

Impact of early or delayed elective resection in complicated diverticulitis

Kai Bachmann, Geeske Krause, Tamina Rawnaq, Lena Tomkotter, Yogesh Vashist, Shanly Shahmiri, Jakob R Izbicki, Maximilian Bockhorn

Kai Bachmann, Geeske Krause, Tamina Rawnaq, Lena Tomkotter, Yogesh Vashist, Shanly Shahmiri, Jakob R Izbicki, Maximilian Bockhorn, Department of General, Visceral and Thoracic Surgery, University Medical Center Hamburg-Eppendorf, 20246 Hamburg, Germany

Author contributions: Bachmann K analyzed and interpreted the data, and drafted the manuscript; Krause G and Rawnaq T acquired, analyzed and interpreted the data; Tomkotter L drafted the manuscript; Vashist Y revised the manuscript; Shahmiri S drafted the manuscript and statistical analysis; Izbicki JR studied concept and designed and studied supervision; Bockhorn M studied concept, and designed and drafted the manuscript.

Correspondence to: Kai Bachmann, MD, Department of Surgery, University Medical Center Hamburg-Eppendorf, Martinistrasse 52, 20246 Hamburg, Germany. k.bachmann@uke.de
Telephone: +49-40-741057346 Fax: +49-40-741044995

Received: May 30, 2011 Revised: September 2, 2011

Accepted: September 9, 2011

Published online: December 28, 2011

Abstract

AIM: To investigate the outcomes of early and delayed elective resection after initial antibiotic treatment in patients with complicated diverticulitis.

METHODS: The study, a non-randomized comparison of the two approaches, included 421 consecutive patients who underwent surgical resection for complicated sigmoid diverticulitis (Hinchey classification I - II) at the Department of Surgery, University Medical Center Hamburg-Eppendorf between 2004 and 2009. The operating procedure, duration of hospital and intensive care unit stay, outcome, complications and socioeconomic costs were analyzed, with comparison made between the early and delayed elective resection strategies.

RESULTS: The severity of the diverticulitis and American Society of Anesthesiologists score were comparable for the two groups. Patients who underwent delayed elective resection had a shorter hospital stay and oper-

ating time, and the rate of successfully completed laparoscopic resections was higher (80% vs 75%). Eight patients who were scheduled for delayed elective resection required urgent surgery because of complications of the diverticulitis, which resulted in a high rate of morbidity. Analysis of the socioeconomic effects showed that hospitalization costs were significantly higher for delayed elective resection compared with early elective resection (9296 € ± 694 € vs 8423 € ± 968 €; $P = 0.001$). Delayed elective resection showed a trend toward lower complications, and the operation appeared simpler to perform than early elective resection. Nevertheless, delayed elective resection carries a risk of complications occurring during the period of 6-8 wk that could necessitate an urgent resection with its consequent high morbidity, which counterbalanced many of the advantages.

CONCLUSION: Overall, early elective resection for complicated, non-perforated diverticulitis is shown to be a suitable alternative to delayed elective resection after 6-8 wk, with additional beneficial socioeconomic effects.

© 2011 Baishideng. All rights reserved.

Key words: Complicated diverticulitis; Resection of sigmoid; Delayed elective resection; Early elective resection; Socioeconomic effects

Peer reviewers: Dr. Bernardino Rampone, Department of General Surgery and Surgical Oncology, University of Siena, viale Bracci, 53100 Siena, Italy; Naoki Ishii, MD, Department of Gastroenterology, St. Luke's International Hospital, 9-1 Akashi-cho, Chuo-ku, 104-8560 Tokyo, Japan

Bachmann K, Krause G, Rawnaq T, Tomkotter L, Vashist Y, Shahmiri S, Izbicki JR, Bockhorn M. Impact of early or delayed elective resection in complicated diverticulitis. *World J Gastroenterol* 2011; 17(48): 5274-5279 Available from: URL: <http://www.wjgnet.com/1007-9327/full/v17/i48/5274.htm> DOI: <http://dx.doi.org/10.3748/wjg.v17.i48.5274>

INTRODUCTION

Diverticular disease of the sigmoid colon is common in Western countries with a prevalence of 27%^[1,2]. It increases with age from approximately 10% in those younger than 40 years to 33% in those older than 45 years, and then to 50%-70% in those older than 80 years. The average age of presentation with diverticulitis is 62 years. In the United States, approximately 130 000 patients per year are admitted to hospital due to diverticulitis. The increase in the number of cases diagnosed in recent years is, in part, due to improvements in non-invasive diagnostic techniques, especially the use of computed tomography (CT) scanning^[3].

The risk of recurrence after a first attack of diverticulitis ranges from 5%-43%^[4]. Complications (which include fistula formation, abscess, bleeding or perforation) occur in 15%-20% of cases and require surgical intervention^[5,6]. The treatment of patients with complicated sigmoid diverticulitis is associated with a significant morbidity and mortality that is mainly influenced by the severity of the disease and the global medical status of the patient. For elective sigmoid resections, the postoperative morbidity rate is 15%-20%^[5] and the mortality rate ranges from between 0%-17%, compared to 30% in patients with perforated diverticulitis^[6-8].

The appropriate timing of elective resection for uncomplicated diverticulitis is a subject of controversy, with discussion focused mainly on the number of previous attacks. Surgery is generally suggested after one to four episodes of diverticulitis^[9]. The American Society of Colon and Rectal Surgeons recommends that the decision regarding resection be made on a case-by-case basis^[10]. Even in patients with clear indication for elective resection, the optimal timing of the operation remains unclear as little data exists, especially for cases of complicated diverticulitis. Therefore, this trial analyzed the impact of both delayed and early elective resections on outcome, mortality and morbidity, and socioeconomic cost.

MATERIALS AND METHODS

Study design and patients

The study analyzed 421 consecutive patients in whom elective surgical resection for complicated sigmoid diverticulitis had been planned at the Department of Surgery at the University Medical Center Hamburg-Eppendorf between 2004 and 2009. The study was approved by the institutional review board of the hospital. The stage of the diverticulitis was classified according to the modified Hinchey score^[11], which is based on the CT scan at the time of diagnosis. Only patients with clear indication for surgery with complicated diverticulitis, but without perforation (Hinchey I - II), were included in this trial. Data, which included the sex and age of the patient, medication and the complications experienced, were obtained from clinical records. Data concerning previous medical history, co-morbidities and the American Society of Anesthesiologists (ASA) score at the time of the presenta-

tion and classification of the disease were recorded, along with the operating procedure and duration of the operation, durations of the hospital and intensive care unit stays, outcome and complications. Clinical follow-up data was obtained by review of the hospital records and by direct communication with the patients or their attending physicians. The socioeconomic costs of the treatment were evaluated in all cases by review of the total amount invoiced to the health insurance companies.

Operation and antibiotic treatment

On the basis of clinical features and CT scan, elective resection of the sigmoid was planned, with laparoscopic resection the operation of choice, where possible, for all patients except those who had undergone previous major abdominal surgery. The operating surgeon decided whether to perform a primary anastomosis with or without diverting stoma, or a Hartman's procedure depending on the intraoperative findings. The patients were assigned by their surgeon to either early or delayed elective surgery without randomization. The group assigned to early elective resection was treated with antibiotics (ceftriaxone and metronidazole) for 2-4 d before the early elective resection was performed. The delayed elective group was treated with intravenous antibiotics (ceftriaxone and metronidazole) for 5-7 d depending on the clinical course of the patient. Once their symptoms had settled, the patients were discharged and an elective resection was performed 6-8 wk later.

Statistical analysis

SPSS[®] for Windows[®] Version 13.0 (SPSS Inc., Chicago, IL, United States) was used for statistical analysis. Data are presented as mean \pm SD. The continuous data for the different groups were compared using the Student's *t* test. For all non-continuous variables, cross-tables were generated, followed by calculation of the *P* value by using the χ^2 test/Fisher's exact test. Statements of significance refer to *P* values for two-tailed tests of less than 0.05.

RESULTS

Patient characteristics

Overall, 421 patients who underwent surgical resection for sigmoid diverticulitis were included. To analyze the impact of the timing of the operation, early elective surgery was compared to delayed elective surgery after 6-8 wk. Early elective surgery was performed in 272 patients at a median of 2 d after admission to hospital. Elective resection after 6-8 wk was planned for 149 patients; however, eight of these required urgent surgery during this period because of the occurrence of severe complications following their initial conservative management.

At the time of surgery, the mean age of the patients was 63 ± 13 years; 184 patients (44%) were men, 237 patients (56%) women. Preoperatively, 14 patients (3%) were classified as ASA 1239 (57%) as ASA 2159 (38%) as ASA 3 and 9 patients (2%) as ASA 4. In 362 patients (86%), complicated diverticulitis or a small confined pericolic or

Table 1 Patient characteristics *n* (%)

	Early elective resection (<i>n</i> = 272)	Delayed elective resection (<i>n</i> = 149)	<i>P</i> value
Age (mean ± SD)	63.5 ± 13.1	64.2 ± 12.6	0.57
Sex			
Male	121 (44.5)	63 (42.3)	0.66
Female	151 (55.5)	86 (57.7)	
Classification of diverticulitis			
Hinchey 1	230 (84.6)	132 (88.6)	0.28
Hinchey 2	42 (15.4)	17 (11.4)	
ASA classification			
ASA 1	10 (3.7)	4 (2.7)	0.69
ASA 2	150 (55.1)	89 (59.7)	
ASA 3	107 (39.3)	52 (34.9)	
ASA 4	5 (1.8)	4 (2.7)	

ASA: American Society of Anesthesiologists.

mesenteric abscess was diagnosed (Hinchey I); while 59 patients (14%) presented with a distant or complex abscess without perforation (Hinchey II).

The distribution of patients who underwent early and delayed elective resection was largely comparable with regards to sex, age, ASA classification and severity of the diverticulitis (Hinchey classification, Table 1).

The operation performed

Overall, 323 patients (77%) underwent laparoscopic resection, while open surgery, including conversions, was performed in 98 patients (23%). Primary anastomosis without a diverting stoma was possible in 387 patients (92%), while 30 patients (7%) received a primary anastomosis and diverting stoma. In four patients (1%) a Hartman's procedure with descendostomy was necessary due to peritonitis. No significant difference in mortality rates between the various procedures (primary anastomosis, with or without diverting stoma, or Hartman's procedure) was identified.

In patients who underwent delayed elective resection after 6-8 wk, the rate of successfully completed laparoscopic resection was significantly higher, as the inflammation had settled down compared with the early elective resection group (80% vs 75%, *P* = 0.032).

Outcome

Three patients (0.7 %) died in hospital. For delayed elective resection, the rate of wound infections was 7.1% vs 11.0% for early surgery; the rate of re-operations 5.7% vs 8.1%; these differences were not statistically significant. However, the operating time (149 min vs 166 min; *P* < 0.001) and the hospital stay (13 d vs 16 d, *P* = 0.002) were significantly shorter (Table 2).

Complications whilst waiting for delayed elective surgery

It is important to note that in eight patients initially planned for delayed elective surgery, urgent surgery was necessary before the 6-8 wk period had elapsed. Reasons for

Table 2 Outcome following early and delayed elective resections performed for complicated diverticulitis *n* (%)

	Early elective resection (<i>n</i> = 272)	Delayed elective resection performed (<i>n</i> = 141)	<i>P</i> value
Operation			
Minimally invasive surgery	204 (75.0)	119 (84.4)	0.032
Open surgery	68 (25.0)	22 (15.6)	
Procedure			
Hartman	1 (0.4)	0 (0.0)	0.75
Protective stoma	17 (6.3)	8 (5.7)	
Primary anastomosis without stoma	254 (93.4)	133 (94.3)	
Surgical complications			
Wound infection	30 (11.0)	10 (7.1)	0.22
Anastomotic leakage	14 (5.1)	6 (4.3)	0.81
Reoperation	22 (8.1)	8 (5.7)	0.43
Medical complications			
Uriary tract infection	16 (5.9)	7 (5.0)	0.82
Pneumonia	9 (3.3)	4 (2.8)	1
Overall morbidity	41 (15.1)	16 (11.3)	0.16
Mortality	1 (0.4)	1 (0.7)	1
Socioeconomic data (mean ± SD)			
Duration of hospital stay (d)	16.1 ± 9.0	13.3 ± 7.9	0.002
Duration of operation (min)	166.2 ± 44.2	149.1 ± 39.1	< 0.001
Duration of ICU stay (d)	0.64 ± 0.90	0.72 ± 0.91	0.47
Overall costs (€)	8423 ± 968	9296 ± 694	< 0.001

ICU: Intensive care unit.

proceeding to urgent surgery were recurrent episodes with covered perforation or perforation with fecal peritonitis in four patients (on days 24, 29, 34 and 41), clinical deterioration in three patients (on days 3, 5 and 6) and re-presentation with acute diverticular bleeding in one patient. This subgroup of patients had a higher rate of complications. Three patients underwent a Hartman's procedure and four underwent re-operations either for a planned second look and lavage, or because of anastomotic leakage; one of these patients died. On analysis of outcome based on the intention to treat, the advantages of delayed elective resection are lost with the exception of the shorter operating time and hospital stay (Table 3).

Socioeconomic effects

The socioeconomic costs of the hospital stay for the two treatment approaches were compared. Early elective resection was found to reduce the overall costs from 9296 € ± 694 € to 8423 € ± 968 € (*P* < 0.001). This is mainly due to costs incurred during the initial intravenous antibiotic treatment. With the inclusion of the eight patients who needed urgent surgery, the advantage for early surgery is even greater.

DISCUSSION

New insights from this study

Taken together, our results suggest that delayed elective resection has a better outcome in complicated diverticulitis than early elective resection as long as no acute complications occur during the 6-8 wk. The occurrence of an

Table 3 Outcome of planned early and delayed elective resections for complicated diverticulitis (intention to treat analysis) *n* (%)

	Early elective resection (<i>n</i> = 272)	Planned for delayed elective resection ¹ (<i>n</i> = 149)	<i>P</i> value
Operation			
Minimally invasive surgery	204 (75.0)	119 (79.9)	0.28
Open surgery	68 (25.0)	30 (20.1)	
Procedure			
Hartman	1 (0.4)	3 (2.0)	0.153
Protective stoma	17 (6.3)	13 (8.7)	
Primary anastomosis without stoma	254 (93.4)	133 (89.3)	
Surgical complications			
Wound infection	30 (11.0)	16 (10.7)	0.92
Anastomotic leakage	14 (5.1)	8 (5.4)	1.0
Reoperation	22 (8.1)	12 (8.1)	1.0
Medical complications			
Urinary tract infection	16 (5.9)	7 (4.7)	0.66
Pneumonia	9 (3.3)	5 (3.4)	1.0
Overall morbidity	41 (15.1)	23 (15.4)	0.92
Mortality	1 (0.4)	2 (1.3)	0.26
Socioeconomic data (mean ± SD)			
Duration of hospital stay (d)	16.1 ± 9.0	14.2 ± 10.0	0.043
Duration of operation (min)	166.2 ± 44.2	148.9 ± 38.4	< 0.001
Duration of ICU stay (d)	0.64 ± 0.90	1.4 ± 4.0	0.004
Overall costs (€)	8423 ± 968	9941 ± 3563	< 0.001

¹It includes the eight patients who required emergency surgery during the period of 6-8 wk whilst awaiting elective surgery. ICU: Intensive care unit.

acute complication is associated with a very unfavorable outcome. Therefore the decision to proceed to early or delayed elective resection should still be made on a case-by-case basis. In patients who are scheduled for delayed elective resection, close clinical monitoring is recommended until the definitive surgical treatment, to allow for early management of any possible clinical deterioration.

The risk of recurrence

In uncomplicated diverticulitis, medical treatment, which consists of broad-spectrum antibiotic therapy for 5-10 d and resting of the bowel with parenteral nutrition, is usually successful. The indication for elective resection and its most appropriate timing in uncomplicated diverticulitis is the subject of controversial discussions. Surgery is primarily suggested after one to four episodes of diverticulitis^[9,12-14]. There is little prospective data on the natural course of diverticulitis^[15,16] and the risk of a recurrence after the first attack ranges from 5%-46%^[4]. Various controversial risk factors for recurrence, such as age and numbers of acute attacks, or preoperative morbidity have been reported^[4,13,17-20].

Therefore, in 2006, the American Society of Colon and Rectal Surgeons stated that the decision regarding elective resection should be made on a “case-by-case basis,” no general recommendation was given for elective resection to prevent additional attacks^[10]. The age of the patient, their medical condition, response to treatment

and wishes should all be considered when making decisions regarding the indication for and timing of such treatment.

The main reason for performing elective resection is the prevention of serious complications, which include recurrent diverticulitis and the possible perforation that are associated with high morbidity and mortality. These factors must be estimated as part of the risk of an elective operation, which has a postoperative morbidity rate of 15%-20%^[5].

Delayed or early elective resection for complicated non-perforated diverticulitis

There is a consensus of opinion that urgent surgery is indicated in perforated diverticulitis; whilst elective resection is the treatment of choice for complicated diverticulitis, there is limited data concerning the timing of elective resection.

It is most common for patients to be treated conservatively with parenteral nutrition and antibiotics for 5-10 d initially, followed by a period of recuperation and readmission to hospital, typically 6-8 wk later, for a delayed elective resection of the sigmoid colon to be performed. Alternatively patients may be treated for approximately 2-5 d with parenteral nutrition and antibiotics, with an early elective resection performed during the same hospital stay. A correlation between the risk of recurrence and the severity of the initial episode has been described. In complicated diverticulitis characterized by phlegmon or a pericolic abscess, a more aggressive approach is recommended because of the high risk of recurrence, and the high rate of severe complications, such as perforation, with a potentially fatal outcome^[4,21,22].

In a comparison of these approaches in patients with complicated and non-complicated diverticulitis, Natarajan found no relationship between outcome and timing^[23], while Reissfelder *et al.*^[24] detected an advantage for delayed elective resection. Zingg reported a higher conversion rate in early elective resection compared with delayed elective resection, but the rate of complicated diverticulitis was higher in the early elective group (73% *vs* 13%); the outcome and major complications were similar^[25]. Patients with inflammation were reported to have a significantly higher conversion rate (35.4% *vs* 13.5%)^[25]. These results partially contradict our findings, but this may be explained by the selection of the patients as in previously reported studies, patients with both complicated and uncomplicated diverticulitis were included; only patients with complicated diverticulitis were included in our study.

The disadvantage of early elective surgery seems to be caused by the continuing presence of the acute inflammation with adhesions, which makes the procedure more technically demanding and therefore results in a higher conversion rate and longer operating time. In addition, the disadvantage of early elective resection detected in our trial may be caused by the selection bias in the other previously reported retrospective non-randomized trials^[23-25] toward a higher severity of diverticulitis in the ear-

ly intervention group. The rate of patients with Hinchey II stage disease was 15.4% in the early elective group, compared with 9.2% in the patients who actually underwent delayed elective resection, which may therefore explain the tendency towards higher rates of complications in this particular group.

Apart from the possibility of selection bias, delayed elective resection does have one major disadvantage that was identified in this trial; the period of 6-8 wk that is intended to allow the inflammation to settle can be associated with clinical deterioration or a recurrent attack; three patients underwent Hartman's procedure because of severe complications during this period.

Socioeconomic effects

To analyze the socioeconomic costs of both approaches, the total hospital costs that were billed to the insurance companies were compared. In the delayed elective group, the costs of the initial hospital stay for intravenous antibiotic treatment and the subsequent admission for surgical resection were both included. The analysis of the socioeconomic costs of the treatment was based on the diagnosis related groups in Germany during the relevant periods. It should also be mentioned that any costs of treatment by general practitioners between or after the hospitalizations were not included, nor were any indirect costs due to the inability of the patient to work.

There was no detailed analysis of the direct costs to the hospital for the hospitalization of each patient, so the financial profit for the hospital cannot be calculated from our data. Irrespective of these limitations, this trial suggested a socioeconomic advantage for early elective resection, which became even greater when the patients who required urgent surgery instead of their scheduled delayed elective resections were included in the analysis.

Limitations

Our trial is the first to analyze the impact of the timing of this operation in patients only with complicated diverticulitis; however, this study also has its limitations. The analysis is retrospective and observational, and the interventions were not randomized. Although the patients in the two groups showed largely comparable co-morbidities and disease stage according to Hinchey, a selection bias may be present since the decision to proceed with early or delayed elective surgery was based on clinical data, the preference of the surgeon and the medical condition of the patient.

Delayed elective resection showed a trend toward lower complication rates; compared with early elective resection, the operation appeared simpler to perform. Nevertheless, delayed elective resection carried a risk of complications occurring during the period of 6-8 wk that could necessitate an urgent resection with its consequent high morbidity which counterbalanced many of the advantages. Overall, early elective resection for complicated, but non-perforated diverticulitis was found to be a suitable alternative to delayed elective resection after 6-8 wk, with additional beneficial socioeconomic ef-

fects. Following the style of the recommendations made by the American Society of Colon and Rectal Surgeons regarding the indication for elective resection, we suggest a case-by-case decision with respect to early or delayed elective resection is similarly appropriate in patients with complicated diverticulitis.

COMMENTS

Background

The optimal management of complicated diverticulitis without perforation remains unclear. The trial, which was the first to include only patients with complicated diverticulitis, compares the outcomes of early elective resection with delayed elective resection after initial antibiotic treatment.

Research frontiers

It is most common for patients to be treated conservatively with parenteral nutrition and antibiotics for 5-10 d initially, followed by a period of recuperation and re-admission to hospital, typically 6-8 wk later, for a delayed elective resection of the sigmoid colon to be performed. Alternatively patients may be treated for approximately 2-5 d with parenteral nutrition and antibiotics, with an early elective resection performed during the same hospital stay. A correlation between the risk of recurrence and the severity of the initial episode has been described. In complicated diverticulitis characterized by phlegmon or a pericolic abscess, a more aggressive approach is recommended because of the high risk of recurrence, and the high rate of severe complications, such as perforation, with a potentially fatal outcome. There is limited data concerning the timing of elective resection.

Innovations and breakthroughs

This trial, which was the first to include only patients with complicated diverticulitis, compares the outcomes of early elective resection with delayed elective resection after initial antibiotic treatment. Overall, early elective resection for complicated, non-perforated diverticulitis is shown to be a suitable alternative to delayed elective resection after 6-8 wk, with additional beneficial socioeconomic effects.

Applications

To investigate the outcomes of early and delayed elective resection after initial antibiotic treatment in patients with complicated diverticulitis.

Peer review

The article reports interesting information on the surgical treatment of complicated diverticulitis. The authors report an adequate series and proper statistical analysis. The authors' comments are very interesting and of great help for the surgeons. The article deserves publication. It is an interesting topic with an analysis on the correct management of a very common disease.

REFERENCES

- 1 **Bordeianou L**, Hodin R. Controversies in the surgical management of sigmoid diverticulitis. *J Gastrointest Surg* 2007; **11**: 542-548
- 2 **Ambrosetti P**, Robert JH, Witzig JA, Mirescu D, Mathey P, Borst F, Rohner A. Acute left colonic diverticulitis: a prospective analysis of 226 consecutive cases. *Surgery* 1994; **115**: 546-550
- 3 **Nelson RS**, Ewing BM, Wengert TJ, Thorson AG. Clinical outcomes of complicated diverticulitis managed nonoperatively. *Am J Surg* 2008; **196**: 969-972; discussion 973-974
- 4 **Frileux P**, Dubrez J, Burdy G, Rouillet-Audy JC, Dalban-Sillas B, Bonnaventure F, Frileux MA. Sigmoid diverticulitis. Longitudinal analysis of 222 patients with a minimal follow up of 5 years. *Colorectal Dis* 2010; **12**: 674-680
- 5 **Antolovic D**, Reissfelder C, Koch M, Mertens B, Schmidt J, Büchler MW, Weitz J. Surgical treatment of sigmoid diverticulitis—analysis of predictive risk factors for postoperative infections, surgical complications, and mortality. *Int J Colorectal Dis* 2009; **24**: 577-584
- 6 **Alvarez JA**, Baldonado RF, Bear IG, Otero J, Pire G, Alvarez P, Jorge JL. Presentation, management and outcome of acute sigmoid diverticulitis requiring hospitalization. *Dig Surg* 2007; **24**: 471-476

- 7 **Hussain A**, Mahmood H, Subhas G, El-Hasani S. Complicated diverticular disease of the colon, do we need to change the classical approach, a retrospective study of 110 patients in southeast England. *World J Emerg Surg* 2008; **3**: 5
- 8 **Vermeulen J**, Akkersdijk GP, Gosselink MP, Hop WC, Mannaerts GH, van der Harst E, Coene PP, Weidema WF, Lange JF. Outcome after emergency surgery for acute perforated diverticulitis in 200 cases. *Dig Surg* 2007; **24**: 361-366
- 9 **Richards RJ**, Hammitt JK. Timing of prophylactic surgery in prevention of diverticulitis recurrence: a cost-effectiveness analysis. *Dig Dis Sci* 2002; **47**: 1903-1908
- 10 **Rafferty J**, Shellito P, Hyman NH, Buie WD. Practice parameters for sigmoid diverticulitis. *Dis Colon Rectum* 2006; **49**: 939-944
- 11 **Hinchey EJ**, Schaal PG, Richards GK. Treatment of perforated diverticular disease of the colon. *Adv Surg* 1978; **12**: 85-109
- 12 **Wong WD**, Wexner SD, Lowry A, Vernava A, Burnstein M, Denstman F, Fazio V, Kerner B, Moore R, Oliver G, Peters W, Ross T, Senatore P, Simmang C. Practice parameters for the treatment of sigmoid diverticulitis--supporting documentation. The Standards Task Force. The American Society of Colon and Rectal Surgeons. *Dis Colon Rectum* 2000; **43**: 290-297
- 13 **Stollman NH**, Raskin JB. Diagnosis and management of diverticular disease of the colon in adults. Ad Hoc Practice Parameters Committee of the American College of Gastroenterology. *Am J Gastroenterol* 1999; **94**: 3110-3121
- 14 **Scarpa M**, Pagano D, Ruffolo C, Pozza A, Polese L, Frego M, D'Amico DF, Angriman I. Health-related quality of life after colonic resection for diverticular disease: long-term results. *J Gastrointest Surg* 2009; **13**: 105-112
- 15 **Parks TG**, Connell AM. The outcome in 455 patients admitted for treatment of diverticular disease of the colon. *Br J Surg* 1970; **57**: 775-778
- 16 **Parks TG**. Natural history of diverticular disease of the colon. A review of 521 cases. *Br Med J* 1969; **4**: 639-642
- 17 **Anaya DA**, Flum DR. Risk of emergency colectomy and colostomy in patients with diverticular disease. *Arch Surg* 2005; **140**: 681-685
- 18 **Mäkelä J**, Vuolio S, Kiviniemi H, Laitinen S. Natural history of diverticular disease: when to operate? *Dis Colon Rectum* 1998; **41**: 1523-1528
- 19 **Chautems RC**, Ambrosetti P, Ludwig A, Mermillod B, Morel P, Soravia C. Long-term follow-up after first acute episode of sigmoid diverticulitis: is surgery mandatory?: a prospective study of 118 patients. *Dis Colon Rectum* 2002; **45**: 962-966
- 20 **Haglund U**, Hellberg R, Johnsen C, Hultén L. Complicated diverticular disease of the sigmoid colon. An analysis of short and long term outcome in 392 patients. *Ann Chir Gynaecol* 1979; **68**: 41-46
- 21 **Tudor RG**, Farmakis N, Keighley MR. National audit of complicated diverticular disease: analysis of index cases. *Br J Surg* 1994; **81**: 730-732
- 22 **Farmakis N**, Tudor RG, Keighley MR. The 5-year natural history of complicated diverticular disease. *Br J Surg* 1994; **81**: 733-735
- 23 **Natarajan S**, Ewings EL, Vega RJ. Laparoscopic sigmoid colectomy after acute diverticulitis: when to operate? *Surgery* 2004; **136**: 725-730
- 24 **Reissfelder C**, Buhr HJ, Ritz JP. What is the optimal time of surgical intervention after an acute attack of sigmoid diverticulitis: early or late elective laparoscopic resection? *Dis Colon Rectum* 2006; **49**: 1842-1848
- 25 **Zingg U**, Pasternak I, Guertler L, Dietrich M, Wohlwend KA, Metzger U. Early vs delayed elective laparoscopic-assisted colectomy in sigmoid diverticulitis: timing of surgery in relation to the acute attack. *Dis Colon Rectum* 2007; **50**: 1911-1917

S- Editor Lv S L- Editor Rutherford A E- Editor Xiong L