideline as a starting point, we conducted a focused literature search using the MEDLINE and Cochrane databases for studies pertaining to the diagnosis and management of chronic and recurrent diverticulitis and published from January 1, 2000, to March 31, 2013. Our search terms and algorithm are provided in the eAppendix in the Supplement. We supplemented this automated search by reviewing additional references identified from included studies and from cited references searches in the Web of Science Citation Index.

Study Selection

We were interested in studies addressing surgical decision making, technical considerations, and outcomes for sigmoid diverticulitis. We included English-language studies reporting primary data on surgical treatment of diverticulitis of the descending and/or sigmoid colon in human adults. Three evidence domains were considered: (1) the indications for resection; (2) elements of surgical approach and technique; and (3) outcomes of surgical treatment. Review articles only reporting information present in other articles that we reviewed as well as case series with fewer than 30 patients were excluded. We also excluded studies with data accrued exclusively before 2000 because clinical practice guidelines[18] and trends in surgical management of diverticulitis changed significantly at that time,[2,11] and we sought to evaluate contemporary data derived primarily from patients treated after these changes.

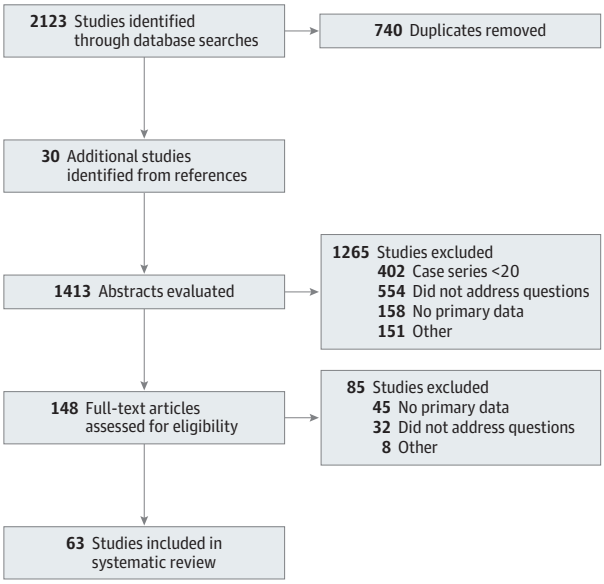
Data Extraction

Studies selected for inclusion were reviewed according to guidelines from the Meta-analysis of Observational Studies in Epidemiology Group.[19] We graded the level of evidence and classified recommendations by size of treatment effect according to the guidelines process from the American College of Cardiology/American Heart Association Task Force on Practice Guidelines.[20] We then compared the resulting recommendations with those of the most recent clinical practice guidelines on management of diverticulitis from the American Society of Colon and Rectal Surgeons.[10]

Results

The database search elicited 2123 published articles, of which 740 were duplicates, leaving 1383 unique abstracts. Our manual review of references identified an additional 30 nonduplicate studies for abstract evaluation. Of these 1413 abstracts, we eliminated 1265 during abstract review and an additional 85 after full-text review based on the defined exclusion criteria described earlier. The remaining 63 studies serve as the basis for the systematic review. The selection process, based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) schema,[21] is detailed in the **Figure**. The included studies and key findings are presented sequentially for each section in **Table 1**, **Table 2**, and **Table 3**.

Figure. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) Flowchart Detailing the Selection of Studies for Systematic Review



Acute Diverticulitis

We identified 6 studies that met the inclusion criteria and specifically reported data relevant to surgical decision making regarding urgent colectomy for diverticulitis (Table 1).[5,22-24,26,27]

In patients presenting with acute diverticulitis, urgent surgery is performed for those with sepsis and diffuse peritonitis or those who fail to improve despite medical therapy and/or percutaneous drainage.[10] Recognizing the substantial morbidity associated with urgent colectomy for complicated diverticulitis, however, there is a trend in favor of medical therapy, even in severe acute diverticulitis, whenever it can be achieved successfully.[2,11] In the absence of severe clinical signs of sepsis, 2 single-institution studies suggest the potential for nonoperative treatment even for patients with complicated, perforated acute diverticulitis. Dharmarajan et al[24] reviewed 136 patients with extraluminal air, fluid, and/or abscess and found that only 5 required urgent operation and another 12 failed expectant management. However, 28% underwent percutaneous drainage and 27% received parenteral nutrition. In a series reported by Costi et al,[23] 7% required surgery and an additional 18% needed percutaneous drainage.[23,24] Nevertheless, in observational series, about 15% to 20% of patients with acute diverticulitis still undergo urgent colectomy during their index hospitalization.[2,26,30,38]

Patients with complicated acute diverticulitis—that is, with extraluminal abscess or pneumoperitoneum—are more likely to undergo urgent operation than those with colonic inflammation

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

Table 1. Included Studies on Indications for Colon Resection for Diverticulitis

Source	Study Focus	Study Design[a]	Patients, No.	Findings	Level of Evidence
Acute Complicated Diverticulitis					
Ambrosetti,[5] 2012	Need for operation	Prospective	542	Severe diverticulitis per CT scan: 26% urgent surgery, 47% complications; moderate diverticulitis per CT scan: 4% urgent surgery, 19% complications	B
Ambrosetti et al,[22] 2005	Need for operation	Prospective	465	Surgery required in 51% with mesocolic abscess, 71% with pelvic abscess	B
Costi et al,[23] 2012	Need for operation	Retrospective	39	92% With perforation did not require urgent surgery	C
Dharmarajan et al,[24] 2011	Need for operation	Retrospective	136	91% With complicated diverticulitis did not require urgent surgery	C
Gaertner et al,[25] 2013	Need for operation	Retrospective	36	After percutaneous abscess drainage followed by nonoperative management, 58% had freedom from recurrence and no late colectomy	C
Kaiser et al,[26] 2005	Need for operation	Retrospective	511	Operation required in 7% with simple diverticulitis, 22% with abscess	B
Poletti et al,[27] 2004	Need for operation	Retrospective	168	Abscess (63% with vs 28% without abscess) and free air (57% with vs 29% without free air) predict need for operation	B
Recurrent Diverticulitis					
Chapman et al,[28] 2005	Risk of perforation	Retrospective	337	Most patients with perforation had history of diverticulitis	C
Boostrom et al,[29] 2012	Recurrence	Retrospective	684	Resolution of symptoms in 93% with atypical diverticulitis and 89% with smoldering diverticulitis	C
Broderick-Villa et al,[30] 2005	Recurrence	Retrospective	3165	13% With recurrence after nonoperative management	B
Chapman et al,[31] 2006	Risk of perforation	Retrospective	150	More common among patients with 1-2 episodes (17%) vs >2 episodes (0%)	C
Eglinton et al,[32] 2010	Recurrence	Retrospective	502	19% With recurrence, 5% with multiple recurrence; 5% with complicated recurrence	B
Hall et al,[33] 2011	Recurrence	Retrospective	672	36% With recurrence; 4% with complicated recurrence	B
Horgan et al,[34] 2001	Recurrence	Retrospective	47	77% Of patients with smoldering diverticulitis had resolution with surgery	C
Issa et al,[35] 2009	Risk of perforation	Retrospective	96	Peritonitis more common in first episode	C
Pittet et al,[36] 2009	Need for operation	Retrospective	271	More common with first episode (16%) than with recurrence (6%)	B
Ritz et al,[37] 2011	Perforation	Prospective	934	More common with first episode (25%) than second (13%) or more (<5%) episodes	B
Shaikh and Krukowski,[38] 2007	Need for operation	Prospective	232	19% Of conservatively managed patients undergo resection, 5% emergency	C
Patient Factors					
Anaya and Flum,[39] 2005	Need for operation	Retrospective	25 058	Young patients more often emergency (7.5% younger vs 5% older)	B
Biondo et al,[40] 2002	Recurrence, need for operation	Prospective	327	No difference by age in recurrence (25% younger vs 22% older) or emergency operation (26% younger vs 23% older)	B
Biondo et al,[41] 2012	Recurrence, perforation	Prospective	931	Immunosuppressed patients had no more risk than immunocompetent patients	B
Faria et al,[42] 2011	Recurrence	Retrospective	157	More recurrence in young patients (26% younger vs 11% older) but lower rate of emergency surgery (3% younger vs 14% older)	B
Guzzo and Hyman,[43] 2004	Recurrence, perforation	Retrospective	762	More elective resections in young patients (40% younger vs 26% older) but only 1 with perforation	B
Hjern et al,[44] 2008	Recurrence, need for operation	Retrospective	234	No difference with age (25% younger vs 20% older)	B
Klarenbeek et al,[45] 2010	Perforation	Retrospective	291	Immunosuppression, renal failure, collagen vascular disease increase risk	C
Kotzampassakis et al,[46] 2010	Recurrence, need for operation	Retrospective	271	Young patients had less urgent surgery (6% younger vs 20% older), less colostomy (1.4% younger vs 9% older)	B
Lahat et al,[47] 2006	Recurrence, need for operation	Prospective	207	Young patients had more recurrence (72% younger vs 45% older), more surgery (38% younger vs 13% older)	B

(continued)

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

Table 1. Included Studies on Indications for Colon Resection for Diverticulitis (continued)

Source	Study Focus	Study Design[a]	Patients, No.	Findings	Level of Evidence
Lopez-Borao et al,[48] 2012	Recurrence	Retrospective	686	No difference by age (24% younger vs 18% older)	B
Mäkelä et al,[49] 2009	Recurrence, perforation	Retrospective	1081	No difference in rates by age category	B
Nelson et al,[50] 2006	Recurrence, need for operation	Retrospective	411	Young patients had low risk of recurrence and emergency surgery	C
Ritz et al,[51] 2011	Perforation, need for operation	Prospective	1019	Young patients were no more likely to have perforation or emergency surgery for recurrence than older patients (5% younger vs 4% older)	B
Yoo et al,[52] 2008	Operation	Retrospective	112	Low albumin level, steroid use, and COPD predict need for surgery	C

Abbreviations: COPD, chronic obstructive pulmonary disease; CT, computed tomography.
[a] All were cohort studies.

Table 2. Included Studies on Technical Factors in Colon Resection for Diverticulitis

Source	Study Focus	Study Design	Participants, No.	Findings	Level of Evidence
PA vs HP					
Vermeulen et al,[53] 2009	Reversal after HP or PA with DLI	Retrospective cohort	158	Reversal of ostomy: HP 45% vs PA and DLI 74%; morbidity of reversal: HP 44% vs PA and DLI 15%	C
Maggard et al,[54] 2004	% of HPs that are reversed	Population-based retrospective cohort	11 582	Emergency HP: 41.7% of patients who had surgery; HP reversal: 65%	B
Gawlick and Nirula,[55] 2012	Outcomes of HP vs PA	Population-based retrospective cohort	2018	Type of surgery not predictive of outcome in multivariate analysis	B
Stumpf et al,[56] 2007	Outcomes of HP vs PA	Retrospective cohort	36	Low-risk patients underwent PA without complications	C
Tabbara et al,[57] 2010	Predictors of PA	Retrospective cohort	194	Patients with PA were younger with lower Hinchey score	C
Trenti et al,[58] 2011	Outcomes of HP vs PA	Retrospective cohort	87	PA associated with fewer complications in multivariate analysis	C
Vermeulen et al,[59] 2007	Outcomes of HP vs PA	Retrospective cohort	200	Type of surgery not predictive of mortality in multivariate analysis	C
Oberkofler et al,[60] 2012	Outcomes of HP vs PA with DLI	Randomized trial	62	Reversal of ostomy: PA with DLI 90% vs HP 57%; serious complications: PA with DLI 0% vs HP 20%	B
Laparoscopic Peritoneal Lavage					
Karoui et al,[61] 2009	Morbidity, LOS, subsequent operation	Retrospective cohort	59	Lower morbidity in patients with lavage: 16% vs 37.5% for matched patients with resection	C
Liang et al,[62] 2012	Subsequent operation	Retrospective cohort	47	3 Early failures, 21 elective operations	C
Myers et al,[63] 2008	Secondary intervention, recurrent diverticulitis	Case series	100	2 Percutaneous drainage, 2 readmissions with diverticulitis	C
Rogers et al,[64] 2012	Morbidity and mortality	Retrospective cohort	427	Lower mortality in patients with lavage: 4% vs 10% and morbidity: 14% vs 25%	C
White et al,[65] 2010	Subsequent operations	Retrospective cohort	35	8 Early failures, 8 late failures, 8 elective resections, 11 no operation	C
Franklin et al,[66] 2008	Subsequent operations	Retrospective cohort	40	20 Elective resection, 20 no further surgery; no acute complicated diverticulitis	C

Abbreviations: DLI, diverting loop ileostomy; HP, Hartmann procedure; LOS, length of stay; PA, primary anastomosis.

alone in reported case series.[5,26] They are also more likely to experience complications and perforation after nonoperative management.[22,26,27] In a series of more than 500 patients treated in a single academic medical center, Kaiser et al[26] found that patients with pelvic abscess, for example, had more than 3 times greater risk of recurrence after nonoperative treatment than after operation (41% vs 13%, respectively). These findings were corroborated in another single-institution series of 465 patients[22] in which 51% of patients with mesocolic abscesses and 71% of those with pelvic abscesses eventually required surgery, either acutely or in follow-up. To codify this additional risk, Ambrosetti et al[6] defined a severity grading system (**Table 4**), based on the presence of an abscess or extraluminal air or on contrast on computed tomography, that provides useful guidance on the likelihood of acute resolution and freedom from recurrence. Patients who recover from acute inflammation with nonoperative management in the presence of perforation are typically encouraged to undergo elective resection because of a higher incidence of late complications.[5,10,22,26] However, some authors have questioned the need for surgery even in this setting.[25,30] In a retrospective, single-institution study, Gaertner et al[25] described 36 patients managed nonoperatively after percutaneous drainage of colonic diverticular abscess, of whom fewer than half had

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

Table 3. Included Studies on Outcomes of Colon Resection for Diverticulitis

Source	Study Focus	Study Design	Participants, No.	Findings	Level of Evidence
30-d Outcomes					
Antolovic et al,[67] 2009	Postoperative morbidity	Prospective cohort	168	Postoperative infection 20%; urgent reoperation 9.5%; mortality 4%	B
Ince et al,[68] 2012	Postoperative morbidity, Hartmann procedure	Retrospective cohort	199	Postoperative complication 51%; urgent reoperation 10%; mortality 15%	B
Larson et al,[69] 2010	Postoperative morbidity, enhanced recovery protocol	Retrospective cohort	334	Traditional vs enhanced recovery protocol: postoperative complication 25% vs 15%; urgent reoperation 2% vs 4%; readmission 7.6% vs 2.9%	B
Lidor et al,[70] 2010	Postoperative morbidity, elderly patients	Population-based retrospective cohort	53 316	Urgent vs elective operation: readmission 21% vs 11.9%; mortality 8% vs 1.8%	B
Lidsky et al,[71] 2012	Postoperative mortality, acute surgery, elderly patients	Retrospective cohort	2264	Nonelderly mortality 1.6%; elderly mortality 9.7%; super elderly (aged >80 y) mortality 17.8%	B
Morks et al,[72] 2010	Postoperative morbidity, elective vs acute surgery	Retrospective cohort	299	Acute vs elective surgery: minor complications 20% vs 17%; major complications 40% vs 20%; mortality 16% vs 1%	B
Pendlimari et al,[73] 2011	Postoperative morbidity, laparoscopic surgery	Retrospective cohort	361	Complicated vs uncomplicated diverticulitis: postoperative complications 27.9% vs 19.6%; readmission 11% vs 5.3%; reoperation 3.7% vs 3.1%	B
Sheer et al,[74] 2011	Postoperative morbidity, elective surgery, elderly patients	Retrospective cohort	22 752	Postoperative complications 22.1%; mortality 1.2%; mortality among patients with congestive heart failure, odds ratio = 3.5 (95% CI, 2.59-4.63)	B
Long-term Outcomes					
Andeweg et al,[75] 2008	Risk factors for recurrence	Retrospective cohort	183	Recurrence rate = 8.7%; risk factors include younger age ($P < .02$), persistence of postoperative pain ($P < .005$); chronic abdominal pain 22%; recurrent diverticulitis not associated with higher proportion of emergency procedures	B
Binda et al,[76] 2012	Risk of recurrent acute diverticulitis	Multicenter cohort study	242	Recurrence rate = 5.8%; mortality = 0.6%	B
Thaler et al,[77] 2003	Laparoscopic vs open surgery recurrence rates	Retrospective cohort	155	Recurrence rate 6.5%; median time of recurrence after surgery, 29 mo; 2 of 11 recurrences after 5 y	B
Patient-Reported Outcomes					
Ambrosetti et al,[78] 2007	Long-term functional outcomes	Cross-sectional survey	43	Bowel function better 56%, unchanged 37%, worse 7%; new postoperative abdominal pain 9%	B
Egger et al,[16] 2008	Incidence and risk of chronic symptoms	Cross-sectional survey	124	Elective vs emergency operation: chronic abdominal pain 25% vs 24%; neither Hinchey stage nor technique were associated with chronicity	B
Pasternak et al,[79] 2012	Quality of life after laparoscopic sigmoidectomy	Cross-sectional regarding preoperative and postoperative states	120	Preoperative vs postoperative: quality of life score 95 vs 114; recurrence 7.5%	B
Levack et al,[80] 2012	Incidence and predictors of postoperative bowel dysfunction	Cross-sectional survey	249	Fecal incontinence 24.8%; urgency 19.6%; incomplete emptying 20.8%	B
Forgione et al,[81] 2009	Functional outcomes, elective laparoscopic sigmoidectomy	Longitudinal survey (baseline and 3, 6, and 12 mo)	46	Most functional scores improved and were sustained; 19 patients improved by >20%; 3 patients decreased by 20% for unclear reasons	B
Käser et al,[82] 2012	Postoperative symptoms	Cross-sectional survey	117	Complete resolution 54%; marked improvement 34%; some improvement 10%; no improvement 2%	C

recurrent diverticulitis, all managed without resection. Broderick-Villa et al[30] likewise found that patients with percutaneously drained abscesses were no more likely than those with simple acute diverticulitis to have future recurrence or complication.

Recurrent and Chronic Diverticulitis

Eleven studies met inclusion criteria and provided data informing decisions about elective surgery for recurrent or chronic diverticulitis (Table 1).[28-38]

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

Elective resection was recommended after 2 episodes of uncomplicated diverticulitis (or a single episode in young patients).[83] This practice was based on the idea that such patients demonstrated, by virtue of recurrence and age at onset, a more "virulent" syndrome at greater risk for rerecurrence. Thus, elective intervention was deemed necessary to prevent future complicated episodes, emergency operation, and/or colostomy.[84] These assumptions have been recently challenged.

The incidence of recurrent diverticulitis may be lower than was previously assumed. In 6 observational studies evaluating recurrence rates after a first episode of uncomplicated diverticulitis, the recurrence rates ranged from 10% to 35%,[5,30,32,33,38,39] meaning that most patients never had another episode and would have no opportunity to benefit from surgery. We identified 11 studies eligible for review that addressed recurrence rates by age, but there was incomplete consensus. Some retrospective studies reported higher recurrence rates in younger patients.[30,39,42,43,47] However, in most case series, the likelihood of recurrence was affected not by age at onset but rather by the severity of the initial episode.[31,35-37,39,83,84]

Second, after 2 bouts of diverticulitis, the likelihood of rerecurrence may be modestly higher,[30] but the severity of attacks generally does not increase.[28,31] Instead, most patients' recurrent episodes will mimic their earlier, uncomplicated ones. For example, in retrospective single-institution reviews with relatively long follow-up, only 3% to 5% of patients experienced a complicated recurrence after nonoperative management of an episode of acute diverticulitis.[32,33] About 5% of patients managed conservatively in a single-institution series from Shaikh and Krukowski[38] and a statewide cohort reported by Anaya and Flum[39] went on to require emergency surgery. Further, the likelihood of free perforation seems to be far greater in patients with no history of diverticulitis than those who have recovered from 1 or more episodes.[28,35-37] In a retrospective cohort of more than 1300 patients, Ritz et al[37] found that free perforation occurred in 25% of patients presenting with their first episode of acute diverticulitis, but only 12% with their second, 6% with their third, and 1% thereafter.

We included 14 studies evaluating patient-specific risk factors for recurrence and complications (Table 1).[39-52] Age at onset had traditionally been a point of emphasis, but the importance of age is increasingly downplayed, as discussed earlier. Observational studies have identified family history, retroperitoneal abscess, and length of the colon segment involved as factors associated with increased risk of recurrence,[33] but it is not clear how well these factors can identify those with enough increased risk to justify prophylactic surgery. There is increased concern for complications of diverticulitis among patients with substantial comorbidity. Patients with immunosuppression, collagen vascular disease, glucocorticoid use, and malnutrition[45,52] are at increased risk for recurrence and perforation with recurrent episodes, in some[41,44] (though not all[41]) series, and might therefore have a lower threshold to consider elective resection. On the other hand, their operative risk may be substantially greater as well.[71,74,85]

The collective evidence supports an individualized approach to consideration of elective resection, which takes into account the severity of prior episodes, patient-specific risk factors, ongoing symptoms, and patients' preferences. The number of episodes and age at onset should be considered secondary to these other factors. For those with recurrent diverticulitis who experience complete recovery between episodes, colectomy is intended to prevent future episodes of diverticulitis of similar severity as those they have already experienced. The data suggest that prophylactic surgery to prevent severe septic complications in asymptomatic patients with a history of diverticulitis is not necessary in most cases. Rather, patients may choose elective operation if the frequency and severity of their episodes is sufficient to justify the burden of surgery.

Table 4. Computed Tomography–Based Severity Grading and Outcomes[a]

Severity Grading	CT Findings	Outcomes
Moderate	Localized thickening of the colonic wall of ≥5 mm and signs of inflammation of the pericolic fat	4% Failure of medical treatment at index episode; 17% initially nonoperative at index episode have recurrence or complication
Severe	Findings above plus ≥1 of abscess, extraluminal air, and extraluminal contrast	26% Failure of medical treatment at index episode; 36% initially nonoperative at index episode have recurrence or complication

Abbreviation: CT, computed tomography.

[a] Based on the study by Ambrosetti et al.[6]

There are other patients who have atypical, chronic, or so-called smoldering diverticulitis in which symptoms are protracted and subacute.[86] These patients may choose surgery as a remedy for their ongoing symptoms, not merely for prophylaxis. In these patients, it is particularly important to consider and exclude other diagnoses such malignant neoplasm and functional bowel disorders, which increase the likelihood of persistent symptoms after resection.[15] In 2 reports of nonoverlapping series of patients from the same institution diagnosed as having chronic diverticulitis, resection relieved symptoms in 77% to 89% of cases, with persistent symptoms mostly related to comorbid irritable bowel syndrome.[29,34] Thus, the decision to perform elective surgery for chronic sigmoid diverticulitis will be made on a case-by-case basis,[10] weighing the severity of the ongoing syndrome and the likelihood of improvement against the short-term morbidity and long-term functional consequences of sigmoid colon resection.

Technical Considerations

Three randomized trials have compared laparoscopic and open colon resection for diverticular disease. In the Sigma trial, 100 patients with recurrent sigmoid diverticulitis were randomized to laparoscopic vs open sigmoid resection in 5 European centers. Patients randomized to laparoscopy experienced decreased incidence of major complications, reduced hospital stay and postoperative pain,[87] and improved subjective quality of life at 6 months after surgery.[88] A similarly designed and powered French study mostly replicated the short-term benefits but concluded that the only long-term advantage of laparoscopic resection was cosmesis.[89,90] A third trial in Germany found no meaningful differences in short- or longer-term outcomes but was underpowered owing to difficulty with enrollment.[91] Indeed, recruiting patients to participate in randomization for diverticulitis has proven difficult, often because of patients' prejudged preference for laparoscopic surgery.[92]

Whether open or laparoscopic, options for definitive surgery in acute or chronic diverticulitis include resection of the affected colon segment with or without anastomosis and/or upstream diversion, depending on the health of the remaining bowel, extent of peritoneal con-

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

tamination, overall condition of the patient, and baseline defecatory function. The data supporting each of these therapies consist predominantly of retrospective comparisons, limiting the conclusions that can be drawn about procedure choice for any given patient.

Because operations to close a colostomy incur substantial rates of major morbidity,[52,71] as many as 45% of patients who undergo a Hartmann procedure with end colostomy and rectal stump closure may never attempt colostomy closure.[53,54] There is therefore increased recent interest in strategies to maintain intestinal continuity with urgent surgery for diverticulitis. We included 8 studies that addressed this question (Table 2).[53-60]

In a series of retrospective reviews comparing the Hartmann procedure against primary colorectal anastomosis with or without diverting loop ileostomy, short-term outcomes were similar and authors concluded that primary anastomosis in carefully selected patients undergoing urgent operations for acute diverticulitis is reasonable and safe.[55-59,93] Conclusions drawn from these retrospective trials are limited importantly, however, by selection bias in the choice of operation. In a small, underpowered trial comparing these approaches, Oberkofler et al[60] randomized 62 patients to primary anastomosis with diverting ileostomy vs Hartmann procedure. Rates of mortality (9% vs 13%, respectively) and complication (75% vs 67%, respectively) were high but not different between groups. However, the likelihood of stoma closure was far greater with primary anastomosis than with the Hartmann procedure (90% vs 58%, respectively) and major complication rates for patients who underwent stoma closure were lower (0% vs 20%, respectively). These data suggest some preference for primary anastomosis with proximal diversion in the acute setting, when clinical conditions allow. However, the clinical factors to inform decision making in this setting are not well defined, leaving surgeons to make case-by-case decisions according to the suitability of the rectum for anastomosis, the clinical condition of the patient in the operating room, and the degree of pelvic and peritoneal inflammation around the intended anastomosis.

Regardless of the reconstruction or diversion method chosen, the margins of resection must be the same, as they appear to be the most important contributor to the likelihood of recurrent diverticulitis after resection. Specifically, in the presence of a colocolonic anastomosis with retained distal sigmoid colon, the odds of recurrent diverticulitis increased 4-fold compared with creation of a colorectal anastomosis.[94] The distal resection margin therefore should extend below the rectosigmoid junction, beyond the point at which the taeniae coli coalesce. Proximally, the resection should include the thickened and chronically inflamed or fibrotic colon segment but need not remove all of the colonic diverticula. Thus, when the inflammation and fibrosis are limited to the sigmoid colon, an anastomosis from descending colon to rectum is adequate, whereas involvement up to the proximal descending colon would necessitate extended left colectomy.

Recognizing that resectional approaches to urgent colectomy incur substantial associated morbidity, there is increasing discussion of nonresectional operations for acute diverticulitis. Laparoscopic peritoneal lavage has been proposed as a damage-control operation to contain contamination and give patients with acute perforation and purulent peritonitis a bridge to elective resection with primary anastomosis. We found 6 studies reporting results of this procedure that met inclusion criteria (Table 2).[61-66] They were uniformly observational, small, single-institution studies that demonstrated fewer complications in patients who underwent lavage compared with primary resection. However, recognizing the substantial selection bias as patients converted from lavage to resection were typically analyzed with the resection group, it is difficult to draw firm conclusions from these comparative data. In addition, skeptics have argued that many of the patients "successfully" managed with lavage may have otherwise been amenable to nonoperative medical therapy with or without percutaneous drainage anyway, as many had localized abscesses and lacked substantial comorbidity.[95] Thus, until results of expected randomized trials[96,97] become known, there is insufficient evidence to recommend laparoscopic lavage as an alternative to resection in patients who fail nonoperative management.

Outcomes of Surgery

We identified 8 recent articles that fit the inclusion criteria and specifically discussed 30-day postoperative outcomes (Table 3).[67-74]

Most studies reported a postoperative infection rate of about 10% to 20%. Some reported substantially higher postoperative complication rates,[72,73] likely related to the relative proportion of urgent rather than elective operations evaluated. Mortality rates tended to be less than 5% and were associated strongly with patients' comorbid conditions and severity of presentation.[68,71,74] Historical recommendations for management of acute and recurrent diverticulitis were based on the poor medical and surgical outcomes of the time. Today, the benefit of an elective operation to avoid the risk of future sepsis must be weighed against the risk of perioperative complications, especially among elderly patients and those with extensive comorbid disease.[71,74,85]

Studies examining long-term outcomes after colectomy for diverticulitis addressed 1 or both of the following: (1) risk of recurrent diverticulitis, and/or (2) patient-reported outcomes, including persistence or recurrence of symptoms. For the former outcome, 3 articles fulfilled our selection criteria (Table 3).[75-77] In these studies, imaging-confirmed postoperative recurrence rates ranged from 5.8% to 8.7%. Time to recurrence tends to be prolonged—29 months was the median and 2 of 5 recurrences were diagnosed more than 5 years after the index diagnosis. Thaler et al[77] evaluated 155 patients who underwent elective laparoscopic or open sigmoid colectomy and reported that postoperative recurrence was not related to the urgency of the initial operation or to surgical approach, a finding corroborated in a slightly larger survey by Andeweg et al[75] in which there was no association between an index emergency procedure and subsequent recurrent disease.

Six survey studies that examined patient-reported outcomes consistently noted that most patients had some relief of symptoms.[16,78-82] However, a substantial proportion of patients also experienced chronic or persistent symptoms of abdominal pain[78,81,82] and, in 1 cohort study, poor postoperative continence.[80] In the study by Andeweg et al,[75] 22% of patients reported ongoing diffuse, chronic abdominal pain that persisted after the operation. Overall, 2% to 20% of respondents reported no real long-term relief of their symptoms postoperatively and between 5% and 10% actually reported worse abdominal pain or gastrointestinal function.

Summary Recommendations

Based on the findings of this systematic review, we compared our interpretation of the evidence and consequent recommendations with those in the most recent practice parameters published by the American Society of Colon and Rectal Surgeons.[10] These recommendations and their class of treatment effect[20] are presented in **Table 5** for comparison.

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

Table 5. Systematic Review of Evidence Regarding Surgical Decision Making, Compared With Practice Parameters From the American Society of Colon and Rectal Surgeons[a]

Indications and Considerations	Current Review		ASCRS	
	Decision Making	Level of Recommendation (Class)	Practice Parameters	Level of Recommendation (Class)
Indications for Surgery, Acute				
Sepsis	Urgent surgery is performed for those with sepsis and diffuse peritonitis or those who fail to improve despite medical therapy and/or percutaneous drainage	B (I)	Urgent colectomy should be performed for diffuse peritonitis or failure of nonoperative management of acute diverticulitis	B (I)
Free air on CT	In absence of severe clinical signs of sepsis, 2 single-institution studies suggest potential for nonoperative treatment even for patients with complicated, perforated acute diverticulitis	B (IIb)	Not addressed	Not applicable
Failure to improve with medical management	Urgent surgery is performed for those who fail to improve despite medical therapy and/or percutaneous drainage	B (I)	Urgent colectomy should be performed for diffuse peritonitis or failure of nonoperative management of acute diverticulitis	B (I)
Indications for Surgery, Elective Setting				
Abscess drained at acute presentation	Patients who recover from acute inflammation with nonoperative management in presence of perforation are typically encouraged to undergo elective resection because of higher incidence of late complications	B (IIa)	Elective colon resection should typically be recommended after an episode of complicated diverticulitis is treated by percutaneous drainage	B (IIa)
Recurrent disease	Evidence supports an individualized approach to consideration of elective resection, which takes into account severity of prior episodes, patient-specific risk factors, ongoing symptoms, and patients' preferences	B (IIa)	Number of attacks of uncomplicated diverticulitis is not an overriding factor in defining appropriateness of surgery	B (IIb)
Chronic symptoms	Elective surgery is decided on a case-by-case basis, weighing risks and benefits of expectant and surgical treatment	C (IIa)	Decision to recommend surgery should be influenced by whether there are persistent symptoms after acute episode	C (I)
Patient age	Age at onset of diverticulitis should be considered secondary to severity and frequency of episodes	B (IIa)	No clear consensus regarding whether younger patients (aged <50 y) are at increased risk for complications; however, they are probably at increased risk for recurrent diverticulitis	B (IIa)
Comorbid disease	Patients with immunosuppression, collagen vascular disease, glucocorticoid use, and malnutrition are at increased risk for recurrence and perforation with recurrent episodes and might therefore have lower threshold to consider elective resection	C (IIa)	Immunocompromised patients are more likely to present with perforation and to fail medical management, so a lower threshold for urgent and elective surgery should be applied to them	C (IIa)
Technical Considerations				
Ostomy formation	Data suggest some preference for primary anastomosis with proximal diversion in acute setting when clinical conditions allow	B (IIa)	For emergency surgery, anastomosis (with or without intraoperative colonic lavage) may be considered depending on patient status and Hinchey classification; primary anastomosis with diverting ostomy is an alternative to Hartmann procedure	C (IIb)
Margins of resection	Proximally, resection should include thickened and chronically inflamed or fibrotic colon segment, but need not remove all of the colonic diverticula; a colorectal anastomosis, not a colocolonic anastomosis, should be performed	B (I)	Resection should be carried proximally to compliant bowel and distally to upper rectum	B (I)
Laparoscopic peritoneal lavage	Insufficient evidence to recommend laparoscopic lavage as alternative to resection in patients who truly fail nonoperative management	C (III)	Not addressed	Not applicable

Abbreviations: ASCRS, American Society of Colon and Rectal Surgeons; CT, computed tomography.

[a] The practice parameters from the ASCRS are from the article by Rafferty et al.[10]

Discussion

Reviewing the published literature on surgical management of diverticulitis since the turn of the millennium, we found substantial changes in contemporary evidence that have reduced the use of urgent surgery for acute diverticulitis,[1,2] restricted the indications for prophylactic surgery in recurrent diverticulitis,[10,31,98] and led a movement toward generally less invasive and morbid approaches to this disease.[99] Because of the rapid pace of recent changes in practice patterns, we focused this review on studies with data predominantly since 2000. At that time, the practice parameters of the American Society of Colon and Rectal Surgeons continued to recommend elective surgery after 2 uncomplicated episodes of diverticulitis, until the 2006 practice guideline that acknowledged the need to individualize timing of surgery.[10,18,83]

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

In this review, we found further evidence to support the practice of individualizing decisions about surgery based on particular characteristics of the patient and his or her presentation. Patients may pursue an operation out of fear of emergency colectomy resulting in colostomy. However, the likelihood of such an event after an uncomplicated episode of diverticulitis in average-risk patients is quite low.[31,33,36,37] Thus, each patient must consider the frequency and severity of his or her recurrent episodes and the degree to which they limit quality of life. Patients who experience complications of diverticular disease, including perforation, fistula, and stricture, often do require surgical intervention. Thus, rather than relying on a number of episodes to guide surgical decision making, clear, patient-specific risk factors are needed to identify those at highest risk for morbidity with expectant management of recurrent diverticulitis. Outcomes registries have improved our recognition of patient factors contributing to operative morbidity and may help with the evaluation of surgical risk, but prognostic tools to predict the course of diverticular disease and the likelihood of important complications are lacking.

For postacute patients who recover with nonoperative therapy for an initial episode of diverticulitis, many authors have recommended endoscopic and/or fluoroscopic evaluation to confirm the diagnosis of diverticulitis and exclude other common causes of segmental colitis such as neoplasm, Crohn disease, and ischemic colitis.[30,100,101] This recommendation remains controversial, however, as the yield and cost-effectiveness of colonoscopy have not been established in this setting. Malignant neoplasms are detected in 0% to 3% of patients with presumed diverticulitis[6,102-105] but perhaps as many as 13% of those with a protracted or otherwise atypical subacute clinical course.[101] Some have argued that all of the patients with important endoscopic findings would have had other clinical indications for colonoscopy.[105] However, practice parameters from surgical societies endorse routine flexible endoscopy to confirm the diagnosis of diverticulitis for any patient who has not recently undergone appropriate colorectal cancer screening.[10,106]

Another important component of these decisions is the patient-reported long-term functional outcomes of colectomy for diverticulitis. Most patients assume that surgery will be curative when they evaluate their options. We did find low rates of recurrent diverticulitis after resection with colorectal anastomosis.[77,94] However, persistent gastrointestinal symptoms were common, perhaps suggesting overlap between chronic or recurrent diverticulitis, inflammatory bowel disease, and irritable bowel and other functional gastrointestinal syndromes that are not improved with resection.[16,86,107] A challenge for future research is differentiating the symptoms of irritable bowel syndrome and inflammatory bowel disease from those of chronically symptomatic diverticulitis—this is particularly difficult because these conditions are so common in Western cultures.

The primary limitation of this study is that the overall quality of the evidence was limited. Retrospective observational trials and epidemiologic studies account for nearly the entire evidence base from which current practice standards are derived. Trials comparing modes of therapy were largely observational and subject to selection bias. Wide variability in surgical technique, diagnostic criteria, and completeness, duration, and method of follow-up made comparisons between studies difficult.

Conclusions

Diverticulitis remains a common, morbid, and costly condition for which optimal surgical management remains controversial across a number of domains. However, recent evidence suggests the safety of avoiding elective colectomy for most patients with uncomplicated disease and opens the door to modern approaches such as selective anastomosis with proximal diversion in the acute setting and laparoscopic colectomy in the elective setting. Ongoing prospective assessments of these emerging strategies are needed to continue to improve surgical management of diverticular disease in the 21st century.

ARTICLE INFORMATION

Accepted for Publication: November 18, 2013.

Published Online: January 15, 2014. doi:10.1001/jamasurg.2013.5477.

Author Contributions: Dr Morris had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Regenbogen, Hardiman, Morris.
Acquisition of data: Hardiman, Morris.
Analysis and interpretation of data: All authors.
Drafting of the manuscript: Regenbogen, Hardiman, Morris.
Critical revision of the manuscript for important intellectual content: All authors.
Administrative, technical, and material support: Hardiman, Morris.
Study supervision: Regenbogen, Morris.

Conflict of Interest Disclosures: None reported.

REFERENCES

1. Etzioni DA, Mack TM, Beart RW Jr, Kaiser AM. Diverticulitis in the United States: 1998-2005: changing patterns of disease and treatment. *Ann Surg*. 2009;249(2):210-217.

2. 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(9):1558-1563.

3. Centers for Disease Control and Prevention; National Center for Health Statistics. CDC/NCHS National Hospital Discharge Survey, 2010. http://www.cdc.gov/nchs/. Accessed April 5, 2013.

4. Yen L, Davis KL, Hodgkins P, Loftus EV Jr, Erder MH. Direct costs of diverticulitis in a US managed care population. *Am J Pharm Benefits*. 2012;4(5):e118-e129.

5. Ambrosetti P. Value of CT for acute left-colonic diverticulitis: the surgeon's view. *Dig Dis*. 2012;30(1):51-55.

6. Ambrosetti P, Becker C, Terrier F. Colonic diverticulitis: impact of imaging on surgical management: a prospective study of 542 patients. *Eur Radiol*. 2002;12(5):1145-1149.

7. Janes S, Meagher A, Frizelle FA. Elective surgery after acute diverticulitis. *Br J Surg*. 2005;92(2):133-142.

8. Collins D, Winter DC. Elective resection for diverticular disease: an evidence-based review. *World J Surg*. 2008;32(11):2429-2433.

9. Salem L, Anaya DA, Flum DR. Temporal changes in the management of diverticulitis. *J Surg Res*. 2005;124(2):318-323.

10. Rafferty J, Shellito P, Hyman NH, Buie WD; Standards Committee of American Society of Colon and Rectal Surgeons. Practice parameters for sigmoid diverticulitis. *Dis Colon Rectum*. 2006;49(7):939-944.

11. Etzioni DA, Cannom RR, Ault GT, Beart RW Jr, Kaiser AM. Diverticulitis in California from 1995 to 2006: increased rates of treatment for younger patients. *Am Surg*. 2009;75(10):981-985.

12. Cohen ME, Bilimoria KY, Ko CY, Hall BL. Development of an American College of Surgeons National Surgery Quality Improvement Program: morbidity and mortality risk calculator for colorectal surgery. *J Am Coll Surg*. 2009;208(6):1009-1016.

13. Schilling PL, Dimick JB, Birkmeyer JD. Prioritizing quality improvement in general surgery. *J Am Coll Surg*. 2008;207(5):698-704.

14. Munson KD, Hensien MA, Jacob LN, Robinson AM, Liston WA. Diverticulitis: a comprehensive follow-up. *Dis Colon Rectum*. 1996;39(3):318-322.

15. Thörn M, Graf W, Stefànsson T, Påhlman L. Clinical and functional results after elective colonic

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

resection in 75 consecutive patients with diverticular disease. *Am J Surg*. 2002;183(1):7-11.

16. Egger B, Peter MK, Candinas D. Persistent symptoms after elective sigmoid resection for diverticulitis. *Dis Colon Rectum*. 2008;51(7):1044-1048.

17. Morris AM, Hardiman KM, Regenbogen SE, Hendren S. Sigmoid diverticulitis: a systematic review. *JAMA*. 2014;311(3). doi:10.1001/jama.2013.282025.

18. Wong WD, Wexner SD, Lowry A, et al; Standards Task Force, American Society of Colon and Rectal Surgeons. Practice parameters for the treatment of sigmoid diverticulitis: supporting documentation. *Dis Colon Rectum*. 2000;43(3):290-297.

19. Stroup DF, Berlin JA, Morton SC, et al; Meta-analysis of Observational Studies in Epidemiology (MOOSE) Group. Meta-analysis of observational studies in epidemiology: a proposal for reporting. *JAMA*. 2000;283(15):2008-2012.

20. Gibbons RJ, Smith S, Antman E; American College of Cardiology; American Heart Association. American College of Cardiology/American Heart Association clinical practice guidelines: part I: where do they come from? *Circulation*. 2003;107(23):2979-2986.

21. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med*. 2009;6(7):e1000100.

22. 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(4):787-791.

23. Costi R, Cauchy F, Le Bian A, Honart JF, Creuze N, Smadja C. Challenging a classic myth: pneumoperitoneum associated with acute diverticulitis is not an indication for open or laparoscopic emergency surgery in hemodynamically stable patients: a 10-year experience with a nonoperative treatment. *Surg Endosc*. 2012;26(7):2061-2071.

24. Dharmarajan S, Hunt SR, Birnbaum EH, Fleshman JW, Mutch MG. The efficacy of nonoperative management of acute complicated diverticulitis. *Dis Colon Rectum*. 2011;54(6):663-671.

25. Gaertner WB, Willis DJ, Madoff RD, et al. Percutaneous drainage of colonic diverticular abscess: is colon resection necessary? *Dis Colon Rectum*. 2013;56(5):622-626.

26. Kaiser AM, Jiang JK, Lake JP, et al. The management of complicated diverticulitis and the role of computed tomography. *Am J Gastroenterol*. 2005;100(4):910-917.

27. Poletti PA, Platon A, Rutschmann O, et al. Acute left colonic diverticulitis: can CT findings be used to predict recurrence? *AJR Am J Roentgenol*. 2004;182(5):1159-1165.

28. Chapman J, Davies M, Wolff B, et al. Complicated diverticulitis: is it time to rethink the rules? *Ann Surg*. 2005;242(4):576-581, discussion 581-583.

29. Boostrom SY, Wolff BG, Cima RR, Merchea A, Dozois EJ, Larson DW. Uncomplicated diverticulitis, more complicated than we thought. *J Gastrointest Surg*. 2012;16(9):1744-1749.

30. 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(6):576-581, discussion 581-583.

31. Chapman JR, Dozois EJ, Wolff BG, Gullerud RE, Larson DR. Diverticulitis: a progressive disease? do multiple recurrences predict less favorable outcomes? *Ann Surg*. 2006;243(6):876-883.

32. 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(6):952-957.

33. 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(3):283-288.

34. Horgan AF, McConnell EJ, Wolff BG, The S, Paterson C. Atypical diverticular disease: surgical results. *Dis Colon Rectum*. 2001;44(9):1315-1318.

35. Issa N, Dreznik Z, Dueck DS, et al. Emergency surgery for complicated acute diverticulitis. *Colorectal Dis*. 2009;11(2):198-202.

36. Pittet O, Kotzampassakis N, Schmidt S, Denys A, Demartines N, Calmes JM. Recurrent left colonic diverticulitis episodes: more severe than the initial diverticulitis? *World J Surg*. 2009;33(3):547-552.

37. Ritz JP, Lehmann KS, Frericks B, Stroux A, Buhr HJ, Holmer C. Outcome of patients with acute sigmoid diverticulitis: multivariate analysis of risk factors for free perforation. *Surgery*. 2011;149(5):606-613.

38. Shaikh S, Krukowski ZH. Outcome of a conservative policy for managing acute sigmoid diverticulitis. *Br J Surg*. 2007;94(7):876-879.

39. Anaya DA, Flum DR. Risk of emergency colectomy and colostomy in patients with diverticular disease. *Arch Surg*. 2005;140(7):681-685.

40. Biondo S, Parés D, Martí Ragué J, Kreisler E, Fraccalvieri D, Jaurrieta E. Acute colonic diverticulitis in patients under 50 years of age. *Br J Surg*. 2002;89(9):1137-1141.

41. Biondo S, Borao JL, Kreisler E, et al. Recurrence and virulence of colonic diverticulitis in immunocompromised patients. *Am J Surg*. 2012;204(2):172-179.

42. Faria GR, Almeida AB, Moreira H, Pinto-de-Sousa J, Correia-da-Silva P, Pimenta AP. Acute diverticulitis in younger patients: any rationale for a different approach? *World J Gastroenterol*. 2011;17(2):207-212.

43. Guzzo J, Hyman N. Diverticulitis in young patients: is resection after a single attack always warranted? *Dis Colon Rectum*. 2004;47(7):1187-1190, discussion 1190-1191.

44. Hjern F, Josephson T, Altman D, Holmström B, Johansson C. Outcome of younger patients with acute diverticulitis. *Br J Surg*. 2008;95(6):758-764.

45. 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(4):670-674.

46. 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(3):333-338.

47. Lahat A, Menachem Y, Avidan B, et al. Diverticulitis in the young patient: is it different? *World J Gastroenterol*. 2006;12(18):2932-2935.

48. Lopez-Borao J, Kreisler E, Millan M, et al. Impact of age on recurrence and severity of left colonic diverticulitis. *Colorectal Dis*. 2012;14(7):e407-e412.

49. Mäkelä JT, Kiviniemi HO, Laitinen ST. Acute sigmoid diverticulitis in young patients. *Hepatogastroenterology*. 2009;56(94-95):1382-1387.

50. Nelson RS, Velasco A, Mukesh BN. Management of diverticulitis in younger patients. *Dis Colon Rectum*. 2006;49(9):1341-1345.

51. Ritz JP, Lehmann KS, Stroux A, Buhr HJ, Holmer C. Sigmoid diverticulitis in young patients: a more aggressive disease than in older patients? *J Gastrointest Surg*. 2011;15(4):667-674.

52. Yoo PS, Garg R, Salamone LF, Floch MH, Rosenthal R, Longo WE. Medical comorbidities predict the need for colectomy for complicated and recurrent diverticulitis. *Am J Surg*. 2008;196(5):710-714.

53. Vermeulen J, Coene PP, Van Hout NM, et al. Restoration of bowel continuity after surgery for acute perforated diverticulitis: should Hartmann's procedure be considered a one-stage procedure? *Colorectal Dis*. 2009;11(6):619-624.

54. Maggard MA, Zingmond D, O'Connell JB, Ko CY. What proportion of patients with an ostomy (for diverticulitis) get reversed? *Am Surg*. 2004;70(10):928-931.

55. Gawlick U, Nirula R. Resection and primary anastomosis with proximal diversion instead of Hartmann's: evolving the management of diverticulitis using NSQIP data. *J Trauma Acute Care Surg*. 2012;72(4):807-814, quiz 1124.

56. Stumpf MJ, Vinces FY, Edwards J. Is primary anastomosis safe in the surgical management of complications of acute diverticulitis? *Am Surg*. 2007;73(8):787-790, discussion 790-791.

57. Tabbara M, Velmahos GC, Butt MU, et al. Missed opportunities for primary repair in complicated acute diverticulitis. *Surgery*. 2010;148(5):919-924.

58. Trenti L, Biondo S, Golda T, et al. Generalized peritonitis due to perforated diverticulitis: Hartmann's procedure or primary anastomosis? *Int J Colorectal Dis*. 2011;26(3):377-384.

59. Vermeulen J, Akkersdijk GP, Gosselink MP, et al. Outcome after emergency surgery for acute perforated diverticulitis in 200 cases. *Dig Surg*. 2007;24(5):361-366.

60. 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(5):819-826, discussion 826-827.

61. Karoui M, Champault A, Pautrat K, Valleur P, Cherqui D, Champault G. Laparoscopic peritoneal lavage or primary anastomosis with defunctioning stoma for Hinchey 3 complicated diverticulitis: results of a comparative study. *Dis Colon Rectum*. 2009;52(4):609-615.

62. Liang S, Russek K, Franklin ME Jr. Damage control strategy for the management of perforated diverticulitis with generalized peritonitis: laparoscopic lavage and drainage vs laparoscopic Hartmann's procedure. *Surg Endosc*. 2012;26(10):2835-2842.

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015

63. Myers E, Hurley M, O'Sullivan GC, Kavanagh D, Wilson I, Winter DC. Laparoscopic peritoneal lavage for generalized peritonitis due to perforated diverticulitis. *Br J Surg*. 2008;95(1):97-101.

64. Rogers AC, Collins D, O'Sullivan GC, Winter DC. Laparoscopic lavage for perforated diverticulitis: a population analysis. *Dis Colon Rectum*. 2012;55(9):932-938.

65. White SI, Frenkiel B, Martin PJ. A ten-year audit of perforated sigmoid diverticulitis: highlighting the outcomes of laparoscopic lavage. *Dis Colon Rectum*. 2010;53(11):1537-1541.

66. Franklin ME Jr, Portillo G, Treviño JM, Gonzalez JJ, Glass JL. Long-term experience with the laparoscopic approach to perforated diverticulitis plus generalized peritonitis. *World J Surg*. 2008;32(7):1507-1511.

67. Antolovic D, Reissfelder C, Koch M, et al. Surgical treatment of sigmoid diverticulitis: analysis of predictive risk factors for postoperative infections, surgical complications, and mortality. *Int J Colorectal Dis*. 2009;24(5):577-584.

68. Ince M, Stocchi L, Khomvilai S, Kwon DS, Hammel JP, Kiran RP. Morbidity and mortality of the Hartmann procedure for diverticular disease over 18 years in a single institution. *Colorectal Dis*. 2012;14(8):e492-e498.

69. Larson DW, Batdorf NJ, Touzios JG, et al. A fast-track recovery protocol improves outcomes in elective laparoscopic colectomy for diverticulitis. *J Am Coll Surg*. 2010;211(4):485-489.

70. 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(12):1867-1873, discussion 1873-1874.

71. Lidsky ME, Thacker JK, Lagoo-Deenadayalan SA, Scarborough JE. Advanced age is an independent predictor for increased morbidity and mortality after emergent surgery for diverticulitis. *Surgery*. 2012;152(3):465-472.

72. Morks AN, Klarenbeek BR, Flikweert ER, et al. Current surgical treatment of diverticular disease in the Netherlands. *World J Gastroenterol*. 2010;16(14):1742-1746.

73. Pendlimari R, Touzios JG, Azodo IA, et al. Short-term outcomes after elective minimally invasive colectomy for diverticulitis. *Br J Surg*. 2011;98(3):431-435.

74. Sheer AJ, Heckman JE, Schneider EB, et al. Congestive heart failure and chronic obstructive pulmonary disease predict poor surgical outcomes in older adults undergoing elective diverticulitis surgery. *Dis Colon Rectum*. 2011;54(11):1430-1437.

75. Andeweg C, Peters J, Bleichrodt R, van Goor H. Incidence and risk factors of recurrence after surgery for pathology-proven diverticular disease. *World J Surg*. 2008;32(7):1501-1506.

76. Binda GA, Arezzo A, Serventi A, et al; Italian Study Group on Complicated Diverticulosis (GISDIC). Multicentre observational study of the natural history of left-sided acute diverticulitis. *Br J Surg*. 2012;99(2):276-285.

77. Thaler K, Weiss EG, Nogueras JJ, Arnaud JP, Wexner SD, Bergamaschi R. Recurrence rates at minimum 5-year follow-up: laparoscopic versus open sigmoid resection for uncomplicated diverticulitis. *Surg Laparosc Endosc Percutan Tech*. 2003;13(5):325-327.

78. Ambrosetti P, Francis K, Weintraub D, Weintraub J. Functional results following elective laparoscopic sigmoidectomy after CT-proven diagnosis of acute diverticulitis evaluation of 43 patients and review of the literature. *J Gastrointest Surg*. 2007;11(6):767-772.

79. Pasternak I, Wiedemann N, Basilicata G, Melcher GA. Gastrointestinal quality of life after laparoscopic-assisted sigmoidectomy for diverticular disease. *Int J Colorectal Dis*. 2012;27(6):781-787.

80. 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(1):10-17.

81. Forgione A, Leroy J, Cahill RA, et al. Prospective evaluation of functional outcome after laparoscopic sigmoid colectomy. *Ann Surg*. 2009;249(2):218-224.

82. Käser SA, Glauser PM, Basilicata G, Müller DA, Maurer CA. Timing of rectosigmoid resection for diverticular disease: the patient's view. *Colorectal Dis*. 2012;14(3):e111-e116.

83. Roberts P, Abel M, Rosen L, et al; Standards Task Force, American Society of Colon and Rectal Surgeons. Practice parameters for sigmoid diverticulitis. *Dis Colon Rectum*. 1995;38(2):125-132.

84. Parks TG, Connell AM. The outcome in 455 patients admitted for treatment of diverticular disease of the colon. *Br J Surg*. 1970;57(10):775-778.

85. Oomen JL, Engel AF, Cuesta MA. Mortality after acute surgery for complications of diverticular disease of the sigmoid colon is almost exclusively due to patient related factors. *Colorectal Dis*. 2006;8(2):112-119.

86. Wolff BG, Boostrom SY. Prophylactic resection, uncomplicated diverticulitis, and recurrent diverticulitis. *Dig Dis*. 2012;30(1):108-113.

87. Klarenbeek BR, Veenhof AA, Bergamaschi R, et al. Laparoscopic sigmoid resection for diverticulitis decreases major morbidity rates: a randomized control trial: short-term results of the Sigma Trial. *Ann Surg*. 2009;249(1):39-44.

88. Klarenbeek BR, Bergamaschi R, Veenhof AA, et al. Laparoscopic versus open sigmoid resection for diverticular disease: follow-up assessment of the randomized control Sigma trial. *Surg Endosc*. 2011;25(4):1121-1126.

89. 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(1):3-8.

90. 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(10):3373-3378.

91. Raue W, Paolucci V, Asperger W, Albrecht R, Büchler MW, Schwenk W; LAPDIV-CAMIC Trial Group. Laparoscopic sigmoid resection for diverticular disease has no advantages over open approach: midterm results of a randomized controlled trial. *Langenbecks Arch Surg*. 2011;396(7):973-980.

92. Raue W, Langelotz C, Paolucci V, et al. Problems of randomization to open or laparoscopic sigmoidectomy for diverticular disease. *Int J Colorectal Dis*. 2011;26(3):369-375.

93. Zingg U, Pasternak I, Dietrich M, Seifert B, Oertli D, Metzger U. Primary anastomosis vs Hartmann's procedure in patients undergoing emergency left colectomy for perforated diverticulitis. *Colorectal Dis*. 2010;12(1):54-60.

94. Thaler K, Baig MK, Berho M, et al. Determinants of recurrence after sigmoid resection for uncomplicated diverticulitis. *Dis Colon Rectum*. 2003;46(3):385-388.

95. O'Leary DP, Myers E. Laparoscopic lavage for perforated diverticulitis: a panacea? *Dis Colon Rectum*. 2013;56(3):385-387. doi:10.1097/DCR.0b013e31827a750c.

96. Swank HA, Vermeulen J, Lange JF, et al; Dutch Diverticular Disease (3D) Collaborative Study Group. The ladies trial: laparoscopic peritoneal lavage or resection for purulent peritonitis and Hartmann's procedure or resection with primary anastomosis for purulent or faecal peritonitis in perforated diverticulitis (NTR2037). *BMC Surg*. 2010;10:29.

97. Thornell A, Angenete E, Gonzales E, et al; Scandinavian Surgical Outcomes Research Group (SSORG). Treatment of acute diverticulitis laparoscopic lavage vs resection (DILALA): study protocol for a randomised controlled trial. *Trials*. 2011;12:186.

98. Salem L, Veenstra DL, Sullivan SD, Flum DR. The timing of elective colectomy in diverticulitis: a decision analysis. *J Am Coll Surg*. 2004;199(6):904-912.

99. Daniels L, de Korte N, Winter D, Boermeester MA, Stockmann HB. Overtreatment of sigmoid diverticulitis: plea for a less aggressive approach. *Dig Dis*. 2012;30(1):86-91.

100. 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(10):1265-1270.

101. Lahat A, Yanai H, Sakhnini E, Menachem Y, Bar-Meir S. Role of colonoscopy in patients with persistent acute diverticulitis. *World J Gastroenterol*. 2008;14(17):2763-2766.

102. Bar-Meir S, Lahat A, Melzer E. Role of endoscopy in patients with diverticular disease. *Dig Dis*. 2012;30(1):60-63.

103. Lam TJ, Meurs-Szojda MM, Gundlach L, et al. There is no increased risk for colorectal cancer and adenomas in patients with diverticulitis: a retrospective longitudinal study. *Colorectal Dis*. 2010;12(11):1122-1126.

104. Schmilovitz-Weiss H, Yalunin E, Boaz M, et al. Does a colonoscopy after acute diverticulitis affect its management? a single center experience. *J Clin Gastroenterol*. 2012;46(4):317-320.

105. Westwood DA, Eglinton TW, Frizelle FA. Routine colonoscopy following acute uncomplicated diverticulitis. *Br J Surg*. 2011;98(11):1630-1634.

106. Fozard JB, Armitage NC, Schofield JB, Jones OM; Association of Coloproctology of Great Britain and Ireland. ACPGBI position statement on elective resection for diverticulitis. *Colorectal Dis*. 2011;13(suppl 3):1-11.

107. Peppercorn MA. The overlap of inflammatory bowel disease and diverticular disease. *J Clin Gastroenterol*. 2004;38(5)(suppl 1):S8-S10.

Copyright 2014 American Medical Association. All rights reserved.

Downloaded From: http://archsurg.jamanetwork.com/ on 10/09/2015