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Results of Laparotomy and Laparoscopy for Perforated Colonic Diverticulitis

Sung Bak An, MD, Byung Chun Kim, MD, PhD, Jeong Yeon Kim, MD, PhD, Jong Wan Kim, MD, Sang-Jeon Lee, MD, PhD

ABSTRACT

Background and Objectives: The applications of laparoscopic surgery are expanding, but there is still controversy about its application in patients with peritonitis resulting from diverticulitis perforation. This study aimed to investigate the factors affecting the postoperative mortality rate in patients undergoing surgery for perforated diverticulitis. Further, we compared the recovery courses of patients between open and laparoscopic surgeries.

Methods: We analyzed the medical records of adult patients with peritonitis caused by perforated diverticulitis from six hospitals of Hallym University Medical Center from January 2006 to December 2016.

Results: A total of 166 patients were identified. In the univariate analysis, the statistically significant factors associated with postoperative mortality were age ≥ 60 years, body mass index ≥ 23 kg/m^2, American Society of Anesthesiologists score ≥ 3, hypertension, serum blood urea nitrogen ≥ 23 mg/dL, creatinine ≥ 1.2 mg/dL, albumin < 3.0 g/dL, modified Hinchey score ≥ grade III, formation of stoma, and laparoscopic surgery. In multivariate analysis, serum albumin < 3.0 g/dL was the only factor associated with mortality. After case-control matching, we compared postoperative hospital course and prognosis between open and laparoscopic surgery groups. There was no significant difference in the clinical course between the groups. No significant difference was observed in the complication rate, reoperation rate, readmission rate, and mortality.

Conclusion: Low preoperative serum albumin level (<3.0 g/dL) affects the mortality rate of patients after surgery. The hospital course and prognosis after laparoscopic surgery and conventional open surgery are comparable in patients with peritonitis caused by diverticulitis perforation.

Key Words: Laparoscopic Surgery, Diverticular Diseases, Colonic Diverticulum.

INTRODUCTION

Colonic diverticular disease is common in the Western population but is rare among Asians.[1] The incidence of this disease is highly related to a high-protein and low-fiber diet, and the occurrence rate is gradually increasing in Korea based on the westernization of diet.[2]

The treatment of acute diverticulitis depends on the severity of the disease.[3] Simple diverticulitis can be sufficiently treated with antibiotics, but perforated diverticulitis with peritonitis requires surgery. Of the patients with diverticulitis, 25% require surgery,[4] and various surgical procedures such as ostomy, stepped bowel resection, and simple peritoneal lavage are used for treatment.[5]

The applications of laparoscopic surgery are gradually increasing. However, laparoscopic surgery for peritonitis is still controversial. This is because of the theoretical background that bacteremia and endotoxemia can get worse if air is introduced into the abdomen causing aeroperitonia.[6,7]

In this study, therefore, we were going to evaluate the stability of laparoscopic surgery in patients with peritonitis caused by perforated diverticulitis. This study aimed to determine the preoperative factors affecting mortality after surgery in patients with perforated diverticulitis requiring

Department Of Surgery, Hallym University Medical Center, Dongtan Sacred Heart Hospital, Hwaseong, Republic of Korea (Drs Sung Bak An, Jeong Yeon Kim, Jong Wan Kim)

Department Of Surgery, Hallym University Medical Center, Kangnam Sacred Heart Hospital, Seoul, Republic of Korea (Dr Byung Chun Kim)

Department of Surgery, College of Medicine, Chungbuk National University and Hospital, Cheongju, Republic of Korea (Dr Sang-Jeon Lee)

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Address correspondence to: Sang-Jeon Lee, MD, Department Of Surgery, College of Medicine, ChungBuk National University and Hospital, 776, 1 Chungdae-ro, Seowon-gu, Cheongju 28644, Republic of Korea. Telephone: +82-43-269-6360, Fax: +82-43-266-6037, E-mail: colon@chungbuk.ac.kr

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surgical treatment to determine whether laparoscopic surgery affects the outcome, and to compare the recovery courses of patients after open surgery and laparoscopic surgery to check if they produce similar results.

PATIENTS AND METHODS

Research Design

We retrospectively reviewed the medical records of patients who underwent surgery for peritonitis caused by perforated diverticulitis at six hospitals of Hallym University Medical Center (Hallym University Sacred Heart Hospital, Kangnam Sacred Heart Hospital, Chuncheon Sacred Heart Hospital, Hangang Sacred Heart Hospital, Dongtan Sacred Heart Hospital, Kangdong Sacred Heart Hospital) between January 2006 and December 2016. The Institutional Review Board of Dongtan Sacred Heart Hospital approved this study.

Inclusion Criteria

Patients who were diagnosed with peritonitis caused by perforated diverticulitis were hospitalized and underwent surgery were included.

Exclusion Criteria

Patients aged < 19 years or ≥ 91 years, expectant mothers, and patients with postoperative pathologic findings were excluded if the perforation of the diverticulum was not confirmed.

Number of Patients

This study was a retrospective, observational study where no specific hypothesis testing was performed. A total of 524 patients were recruited. Of them, 358 patients were excluded due to exclusion criteria. As a result, 166 patients were examined without the need for a separate sample count calculation.

Assessment Methods

We analyzed the age, sex, underlying disease, medical history, social history, body mass index, and American Society of Anesthesiologists scores of patients who underwent peritonitis surgery because of perforated diverticulitis. We analyzed the history such as previous abdominal surgery, history of diverticulitis, and history of constipation, as well as social history concerning smoking and drinking. Further, we analyzed the body temperature and levels of white blood cell, serum C-reactive protein, blood urea nitrogen, creatinine, total bilirubin, direct bilirubin, and albumin at the time of admission. Modified Hinchey score, perforation location, operation method, and duration of operation were analyzed in patients who underwent surgery. The modified Hinchey score was referenced in 1999 by Wasvary et al.[8] with the following classification (Hinchey classification (Wasvary Modification):

0 Mild clinical diverticulitis
Ia Confined pericolic inflammation or phlegmon
Ib Pericolic or mesocolic abscess
II Pelvic, distant intra-abdominal or retroperitoneal abscess
III Generalized purulent peritonitis
IV Generalized fecal peritonitis

For determining location of perforation, cecum, ascending colon, and hepatic flexure were classified as the right side and splenic flexure, descending colon, and S colon were classified as the left side.

Surgical procedures were classified based on the choice of open or laparoscopic procedures, bowel resection requirement, and formation of ostomy. Because this study was a retrospective study, there were no clear criteria for determining the surgical procedure. Therefore, the surgical procedure was determined by the physician according to the patient's condition.

We analyzed patients who underwent surgery for peritonitis resulting from perforated diverticulitis for recovery time of bowel movements, time to drinking, time to ingestion of soft meal, duration of hospitalization, complication, reoperation, and death. The recovery time was the first time the patient farted after surgery. Complications were defined as enteritis, enteroplegia, anastomotic leakage, wound infection, pneumonia, cardiovascular disease (such as heart failure and pulmonary embolism), acute renal failure, and sepsis. Reoperation was defined as an operation performed to treat complications appearing within 1 month after surgery. Finally, death was defined as death occurring within 1 month after surgery.

Univariate and multivariate analyses were performed to find predictors in patients who died after surgery. Case-control matching was performed to compare open and laparoscopic surgeries for postoperative outcome and prognosis of patients who underwent surgery. Matching was performed based on factors that were significant in univariate and multivariate analyses to find predictors in patients who died after surgery. As a result, 40 patients were selected from each group and compared.

Table 1.
Patient's Demographics and Clinical Manifestation

	No (%)
Age (years)	54.8 (17.8)
Male:female	99:67
BMI (kg/m^2)	23.9 (3.6)
ASA, n (%)	
1	58 (34.9)
2	65 (39.2)
3	40 (24.1)
4	2 (1.2)
5	1 (0.6)
Hypertension, n (%)	45 (27.1)
Hepatitis, n (%)	4 (2.4)
DM, n (%)	20 (12.0)
Tuberculosis, n (%)	3 (1.8)
Abdominal operation history, n (%)	45 (27.1)
Constipation, n (%)	13 (7.8)
Smoking, n (%)	49 (29.5)
Alcohol, n (%)	22 (13.3)
History of diverticulitis, n (%)	13 (7.8)
Body temperature (°C)	37.4 (1.0)
WBC ($\times 10^3/\mu$L)	12.9 (5.0)
Serum CRP (mg/L)	117.1 (91.5)
Serum BUN (mg/dL)	17.1 (11.6)
Serum creatinine (mg/dL)	1.04 (0.87)
Serum total bilirubin (mg/dL)	1.3 (1.4)
Serum direct bilirubin (mg/dL)	0.5 (1.1)
Serum albumin (g/dL)	3.9 (0.7)
Modified hinchey score, n (%)	
Ia	46 (27.7)
Ib	41 (24.7)
II	39 (23.5)
III	36 (21.7)
IV	4 (2.4)
Perforation site, n (%)	
Right	91 (54.8)
Left	75 (45.2)
Operation method, n (%)	
Laparoscopy	59 (35.5)
Open	107 (64.5)
Bowel resection, n (%)	150 (90.4)
Laparoscopy	55
Open	95
Stoma formation, n (%)	50 (30.1)
Laparoscopy	4
Open	46
Operation time (min)	172.9 (67.6)

Data are presented as the number of patients (%) or mean (standard deviation) unless otherwise stated.

ASA, American Society of Anesthesiologists; BMI, body mass index; BUN, blood urea nitrogen; CRP, C-reactive protein; DM, diabetes mellitus; WBC, white blood cell.

Statistical Processing

The results were expressed as mean (standard deviation) paired-sample *t*-test was performed for the comparison of continuous variables. The discontinuous variables were expressed as the number of patients and percentage (%), or number of patients after crossover analysis. Univariate analysis was performed using Fisher's exact test. Multivariate analysis was performed using logistic regression to analyze factors that predict postoperative complications. Case-control matching was performed based on factors significantly associated with multivariate and univariate analyses. Statistical analysis was performed using SPSS version 21.0 (Chicago, Illinois, USA) and $P < .05$ was used for statistical significance.

RESULTS

Patient Characteristics

During the 11-year study period, 524 patients were included. Of them, 358 patients were excluded due to exclusion criteria. As a result, 166 patients were included, of whom, 107 and 59 underwent open laparoscopic surgeries, respectively. The mean age of the patients was 54.8 years. There were 99 males and 67 females. The distribution of Modified Hinchey score was as follows: 27.7% in Ia, 24.7% in Ib, 23.5% in II, 21.7% in III, and 2.4% in IV. With regard to the location of perforation, right side perforations were observed in 91 patients and left side in 75 patients, with more patients having right side perforations.

Most patients underwent bowel resection (90.4%) and 50 patients (30.1%) developed ostomy (**Table 1**).

Rehospitalization and reoperation rates were 5.4% and 4.8%, respectively. The complication and mortality rates were 43.4% and 8.4%, respectively (**Table 2**).

Predictors of Postoperative Death

Univariate and multivariate analysis for various factors were performed to determine the factors that predicted postoperative death. A serum albumin level of less than 3.0 g/dL was the only factor that significantly associated with mortality ($P = .011$; **Table 3**).

Comparison Between Open Surgery and Laparoscopic Surgery After Case Matching

Case-control matching was performed to compare the open surgery group and laparoscopic group after reducing the differences in factors that may affect the recovery process. In all, 40 patients were selected for performing case-control matching with different variables (age, body mass index, American Society of Anesthesiologists score, hypertension, serum blood urea nitrogen level, creatinine level, albumin level, modified Hinchey score, formation of ostomy, and laparoscopic surgery), which were significantly associated with postoperative mortality in the univariate analysis. There were no statistically significant differences between the two groups in terms of factors that could affect the prognosis (**Table 4** and **Table 5**).

There was no statistically significant difference in prognosis (**Table 6**).

Table 2.
Patient's Clinical Course After Surgery

	No (%)
Time to gas passing (days)	3.6 (2.0)
Time to drinking water (days)	4.9 (2.9)
Time to soft diet (days)	6.4 (3.2)
Length of hospital stay (days)	18.2 (12.0)
Post-operation hospital stay (days)	14.7 (11.4)
Complication, n (%)	72 (43.4)
Re-admission, n (%)	9 (5.4)
Re-operation, n (%)	8 (4.8)
Mortality, n (%)	14 (8.4)

Data are presented as the number of patients (%) or mean (standard deviation) unless otherwise stated.

DISCUSSION

Colonic diverticular disease is a condition where in small sacs protrude abnormally from the colon wall. It can be classified as a true diverticulum in which the entire layer of the colon is pushed out and a false diverticulum in which there are mucosa or submucosal protrusions through the weakened wall of the colon due to degenerative changes.[1–3] The Western population is more likely to have false diverticulum of the S colon, while Asian patients have frequent occurrences of appendicitis and true diverticulum of the ascending colon.[2,3]

The diverticulum of the large intestine is mostly symptomless, but it causes various problems depending on the progression. Among them, diverticulitis is a common condition. The feces enter the diverticulum and form feces stones that cause erosion of the mucous membrane of the diverticula. If this condition persists, inflammation becomes more severe and spreads to other tissues around the diverticulum. Western and Oriental sex ratios of diverticulitis differ slightly. In the case of the West, the ratio of male to female is similar, or 1:1.5~2, with a higher occurrence in females.[9] In Korea and Asia, however, the male to female ratio is 1.5:1, with a higher occurrence in males.[10] In this study, the male to female incidence was 1.47:1, which was higher in males.

If inflammation of the diverticulum gets worse, about 15% patients have complications such as perforation.[11] In most cases, perforation with peritonitis requires emergency surgery.[1,3–5] Although the incidence of perforating peritonitis is low, once it occurs, the mortality rate is 4% to 26% regardless of the treatment method.[12–15] In our study, mortality after surgery was observed in 14 of 166 patients (8.4%).

Many studies have suggested that poor preoperative nutritional status adversely affects recovery after surgery,[16,17] and postoperative complications and mortality are likely to increase.[18–20] Serum albumin acts as a carrier of various minerals, hormones, and fatty acids and plays an important role in maintaining the osmotic pressure between blood vessels and tissues,[21] and albumin levels are used as one of the various measures for assessing the nutritional status in patients.[22–24] In this study, serum albumin levels below 3.0 g/dL were associated with postoperative mortality (OR, 22.811; 95% CI, 2.068–251.587; $P = .011$). This suggests that a low serum albumin level reflects poor nutritional status before surgery and this affects postoperative mortality.

Laparoscopic colonic surgery has been shown not to be inferior to open surgery in terms of postoperative recovery in several studies.[25–27] In this study, according to the

Table 3.
Univariate and Multivariate Analyses of Mortality

Variable	Univariate Analysis		Multivariate Analysis	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Age ≥ 60 years	19.393 (2.473–152.107)	.005	5.403 (0.464–62.985)	.178
Males	0.652 (0.218–1.953)	.445		
BMI ≥ 23 kg/m^2	0.192 (0.040–0.924)	.040	0.570 (0.043–7.589)	.670
ASA ≥ 3	4.457 (1.449–13.713)	.009	0.665 (0.102–4.318)	.669
Hypertension	8.357 (2.469–28.292)	.001	3.687 (0.633–21.454)	.147
DM	1.241 (0.257–5.998)	.788		
Hepatitis	3.821 (0.371–39.388)	.260		
Tuberculosis	2.020 (0.243–16.783)	.515		
Abdominal operation history	3.000 (0.989–9.104)	.052		
Constipation	0.897 (0.108–7.459)	.920		
Smoking	0.167 (0.021–1.311)	.089		
Alcohol	0.442 (0.055–3.541)	.442		
History of diverticulitis	0.897 (0.108–7.459)	.920		
Body temperature ≥ 38.3°C	0.373 (0.047–2.976)	.352		
WBC ≥ 10 × 10^3/μL	0.492 (0.161–1.506)	.214		
Serum CRP ≥ 40 mg/L	0.493 (0.141–1.715)	.266		
Serum BUN ≥ 23 mg/dL	4.432 (1.402–14.009)	.011	1.010 (0.169–6.060)	.991
Serum creatinine ≥ 1.2 mg/dL	6.238 (1.986–19.592)	.002	6.320 (0.976–40.945)	.053
Serum total bilirubin ≥ 1.2 mg/dL	0.955 (0.194–6.199)	.961		
Serum direct bilirubin ≥ 1.2 mg/dL	0.356 (0.100–1.276)	.113		
Serum albumin < 3.0 g/dL	16.000 (3.135–81.665)	.001	22.811 (2.068–251.587)	.011
Modified Hinchey score ≥ III	5.000 (1.618–15.448)	.005	2.186 (0.320–14.933)	.425
Left side perforation	2.345 (0.751–7.329)	.142		
Bowel resection	1.423 (0.174–11.654)	.742		
Stoma formation	3.492 (1.143–10.666)	.028	0.332 (0.046–2.404)	.275
Laparoscopy	8.021 (1.022–62.942)	.048	2.480 (0.157–39.161)	.519
Operation time ≥ 180 min	2.685 (0.859–8.399)	.090		

ASA, American Society of Anesthesiologists; BMI, body mass index; BUN, blood urea nitrogen; CI, confidence interval; CRP, C-reactive protein; DM, diabetes mellitus; OR, odds ratio; WBC, white blood cell.

prognosis of the two groups after case matching, there was no significant difference between the laparoscopic surgery group and the open surgery group with regard to the time to recovery (3.2 days vs. 3.0 days; $P = .776$), time to drinking (4.6 days vs. 3.8 days; $P = .067$), time to ingestion of soft meal (5.9 days vs. 5.2 days; $P = .080$), total duration of hospitalization (15.8 days vs. 14.0 days; $P = .279$), and postoperative duration of hospitalization (12.1 days vs. 10.7 days; $P = .361$). In addition, there were no statistically significant differences in the complication rate (35.0% vs. 32.6%; $P = 1.000$), reoperation rate (5.0% vs. 10.0%; $P = .675$), readmission rate (5.0% vs. 0.0%; $P = .464$), and mortality (2.5% vs. 2.5%; $P = 1.000$) between groups. Based on this, we believe that the recovery and prognosis after laparoscopic surgery in peritonitis patients with perforated diverticulitis are not inferior to those after open surgery.

This study has some limitations. First, because this study is a retrospective study, there could be selection bias. The

Table 4.
Patients' Demographics and Clinical Manifestation According to the Type of Surgery (Case-Control Matching)

	Open (n = 40)	Laparoscopy (n = 40)	*P*
Age (years)	43.2 (17.1)	47.4 (16.0)	.263
Male, n (%)	29 (72.5)	27 (67.5)	.807
BMI (kg/m^2)	24.4 (4.4)	24.4 (3.3)	.981
ASA (%)			.765
1	19 (47.5)	20 (50.0)	
2	17 (42.5)	15 (37.5)	
3	4 (10.0)	4 (10.0)	
4	0 (0.0)	1 (2.5)	
5	0 (0.0)	0 (0.)	
Underlying disease, n (%)	10 (25.0)	12 (30.0)	.802
Hypertension	5	9	.239
DM	1	4	.359
Abdominal operation history, n (%)	12 (30.0)	10 (25.0)	.802
Constipation, n (%)	0 (0.0)	1 (2.5)	1.000
Alcohol, n (%)	6 (15.0)	10 (25.0)	.402
Smoking, n (%)	20 (50.0)	13 (32.5)	.173
History of diverticulitis, n (%)	4 (10.0)	4 (10.0)	1.000
Body temperature (°C)	37.4 (0.83)	37.6 (0.84)	.281
WBC ($\times 10^3/\mu L$)	14.9 (5.8)	13.1 (4.3)	.116
Serum CRP (mg/L)	122.9 (91.5)	98.0 (64.7)	.321
Serum BUN (mg/dL)	14.0 (12.9)	12.9 (5.5)	.615
Serum creatinine (mg/dL)	0.84 (0.16)	0.89 (0.20)	.194
Serum total bilirubin (mg/dL)	1.2 (1.0)	1.2 (0.6)	.919
Serum direct bilirubin (mg/dL)	0.3 (0.2)	0.4 (0.3)	.153
Serum albumin (g/dL)	4.0 (0.6)	4.1 (0.4)	.460
Modified Hinchey score, n (%)			.575
Ia	14 (35.0)	14 (35.0)	
Ib	16 (40.0)	10 (25.0)	
II	7 (17.5)	12 (30.0)	
III	2 (5.0)	3 (7.5)	
IV	1 (2.5)	1 (2.5)	
Perforation site, n (%)			.401
Right	28 (70.0)	30 (75.0)	
Left	12 (30.0)	10 (25.0)	

Data are presented as the number of patients (%) or mean (standard deviation) unless otherwise stated.

ASA, American Society of Anesthesiologists; BMI, body mass index; BUN, blood urea nitrogen; CRP, C-reactive protein; DM, diabetes mellitus; WBC, white blood cell.

Table 5.
Comparison Between Open and Laparoscopy Group (Case-Control Matching)

	Open (n = 40)	Laparoscopy (n = 40)	*P*
Bowel resection, n (%)	36 (90.0)	36 (90.0)	1.000
Stoma formation, n (%)	7 (17.5)	4 (10.0)	.518

Data are presented as the number of patients (%) or mean (standard deviation) unless otherwise stated.

Table 6.
Clinical Recovery Course According to the Type of Surgery (Case-Control Matching)

	Open (n = 40)	Laparoscopy (n = 40)	*P*
Time to gas passing (days)	3.2 (1.4)	3.0 (1.7)	.776
Time to drinking water (days)	4.6 (2.2)	3.8 (1.4)	.067
Time to soft diet (days)	5.9 (2.3)	5.2 (1.5)	.080
Length of hospital stay (days)	15.8 (8.9)	14.0 (6.0)	.279
Postoperative hospital stay (days)	12.1 (7.5)	10.7 (6.0)	.361
Complication, n (%)	14 (35.0)	13 (32.6)	1.000
Re-admission, n (%)	2 (5.0)	4 (10.0)	.675
Re-operation, n (%)	2 (5.0)	0 (0.0)	.464
Mortality, n (%)	1 (2.5)	1 (2.5)	1.000

Data are presented as the number of patients (%) or mean (standard deviation) unless otherwise stated.

process of determining the surgical procedure in the course of treatment was not recorded in the medical record and could not be evaluated. Second, because this study was conducted for multiple institutions rather than a single institution, it is possible that the operation method changed according to the doctor's experience and preference. Third, the number of patients in the laparoscopic surgery group was lower than that in the open surgery group, and high-risk patients in the open surgery group were excluded from case-matching. Although these limitations exist, this study is significant and confirms the factors affecting postoperative mortality, and laparoscopic surgery may be a good choice in peritonitis cause by perforated diverticulitis. We believe that a prospective study is required with a higher number of cases in the future.

CONCLUSION

In cases where the preoperative serum albumin level is low, postoperative mortality is high. On comparing the open surgery group and laparoscopic surgery group after case-control matching, postoperative recovery progress in the laparoscopic surgery group was not bad compared with that in the open surgery group for patients with peritonitis caused by perforated diverticulitis.

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