World Journal of Gastroenterology

Online Submissions: http://www.wjgnet.com/1007-9327office
wjg@wjgnet.com
doi:10.3748/wjg.v16.i7.804

World J Gastroenterol 2010 February 21; 16(7): 804-817
ISSN 1007-9327 (print)

TOPIC HIGHLIGHT

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Current indications and role of surgery in the management of sigmoid diverticulitis

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Received: November 14, 2009 Revised: December 9, 2009
Accepted: December 16, 2009
Published online: February 21, 2010

Abstract

Sigmoid diverticulitis is a common disease which carries both a significant morbidity and a societal economic burden. This review article analyzes the current data regarding management of sigmoid diverticulitis in its variable clinical presentations. Wide-spectrum antibiotics are the standard of care for uncomplicated diverticulitis. Recently published data indicate that sigmoid diverticulitis does not mandate surgical management after the second episode of uncomplicated disease as previously recommended. Rather, a more individualized approach, taking into account frequency, severity of the attacks and their impact on quality of life, should guide the indication for surgery. On the other hand, complicated diverticular disease still requires surgical treatment in patients with acceptable comorbidity risk and remains a life-threatening condition in the case of free peritoneal perforation. Laparoscopic surgery is increasingly accepted as the surgical approach of choice for most presentations of the disease and has also been proposed in the treatment of generalized peritonitis. There is not sufficient evidence supporting any changes in the approach to management in younger patients. Conversely, the available evidence suggests that surgery should be indicated after one attack of uncomplicated disease in immunocompromised individuals. Uncommon clinical presentations of sigmoid diverticulitis and their possible association with inflammatory bowel disease are also discussed.

Key words: Sigmoid diverticulitis; Diverticulitis management; Diverticulitis surgery; Acute diverticulitis; Complicated diverticulitis; Perforated diverticulitis; Laparoscopic colectomy

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Stocchi L. Current indications and role of surgery in the management of sigmoid diverticulitis. *World J Gastroenterol* 2010; 16(7): 804-817 Available from: URL: http://www.wjgnet.com/1007-9327/full/v16/i7/804.htm DOI: http://dx.doi.org/10.3748/wjg.v16.i7.804

INTRODUCTION

Sigmoid diverticulitis is a common disease of the Western World and results in a significant number of hospital admissions[1] with considerable societal costs due to loss of productivity. The prevalence of diverticula in the sigmoid increases proportionally with aging and only rarely results in the inflammation referred to as sigmoid diverticulitis. Sigmoid diverticula may cause significant bleeding which is generally unrelated to diverticular inflammation and is generally referred to as diverticular bleeding or bleeding diverticulosis. Bleeding caused by diverticula will therefore not be included in this review article. The spectrum of sigmoid diverticulitis ranges from a single episode of mild sigmoid inflammation amenable to outpatient treatment to a life-threatening generalized peritonitis caused by acute diverticular perforation which

requires urgent surgical intervention.

The aim of this review article is to analyze the clinical presentation, treatment modalities for the various forms of sigmoid diverticulitis, the indications for elective and urgent surgery and the postoperative and functional outcomes reported in the literature.

RISK FACTORS AND PREVENTIVE STRATEGIES

There are few studies which present evidence of a causal relationship with preventable factors. The data obtained from a prospective cohort of 47 228 male health professionals who were free from diverticular disease in 1986 has been fundamental in providing evidence-based outcomes. Obesity is significantly associated with an increased incidence of both diverticular bleeding and diverticulitis, which have often been considered together in the studies from this large dataset. The relative risk of diverticulitis was found to be between 1.5 and 2, depending on whether body mass index (BMI), waist circumference or waist to hip ratio were considered[2]. Correspondingly, physical activity, particularly if vigorous, is associated with decreased incidence of sigmoid diverticulitis and diverticular bleeding[3]. A diet with an increased fiber intake, particularly cellulose, is also significantly associated with a decreased risk of diverticular disease[4]. On the other hand, the presumed correlation between incidence of sigmoid diverticulitis and the consumption of nut, corn and popcorn has not been confirmed when analyzing this large prospective cohort of men[5]. With respect to the use of medications, the regular and consistent use of nonsteroidal antiinflammatory drugs and acetaminophen is associated with symptoms of severe diverticular disease, particularly bleeding[6].

CLINICAL PRESENTATION AND DIAGNOSIS

Sigmoid diverticulitis generally presents with abdominal pain, typically located in the left lower quadrant and associated with a variable degree of peritoneal irritation, which can range from none to generalized peritonitis. Localized peritoneal reaction with guarding and rebound tenderness may be noted. Fever and elevation of the white blood cell count can aid in the diagnosis when present. A redundant sigmoid colon may reach the right lower quadrant, and sigmoid diverticulitis under these circumstances may resemble acute appendicitis. In cases of complicated diverticulitis a stricture may lead to obstructive symptoms with nausea and vomiting as the most noticeable symptoms. On the other hand, a history of recurrent urinary tract infection, dysuria with or without urgency, pneumaturia and fecaluria can suggest a colovesical fistula. When a patient reports passing stools per vagina, insertion of a vaginal speculum can reveal a fistulous opening at the vaginal apex, thus confirming a colovaginal fistula. A previous history of hysterectomy is a valuable clinical clue to the correct diagnosis as colovaginal and colovesical fistulas are rare in females with their uterus in place, as the uterus becomes a screen interposed between the inflamed colon and the bladder and vagina. Less commonly, sigmoid diverticulitis can involve other surrounding structures and cause coloenteric, colouterine or colocutaneous fistulas.

A full colonoscopy should be typically avoided during an episode of acute diverticulitis because of an increased risk of perforation. In select cases and experienced hands, a gentle flexible sigmoidoscopy can provide additional information and help rule out alternative diagnoses such as cancer, inflammatory bowel disease, or ischemic colitis. Computed tomography (CT) is the most commonly used imaging modality to determine the diagnosis of sigmoid diverticulitis. In this respect, CT has supplanted barium enema and gastrografin enema in the routine evaluation of the sigmoid colon[7]. It can also help establish a differential diagnosis with other conditions which might exhibit similar symptoms such as gynecologic or urinary tract disorders. Irritable bowel syndrome and diverticulitis may present with similar symptoms and physical findings. It is therefore important to confirm the diagnosis of sigmoid diverticulitis by imaging before recommending surgery.

CLASSIFICATIONS OF SIGMOID DIVERTICULITIS AND IMPLICATIONS FOR MANAGEMENT

It is appropriate to classify sigmoid diverticulitis into different categories as the morbidity and mortality of this condition are greatly variable. Traditionally, the Hinchey classification has been used to subdivide sigmoid diverticulitis into subgroups based on the degree and extent of the abdominal and pelvic disease identified at the time of surgery and associated with perforated diverticular disease of the colon[8]. Of note, Hinchey credited Hughes for the development of an earlier, similar classification in 1963[9]. The Hinchey classification, developed before the advent of routine CT imaging, remains the most widely used classification and a few updated modifications have therefore been proposed in recent years (Table 1). In fact, the original Hinchey classification might not be the most practical classification to help in the contemporary management of at least some cases of diverticular disease. For example, the Hinchey classification separates a pericolic abscess (Hinchey 1) from a distant abscess (Hinchey 2). However, larger pericolic abscesses and similarly sized distant abscesses might carry similar morbidity and require similar management. In these cases, more important factors in the clinical management of this complication of diverticular disease might instead be the abscess size, location in the pelvis or mesocolon and also the ability to percutaneously drain the abscess regardless of its vicinity to the sigmoid, and therefore maximize the feasibility of a subsequent one-stage operation. In this respect, some proposed modifications of the Hinchey classification spe-

Table 1 Hinchey classification and its modifications

	Original Hinchey classification	Sher[10], Kohler modification[11]	Wasvary modification[33]	Kaiser modification[71][1]
Stage Ⅰ	Pericolic abscess confined by the mesentery of the colon	Pericolic abscess	Ⅰa phlegmon	Ⅰa confined pericolic inflammation-phlegmon
			Ⅰb pericolic abscess	Ⅰb confined pericolic abscess
Stage Ⅱ	Pelvic abscess resulting from a local perforation of a pericolic abscess	ⅡA distant abscess amenable to percutaneous drainage ⅡB complex abscess associated with/without fistula	Pelvic abscess	Pelvic, distant intrabdominal or retroperitoneal abscess
Stage Ⅲ	Generalized peritonitis resulting from rupture of pericolic/pelvic abscess into the general peritoneal cavity	Generalized purulent peritonitis	Purulent peritonitis	Generalized purulent peritonitis
Stage Ⅳ	Fecal peritonitis results from the free perforation of a diverticulum	Fecal peritonitis	Fecal peritonitis	Fecal peritonitis

[1]This modification also includes stage 0, defined as mild clinical diverticulitis.

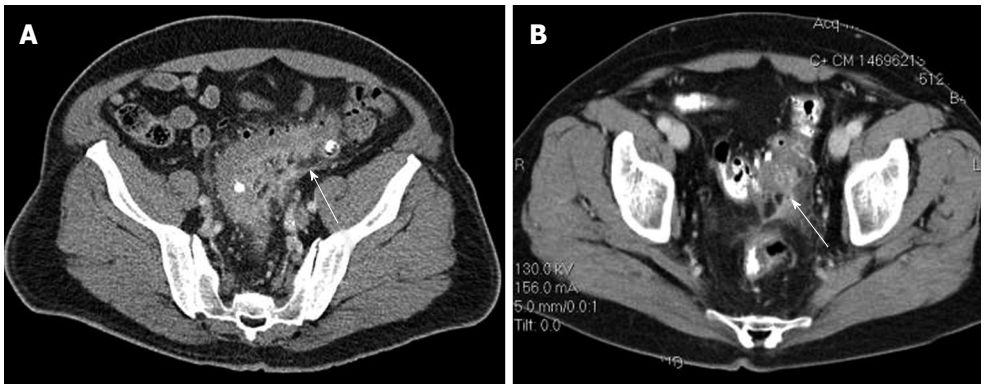

Figure 1 Diverticulitis. A: Uncomplicated sigmoid diverticulitis with colonic thickening and straining at CT (arrow), also referred to as "mild" CT diverticulitis. Two diverticula contain contrast medium without evidence of extravasation outside the sigmoid; B: "Severe" CT diverticulitis with extravasation of contrast and small amount of extraluminal air (arrow). This patient was initially managed non-operatively and eventually required surgery for recurrent disease.

Table 2 Ambrosetti classification[12]

Moderate diverticulitis	Severe diverticulitis
Localized sigmoid wall thickening (> 5 mm) Inflammation of pericolic fat	Same as mild diverticulitis plus one of the following: Abscess Extraluminal air Extraluminal contrast

cifically include the ability to percutaneously drain the abscess[10,11]. Furthermore, the Hinchey classification was developed based on the description of surgical findings and was not specifically designed to evaluate cases of sigmoid diverticulitis treated with antibiotics only. More recently, CT scanning has become the imaging modality of choice to diagnose sigmoid diverticulitis and has been proposed as being the imaging modality providing the most important and valuable indication as to the likelihood that medical treatment with antibiotics will fail. In this regard, Ambrosetti *et al*[12] have proposed a CT-based classification of sigmoid diverticulitis subdivided into "moderate disease" or "mild disease" in the case of localized sigmoid wall thickening (greater than 5 mm) and inflammation of the pericolic fat (Figure 1A). On the other hand, the term "severe disease" is used instead in the case of abscess, extraluminal air or extraluminal contrast extravasation (Figure 1B and Table 2).

UNCOMPLICATED DIVERTICULITIS

When the inflammatory process is limited to the sigmoid it is generally treated with antibiotics. If symptoms are not severe and the patient is otherwise healthy and compliant with medical treatment, wide spectrum antibiotic treatment can be administered orally on an outpatient basis and the patient followed with serial office visits. On the other hand, if the patient is systemically ill, elderly or has significant comorbidities, a hospital admission and treatment with intravenous antibiotics are warranted. Even when hospital admission is necessary, the appropriateness of an initially conservative approach with antibiotic management has been confirmed[13-17]. Most patients with uncomplicated sigmoid diverticulitis respond to medical treatment and generally experience significant decreases in their abdominal pain, temperature and white blood cell count within the first 48 h after initiation of antibiotic treatment[17,18].

In a minority of patients non-operative treatment fails, and symptoms either persist or worsen. In these cases,

urgent or semi-urgent surgery may become necessary during the same hospital stay. Among the remaining patients who successfully recover from their first episode of sigmoid diverticulitis, only a few eventually require elective sigmoid resection for recurrent disease and even more rarely are urgent operations necessary.

Following recovery from a new onset attack of uncomplicated diverticulitis the patient should undergo colonoscopy, or alternatively a barium enema, to rule out alternative diagnoses such as ischemic colitis, inflammatory bowel disease or, most importantly, a carcinoma.

INDICATIONS FOR ELECTIVE SURGERY

The indications for elective operation for sigmoid diverticulitis are evolving. For several years the traditional teaching has been that elective sigmoidectomy was warranted after 2 attacks of uncomplicated diverticulitis. This recommendation was based on the assumptions that after 2 attacks there was not only a very high probability of recurrent attacks of uncomplicated diverticulitis but also an increased risk of complicated diverticulitis including free perforation causing diffuse peritonitis. From this viewpoint surgery would therefore prevent the risk of complicated diverticulitis with its inherently increased morbidity and mortality. Recent studies have questioned this hypothesis[19] and suggest instead that most patients who have complicated diverticulitis experience this clinical presentation as their first manifestation of diverticular disease[20,21]. Other studies based on decision analysis models have indicated that the preferred timing of elective surgery to optimize life expectancy should be after the third[22] or fourth[23] attack of uncomplicated diverticulitis. This changed view on the indications for elective surgery has reduced the overall number of surgical procedures performed for diverticulitis. In a study of 685 390 hospital discharges for sigmoid diverticulitis, based on the Nationwide Inpatient Sample during the period 1991-2005, the ratio of hospital discharges for diverticulitis increased from 5.1 to 7.6 cases per 1000 inpatients. However, the proportion of patients who underwent surgery for uncomplicated diverticulitis declined from 17.9% to 13.7% ($P < 0.001$). In spite of these shifts, the percentage of patients with free perforation from diverticular disease remained stable throughout the study period at 1.5%[24]. With the limitation of a retrospective study based on administrative data, this study with a large number of patients also confirms that a less aggressive strategy for elective surgery did not result in any worrisome increase in the rate of presentation with diffuse peritonitis from diverticular perforation. Contemporary proponents of surgery after 2 attacks argue that earlier surgery favorably impacts patient symptoms[25] and that an increased number of diverticulitis attacks proportionally increases the conversion rates at the time of elective laparoscopic sigmoidectomy[26].

Overall, the recent data from the literature defining the natural history of uncomplicated diverticulitis has contributed to reducing the emphasis on the rule of surgery after the second attack. As a result of this shift, the most recent version of the Practice Parameters for Diverticulitis from the American Society of Colon and Rectal Surgery states that "the number of attacks of uncomplicated diverticulitis is not necessarily an overriding factor in defining the appropriateness of surgery"[27].

SURGICAL TREATMENT

The tenets of surgical treatment of diverticulitis are resection of the entire sigmoid and anastomosis between a soft and pliable area of descending colon and the upper rectum. The latter is generally recognized by the confluence of the teniae, which frequently occurs at the level of the sacral promontory. Failure to completely remove the sigmoid is associated with increased recurrence rates[28,29]. Some surgeons have emphasized preservation of the inferior mesenteric artery which might minimize the risk of anastomotic leakage[30], sexual dysfunction from intraoperative nerve injury[31], and optimize functional results[32]. Mobilization of the splenic flexure should be left to the discretion of the operating surgeon and is generally not necessary in the case of redundant left colon. The involvement of the tissue surrounding the sigmoid colon by the inflammatory process is variable. Often it is possible to identify the ureters intraoperatively and the required pelvic dissection can be limited to the upper rectum. However, there may be cases of complicated diverticulitis in which the extent and degree of inflammatory changes warrant the use of ureteral stents and/or the creation of a colorectal anastomosis in the more distal rectum. In such cases a difficult, prolonged dissection with significant blood loss may also justify the creation of a proximal diverting stoma. With respect to the required extent of resection, it is not necessary to remove the entire colonic segment bearing diverticula, which may actually be impossible in some cases due to the extent and density of diverticula throughout the colon. However, care should be taken to prevent inclusion of any diverticula into a stapled colorectal anastomosis. These principles are generally accepted and should apply equally to open or laparoscopic surgery. On the other hand, the timing of surgery in relation to the last diverticulitis attack has been the subject of controversy. The traditional practice entails a waiting period of 4-6 wk after a diverticulitis attack before performing an elective operation. Alternatively, some surgeons have suggested that early intervention for complicated diverticular disease may avoid the prolonged hospitalization and possibly multiple hospital admissions related to the traditional stepwise approach with initial antibiotic management and delayed elective surgery[33]. It has also been suggested that early surgery might obviate the creation of a stoma with its associated possible complications[34]. In addition, there is some evidence suggesting that an earlier timing of surgery, to within 30 d from the last diverticulitis attack, is not associated with increased morbidity when compared with operations performed between 30 and 60 d, or after 60 d following the last attack[35]. However, other investigators have reported less encouraging results. In the

case of laparoscopic surgery early surgical intervention has been associated with an increased conversion rate due to inflammation[36]. More importantly, a prospective study evaluating early elective sigmoid resection, carried out after 5-8 d of initial antibiotic treatment, has shown that this approach was associated with increased morbidity when compared with operations carried out 4-6 wk after the initial hospitalization[37]. While the data regarding the outcomes of early surgery following hospitalization for sigmoid diverticulitis remains controversial, there does not seem to be sufficiently consistent evidence at the moment to justify any anticipation of elective surgery before the traditional 4-6 wk waiting period.

INCREASED ROLE OF LAPAROSCOPIC SURGERY

While open surgery continues to be performed, especially in low volume centers and by low volume surgeons[38], laparoscopic surgery is increasingly preferred in the elective treatment of sigmoid diverticulitis. Several single-institutional series have confirmed feasibility and safety of the laparoscopic approach[39-42]. Laparoscopic sigmoidectomy is associated with reduced recovery time and return to bowel function, reduced hospital stay, and at least in some cases decreased morbidity[43-47] and costs[45,48]. Single-institutional series by experienced surgeons have reported conversion rates of as low as 2.8% and a median hospital stay of 4 d[42]. Minimally invasive sigmoidectomy can be performed using a straight laparoscopic technique or a laparoscopic hand-assisted technique[49,50]. A single-access sigmoidectomy has also been recently described[51]. The controversy persists as to whether the hand-assisted technique allows a reduction of operative times and conversion rates while extending the benefits of laparoscopic surgery to more difficult cases.

In general, the benefits of laparoscopic surgery have been confirmed by a large study based on data from the Nationwide Inpatient Sample during the years 1998-2000, which included 709 patients treated laparoscopically *vs* 17735 treated with the open technique. Laparoscopically completed patients had a mean reduction of hospital stay of almost 2 d and also reduction of postoperative morbidity when compared to their open counterparts. An important limitation of this study was that, due to the nature of the administrative database used, converted patients were not analyzed combined with the cases completed laparoscopically, which skews the results in favor of laparoscopic surgery[52]. However, a more recent study using the University Health System Consortium Database, in which converted patients were appropriately included in the laparoscopic group, confirmed a reduction in hospital stay, overall postoperative morbidity and total hospital cost in favor of laparoscopic sigmoidectomy for benign diseases[53]. In addition, there is further evidence of the benefits of laparoscopic surgery emerging from a prospective randomized trial, which has demonstrated reduction of major complications after laparoscopic surgery when compared with open sigmoidectomy[54]. This multicenter, randomized, double-blinded study accrued 104 patients in 5 centers from 2002 to 2006. Double-blinding was carried out by covering the patient abdomen with a large dressing at the time of surgery so that patients, as well as physicians in charge of patients discharge, were unaware of the surgical technique used. Eligible patients were randomized to open *vs* laparoscopic sigmoid resection. Patients were similar with respect to gender, age, BMI, comorbidities, indications for surgery and previous surgical procedures. Conversion rate was 19% and mortality 1%. Laparoscopic surgery resulted in expected recovery benefits including significant reduction of pain based on visual analog scores and systemic analgesia requirements, decreased hospital stay and improved quality of life based on short-term SF-36 questionnaires. In addition, laparoscopic surgery resulted in significant reduction of major complications, defined as a composite inclusive of intrabdominal abscess, anastomotic leakage, pulmonary embolism and myocardial infarction. Major complications combined for a 25% rate after open surgery *vs* 10% after laparoscopic procedures[54].

Based on the data from the last decade, it is reasonable to offer laparoscopic surgery in the surgical management of sigmoid diverticulitis and expect at least the recovery advantages reported after laparoscopic bowel resection.

RELATIONSHIP BETWEEN SURGICAL VOLUME AND OUTCOMES

A number of studies have investigated possible differences in outcomes related to the experience of the operators. With respect to the use of laparoscopic surgery, there is evidence that the volumes of both individual surgeons and hospitals are directly proportional to the likelihood of performing laparoscopic surgery for diverticular disease. Using National Inpatient Sample Data based on over 55000 patients, high-volume surgeons were almost 9 times more likely to perform laparoscopic surgery and high-volume hospitals were over 3 times more likely to perform laparoscopic surgery than their low-volume counterparts. These differences remained statistically significant when the data were stratified for age of the patient and timing of surgery; elective *vs* nonelective[38]. Volume/outcome studies have also been conducted within the subgroup of patients treated with laparoscopic surgery. In the multicenter, observational, German study from the Laparoscopic Colorectal Surgery Study Group of 1545 patients, the 52 participating institutions were divided into 3 groups according to the number of cases performed; greater than 100, between 30 and 100, and less than 30. While the percentage of patients with complicated diverticulitis was significantly increased in high-volume institutions (21% *vs* 8% in low-volume centers), operating times in these same institutions were shorter by approximately 30 min. Intraoperative complications, conversion rates and postoperative morbidity and mortality were numerically lowest in the high-volume centers, but these differences were not

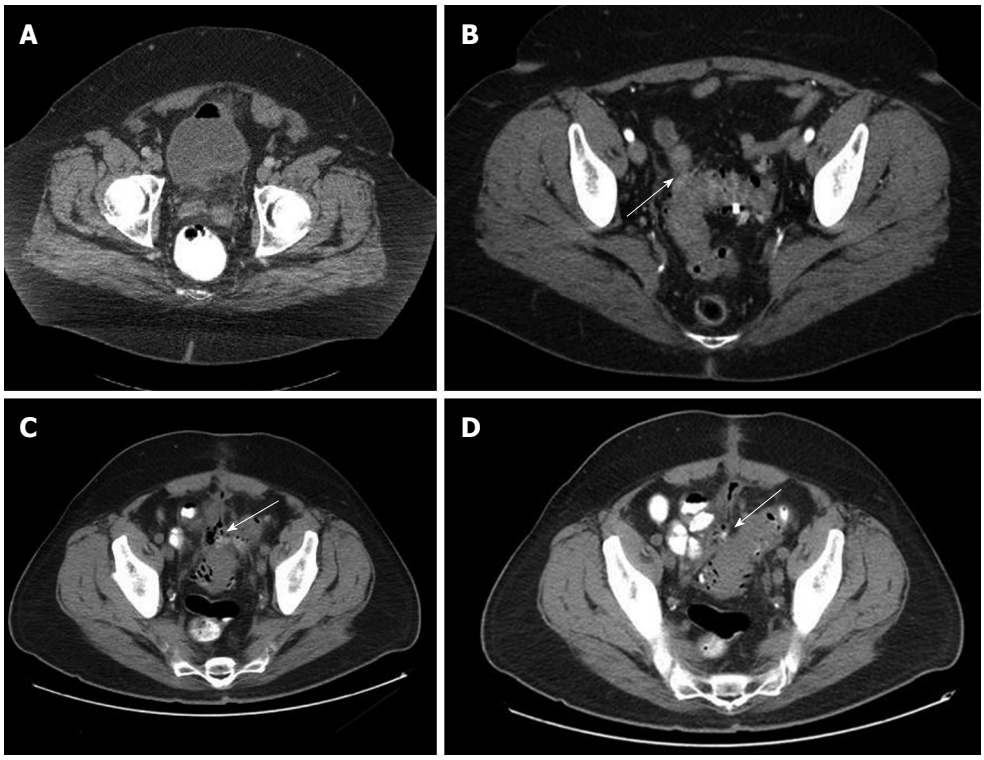

Figure 2 Fistula. A: Colovesical fistula as indicated by the presence of air in the bladder. This patient had symptoms and other CT findings consistent with sigmoid diverticulitis; B: Sigmoid diverticulitis and colovaginal fistula. This patient had undergone previous hysterectomy and complained of feculent discharge from her vagina. CT scan indicated inflamed sigmoid with adherent small bowel loop (arrow). The small bowel loop could be successfully separated from the sigmoid at the time of laparoscopic sigmoidectomy. There was no evidence of coloenteric fistula; Sigmoid diverticulitis with colocutaneous fistula (arrows) (C and D) (courtesy of Dr. Ravi Pokala Kiran, Department of Colorectal Surgery, Digestive Disease Institute, Cleveland Clinic, Cleveland, Ohio, USA).

statistically significant[55]. The results from this study seem to indicate that experienced surgeons in high-volume centers might be more facile at treating more complex cases with laparoscopic surgery. However, even low-volume centers can still achieve comparable postoperative outcomes and should therefore not be discouraged from performing laparoscopic surgery.

RESULTS OF SURGERY FOR DIVERTICULITIS

Contemporary surgical treatment of diverticulitis following the principles described above is considered curative with a less than 5% recurrence rate[29,56]. A suspicion of recurrent sigmoid diverticulitis following surgical resection should be confirmed by CT scan of the abdomen and pelvis after which antibiotic treatment should be initiated, as for a case of primary uncomplicated sigmoid diverticulitis. It is important to preoperatively discuss with the patient that the risk exists that surgery might not lead to resolution of the patient's complaints. When this is the case, an anastomotic stenosis should be ruled out as a possible source of the problem which can often be successfully treated[57]. However, persistent or recurrent symptoms can be more difficult to elucidate. At least one contemporary series has reported a 25% rate of persistent symptoms after surgery[58], which the authors felt could be only partially explained by an overlap with irritable bowel syndrome. One of the limitations of the assessment of symptoms and functional results after surgery is that sigmoid diverticulitis can cause a significant impairment of quality of life before surgery, a time at which quality of life is even more rarely assessed. The functional results of surgery should therefore be most accurately assessed when compared to the patient's preoperative status. A recent study has appropriately addressed this issue and reported a prospective evaluation of functional outcomes after laparoscopic sigmoid colectomy. A sample of 46 individuals underwent evaluation of their quality of life using the gastrointestinal quality of life indicator (GIQLI) administered before surgery and then at 3, 6, and 12 mo postoperatively. The quality of life significantly improved for the majority of the overall group, whereas it declined in only 5 patients. Urinary and sexual function were also tested using validated scores and did not change as a result of surgery[31]. When appropriately diagnosed by CT scan, sigmoid diverticulitis requiring surgery should be followed by improvement in symptoms and function in a substantial majority of cases.

COMPLICATED DIVERTICULITIS

There are several complications which may be associated with diverticular inflammation. These include fistula (Figure 2), phlegmon, stricture, abscess and free perforation. At times the definition of complicated disease may depend on the individual clinical judgment, as uncomplicated and complicated diseases are a continuum of in-

Figure 3 Sigmoid stricture (arrow) causing large bowel obstruction with proximal colonic dilatation. Clinical and imaging findings at presentation did not allow ruling out sigmoid carcinoma. This patient was treated with initial Hartmann procedure and the pathology report revealed sigmoid diverticulitis. He subsequently underwent Hartmann takedown after 3 mo.

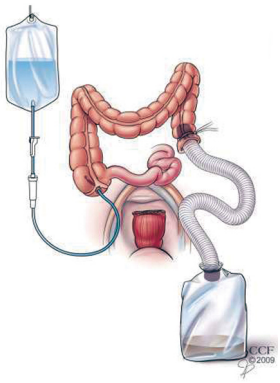

Figure 4 On-table intraoperative colonic lavage (see explanation in text).

creasingly severe inflammation which can cause a variable degree of stricture, intramural abscess or phlegmon. In the United States, complicated disease at presentation is more common in African-American patients and in individuals who lack medical insurance, based on an analysis from the Nationwide Inpatient Sample[59].

In general, surgery is recommended for complicated diverticulitis after the first episode as the risk of recurrent disease without surgery is very high. However, when age or comorbidities prohibitively increase perioperative risks, it may be appropriate to approach complicated diverticulitis with medical treatment alone[60].

Laparoscopic surgery remains feasible also for complicated diverticulitis[55,61,62] including cases with fistulas[63-66]. The morbidity after laparoscopic surgery for complicated diverticulitis might exceed that of uncomplicated disease, but this has not been uniformly proven[42].

It remains controversial whether the act of conversion, which is more likely for complicated diverticular disease[67], increases postoperative morbidity or not. It is generally accepted that when a conversion is necessary, an early conversion can minimize major complication so that it causes only minor morbidity[68] or does not result in any increased morbidity rate at all[69].

In general, a more selective use of laparoscopic surgery for more straightforward, uncomplicated cases of diverticular disease could minimize conversion rates and therefore capitalize on the advantages derived from the laparoscopic approach. On the other hand, a more liberal use of laparoscopic surgery, including for complicated cases in patients with a previous laparotomy, is likely to result in increased conversion rates. However, this less stringent patient selection could still offer the potential benefits of laparoscopic surgery to an increasing number of individuals requiring surgery for sigmoid diverticulitis without adverse effects on long-term patient outcomes[68].

STRICTURE

Sigmoid diverticulitis can present in the form of a stricture which may or may not be associated with typical symptoms. In the case of stricture, the indications for surgery may range from colonic obstruction requiring acute surgical intervention to the inability to rule out carcinoma as the cause of stricture (Figure 3). Sigmoid strictures can cause significant dilatation in the proximal colon, which can complicate the creation of a colorectal anastomosis after sigmoid resection. A staged procedure with sigmoidectomy and creation of a colostomy may therefore become necessary. A possible option in the surgical management of severe sigmoid stricture causing significant fecal loading is a resection with on-table colonic lavage and primary anastomosis (Figure 4). This is carried out by inserting a large Foley catheter through an appendicostomy or distal ileal enterotomy secured with a purse-string suture with the tip of the catheter placed into the cecum. This Foley catheter is connected to a bag of warm saline solution which is typically used for irrigation. A large corrugated tube, such as an anesthesia ventilator tube, is then placed in the open end of the descending colon and secured with umbilical tape or large suture to the bowel wall. The distal end of the tubing is placed into a bucket on the floor where the effluent is collected. It is frequently necessary to mobilize both the hepatic and splenic flexures and manually propel solid stools towards the distal end which can significantly increase operative times. A proximal stoma diversion in addition to a colorectal anastomosis may be a prudent adjunct to the operative procedure, with or without intraoperative colonic lavage. Alternatively, a stricture can be treated with placement of endoluminal metallic stents to correct the obstruction, reduce the discrepancy in bowel diameter and allow a subsequent one-stage surgical procedure consisting of sigmoid resection and primary colorectal anastomosis[70]. Other options in the management of large bowel obstruction related to diverticular disease are subtotal colectomy and primary ileorectal anastomosis, and, in the most difficult cases, creation of a decompressive colostomy proximal to the strictured sigmoid followed by delayed sigmoid resection. The choice among these various options depends on both the individual patient and the surgeon's level of confidence in performing each of the approaches described above.

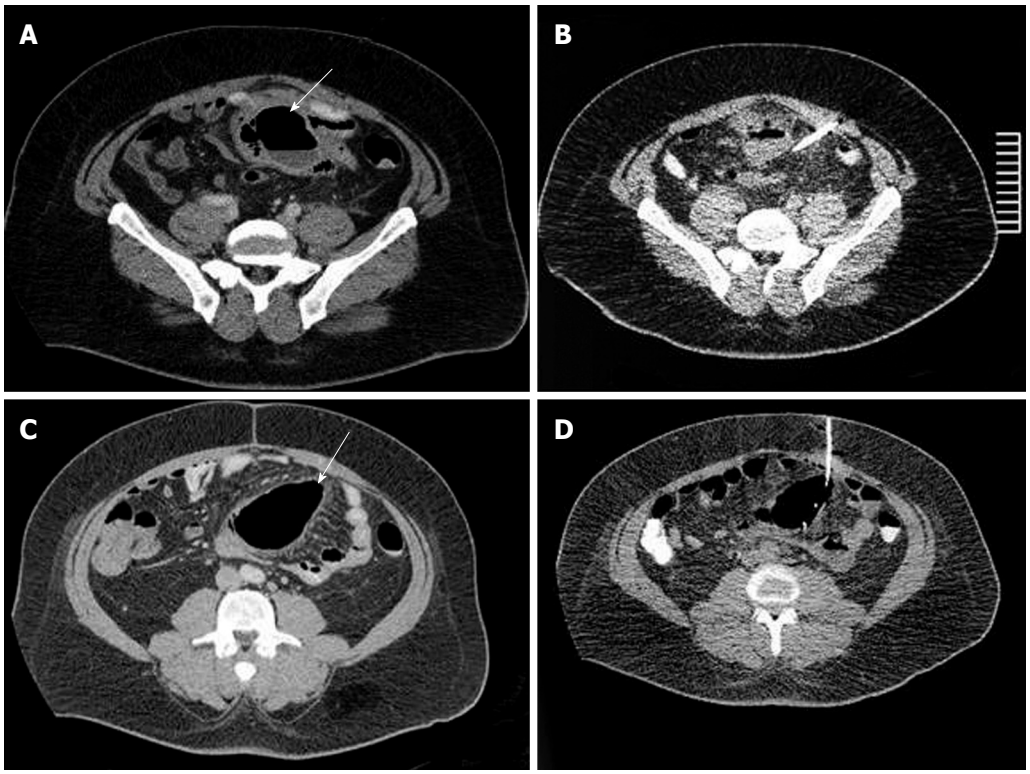

Figure 5 Sigmoid diverticulitis complicated by pericolic abscesses (A and C, arrows) requiring treatment by placement of two separate CT-guided percutaneous drains (B and D). This patient underwent laparoscopic sigmoidectomy with primary colorectal anastomosis and removal of both drains 6 wk after percutaneous drain placement.

PERIDIVERTICULAR ABSCESS

There is evidence suggesting that clinical presentation of sigmoid diverticulitis as peridiverticular abscess has increased in recent years[24]. It is generally acknowledged that elective surgery should be performed after percutaneous drainage of peridiverticular abscess (Figure 5) due to the high risk of recurrent diverticulitis[13,71]. In these cases surgery is generally performed 4-6 wk after initial percutaneous drainage. Some surgeons prefer to leave the drain in place until surgery, others remove the drain if the output becomes minimal and a drain contrast study rules out an existing sigmoid fistula. An accepted exception is the use of percutaneous drainage alone to obviate the need of surgery in poor risk patients[72].

The safety and effectiveness of percutaneous drainage in controlling the immediate symptoms of diverticular disease presenting with an abscess have been reported by several authors[14,73-77]. A number of variables have been examined as possible factors associated with the success rate of non-operative management.

Firstly, the size of the abscess seems to be an important indicator for success of non-operative management, especially when antibiotics alone are considered as first line treatment. A diameter of approximately 3-4 cm or less is more likely to be associated with successful antibiotic treatment[14,76,77]. Based on the ability of antibiotics alone to control smaller abscesses, some authors have suggested that the role of CT-guided drainage of diverticular-related abscesses should be re-evaluated and percutaneous drainage should be utilized less often[14]. Another factor with a possible impact on management is the abscess location. In fact, there is evidence suggesting that an abscess located in the mesocolon might be more responsive to non-operative treatment than a pelvic abscess[15,71]. In this regard, in a study analyzing 73 patients initially treated with antibiotics and undergoing CT-guided drainage only in case of failure of medical treatment, 71% of patients with a pelvic abscess ultimately required surgery *vs* 51% after percutaneous drainage of a mesocolic abscess. Based on these results, the authors suggested that sigmoid colectomy should be recommended after drainage of a pelvic abscess but not necessarily after percutaneous drainage of a mesocolic abscess[74]. The success of non-operative treatment in at least some patients has prompted other investigators to question the role of routine surgery after successful drainage of pericolonic abscess[20].

It remains difficult to critically evaluate the results of the various treatment options available for abdominal and pelvic abscesses related to diverticulitis because of both variability in clinical practices and data reporting. In some institutions percutaneous drainage is the preferred approach whenever technically feasible, which generally requires an abscess diameter of at least 3 cm. On the other hand, in other institutions the initial treatment of diverticular abscesses includes antibiotics alone and only after failure of antibiotic treatment is a percutaneous drainage considered. In addition, the data regarding the effectiveness of percutaneous drainage alone without

subsequent surgery remain limited, because of both small sample sizes and short follow-up. Further studies will be necessary before the standard of care of elective surgery after initial percutaneous drainage is abandoned.

GENERALIZED PERITONITIS FROM PERFORATED SIGMOID DIVERTICULITIS

A perforation of a sigmoid diverticulum into the free peritoneum is a life-threatening condition requiring immediate surgical intervention. The standard of care in most of these cases is a resection of the colonic segment including the perforation and creation of a proximal colostomy. Several authors refer to this operation as a Hartmann procedure, which by definition involves the resection of the sigmoid, closure of the rectal stump and creation of an end-descending colostomy, and which has also been performed laparoscopically[78,79]. Other surgeons have suggested that especially when the patient is severely septic and hemodynamically unstable the initial goal should be an expedited resection limited to the involved segment[80], sometimes referred to as a "perforectomy", in which at least some of the sigmoid should be left intact until the patient completes his or her recovery from the initial operation. In this case, a completion sigmoid resection would be typically performed at the time of colostomy takedown several months later so that the patient ultimately receives appropriate surgical treatment for sigmoid diverticulitis[81]. The morbidity and mortality from Hartmann procedure for free diverticular perforation remain substantial. The aggregate mortality in a total of 1051 patients reported in 54 combined studies conducted between 1966 and 2003 was almost 19% and was associated with a 24% incidence of wound infection and a 10% incidence of stoma complications[82]. In spite of advancements in intensive care, imaging and medical treatments, the mortality for this condition has remained stable over time[83]. Intestinal continuity can generally be reestablished 3-6 mo after the initial operation[84] although it has been reported that between approximately 30% and 70% of patients never have their colostomy closed[81,85-87]. In addition, a Hartmann takedown remains a difficult elective procedure[88] fraught with significant morbidity[89].

Considering the significant morbidity and mortality associated with a Hartmann procedure and its sequelae, some authors have suggested that in select circumstances it might be possible to resect the perforated segment and primarily reestablish intestinal continuity[90,91], which some surgeons feel can benefit from intraoperative colonic lavage as described above[92,93] (Figure 4). This view remains controversial and most surgeons would not recommend a resection and primary colorectal anastomosis for generalized peritonitis from diverticular perforation. However, in select circumstances it is possible to perform a colorectal anastomosis and proximal diverting loop ileostomy. This approach seems to be preferable to a Hartmann resection when the degree of intraoperative contamination and the underlying patient condition allow this approach. In these cases, the use of a defunctioning stoma in addition to colorectal anastomosis might result in a good compromise between postoperative morbidity, quality of life and probability of permanent stoma[94].

LAPAROSCOPIC LAVAGE, A NOVEL SURGICAL APPROACH TO GENERALIZED PERITONITIS

The advent of laparoscopic surgery and the increased use of the laparoscopic approach to treat perforated peptic ulcers and appendicitis have led to the development of laparoscopic strategies for the treatment of perforated diverticulitis. In this regard, laparoscopic lavage is a recently proposed treatment option which would potentially save the patient from both a major bowel resection and the creation of a stoma. The initial experiences of laparoscopic lavage have been promising with respect to perioperative mortality and complications[95]. In addition, while most proponents of initial laparoscopic lavage have decided in favor of an elective, delayed sigmoidectomy[96-100], a multicenter study from Ireland has reported encouraging results following a policy of lavage followed by continued observation. In fact, Myers *et al*[101] noted recurrence of sigmoid diverticulitis in 4 out of 92 treated patients, none of whom required surgery after a median follow-up of 36 mo. These data from different centers suggest that laparoscopic lavage has the potential to become, at least in select cases, the definitive treatment for perforated diverticulitis. However, the data on laparoscopic lavage for diverticular peritonitis remains limited and further investigations into this option are warranted to confirm these initial, promising results.

YOUNGER PATIENTS: SHOULD THE INDICATIONS FOR SURGERY CHANGE?

The indication for surgery in younger patients, generally defined as those who are 50 years old or younger, has been the subject of controversy. It has been reported that younger patients more frequently require surgery for diverticulitis[102] or are prone to recurrent disease[103]. Based on the presumed association between younger age and more virulent disease, some surgeons have suggested that elective surgery should be recommended in patients younger than 50 years old after their first attack of uncomplicated diverticulitis[104,105]. However, other retrospective series have not confirmed a correlation between younger age and more severe disease[106-109]. In addition, prospective data do not support a more aggressive surgical approach for younger patients. In this regard, Guzzo and Hyman[110] examined 762 patients admitted to their institution with sigmoid diverticulitis between 1990 and 2001, including 259 individuals younger than 50. The risk of requiring surgery during the first admission was comparable between older and younger patients. In addition,

out of 196 younger patients who were treated medically at the time of their initial admission, only one (0.5%) presented with perforation during a median follow-up of 5.2 years. In another prospective study with a median follow-up of 9.5 years, 118 patients were followed after their initial attack of diverticulitis, 28 of whom were 50 years old or younger. Age and findings at initial CT scan were analyzed as possible predictive factors for risk of poor outcome during the follow-up period, defined as recurrent, persistent or complicated diverticulitis. The probability of poor outcome at 5 years was 54% in younger patients with initially severe CT diverticulitis *vs* 19% for older patients with mild disease, based on CT imaging. At univariate analysis, age was a predictive factor for poor outcome. However, after stratification for severity of disease, age was no longer a significant factor[111]. Based on the available contemporary data there does not seem to be sufficient justification to recommend elective surgery after one attack of sigmoid diverticulitis in younger patients and rather the disease should be treated similarly in both younger and older patients depending on its severity and inclination to recurrence.

IMMUNOSUPPRESSED OR IMMUNOCOMPROMISED PATIENTS

Transplant recipients or patients with chronic diseases affecting the immune system are at increased risk of more aggressive and complicated diverticulitis[112-114], including initial presentation as free peritoneal perforation[115,116]. Chronic use of steroids is also associated with increased postoperative mortality after surgery for diverticulitis[20].

Therefore, it is generally recommended that surgery should be offered to this subset of patients after their first documented episode of diverticulitis. The studies supporting this practice are generally retrospective with small sample sizes[114]. On the other hand, there is no data presenting evidence against this practice. Therefore it seems reasonable to continue offering surgery after one episode of uncomplicated diverticulitis in immunocompromised patients. In this respect, some surgeons have emphasized that surgery should be carried out after the diverticulitis attack during the same hospital stay and a proximal diversion should be considered[117]. Other authors have even suggested that patients with one episode of uncomplicated diverticulitis who are transplant candidates should undergo prophylactic sigmoidectomy before their transplant. The evidence in favor of this practice remains scant, based on earlier studies and generally restricted to renal transplant recipients[118,119]. On the other hand, patients awaiting liver, heart and lung transplant are typically in poor health from their primary disease and generally should not be considered for prophylactic sigmoidectomy prior to their transplantation.

With respect to HIV infection and AIDS, there is no substantial data specific for sigmoid diverticulitis[120]. In general, the outcome of major abdominal surgery in HIV-positive individuals without AIDS is not significantly different from the general population. However, when a patient develops diverticulitis in the presence of AIDS or other causes of acute immunosuppression, postoperative infections are more likely. If surgery becomes necessary in these cases, a Hartmann procedure or a primary sigmoid resection with anastomosis and proximal diversion should be therefore preferable.

EVOLVING CONCEPTS IN DIVERTICULAR DISEASE

Sigmoid diverticulitis may have clinical manifestations which are difficult to accurately characterize. Its symptoms may overlap in some cases with the conditions collectively referred to as irritable bowel syndrome. Our understanding and therapeutic approach for this condition are evolving. From a surgical perspective it is imperative to minimize unnecessary surgery if diverticulitis cannot be documented radiologically, especially with a concurrent clinical history suggestive of irritable bowel syndrome. However, if irritable bowel syndrome can be ruled out, there seem to be a group of patients with chronic left lower quadrant abdominal pain and occasional alteration of bowel habits, but without fever or leukocytosis, who might still benefit from surgery. The condition of this subgroup of patients has been referred to as "smoldering diverticulitis". Horgan and colleagues identified smoldering diverticulitis in 47 patients, corresponding to approximately 5% out of their denominator of 930 patients undergoing sigmoid resection for diverticulitis. A total of 88% of these patients remained pain-free after at least 12 mo of follow-up following sigmoidectomy and primary anastomosis[121]. Atypical sigmoid diverticulitis should be part of the differential diagnosis in the patient with left lower quadrant pain, as surgery is curative in the majority of these cases.

An additional, novel clinical syndrome recently proposed as a separate entity within the realm of diverticular disease is referred to as segmental colitis associated with diverticulosis (SCAD)[122-124]. This is a non-specific, localized inflammatory process associated with diverticulosis involving the sigmoid but not the rectum or the proximal colon, generally presenting in middle-aged or elderly patients with rectal bleeding, diarrhea and abdominal pain variably combined. It most commonly affects males. Histology indicates inflammation without granulomas and serology should be negative for anti-neutrophil cytoplasmic antibodies (ANCA) and anti-Saccharomyces cerevisiae antibodies (ASCA). Treatment with 5-aminosalicylate is generally effective in resolving the inflammation both symptomatically and endoscopically[122].

The pathogenesis of SCAD and its relationship with inflammatory bowel disease remain controversial[122,125]. Regardless, SCAD is becoming increasingly accepted as a separate entity from the traditional sigmoid diverticulitis and its known complications. While anti-inflammatory agents have been effective in the management of SCAD,

their role in the more common forms of diverticular disease remain unproven.

Another area of investigation concerns the potential causal relationship between sigmoid diverticulitis and colorectal cancer, which has been suggested based on comparisons with patients having diverticulosis without diverticulitis[126]. This association has not yet been validated and will therefore require further study. At the moment, sigmoid diverticulitis is not considered a precancerous or high-risk condition for the development of colorectal cancer and the recommended screening modalities do not differ from the guidelines accepted for the average-risk population.

CONCLUSION

Sigmoid diverticulitis is a condition ranging from mild inflammation of the sigmoid to life-threatening colonic perforation. Antibiotics are generally effective in mild forms of the disease while surgery is indicated in cases of multiple recurrences or complicated disease. Based on recent data, the systematic indication for surgery after 2 attacks should be abandoned in favor of a more individualized approach. Laparoscopic surgery is gaining favor in the surgical treatment of sigmoid diverticulitis. A subset of patients with atypical presentation presents a significant challenge in management; some may benefit from surgery whereas others could benefit from anti-inflammatory agent treatment.

ACKNOWLEDGMENTS

The author would like to thank Ms Joyce Balliet for her invaluable help with the figures included in this article.

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