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ORIGINAL ARTICLE

Surgical outcomes and prognostic factors of emergency surgery for colonic perforation: would fecal contamination increase morbidity and mortality?

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Abstract

Purpose Complications resulting from colonic perforation are related to secondary peritonitis due to bacterial or fecal contamination. We investigated outcomes of emergency surgery for colonic perforation associated with fecal contamination with regard to early and late postoperative complication rates and mortality rates, and investigated prognostic factors influencing those outcomes.

Methods A retrospective analysis of prospectively collected data on factors influencing complications and mortality rates was conducted on data from 152 patients who had undergone emergent operations for colonic perforation between January 2005 and December 2011. Patients were categorized into two groups: those with and without gross fecal contamination at the time of operation.

Results Forty-one (26.9 %) patients had gross fecal contamination. Patients who had fetal contamination had a higher Mannheim peritonitis index (31.3±5.1 vs. 21.9±7.2, $p<0.001$), higher organ failure rate (53.7 vs. 24.3 %, $p=0.001$), and longer operating time (168.8±49.9 vs. 144.8±66.1 min, $p=0.036$) than patients without fecal contamination. Early complications (<30 days) occurred more frequently in the fecal contamination group (82.9 vs. 49.5 %, $p=0.001$), although late complications (46.2 vs. 39.3 %, $p=0.942$) and mortality (17.1 vs. 8.1 %, $p=0.110$) did not differ. In multivariate analysis, fecal contamination significantly predicted early complications (odds ratio, 2.78; $p=0.037$) but not late complications or mortality.

Conclusions The frequency of early complications can increase if fecal contamination exists. However, when early complications are well managed, fecal contamination does not significantly influence occurrences late complications or mortality.

Keywords Colonic perforation · Fecal contamination · Morbidity · Mortality · Risk factors

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Introduction

Colonic perforation is a life-threatening problem that presents with high morbidity and mortality of approximately >30 %, even after immediate treatment with emergency surgery [1]. This condition can occur because of various causes, and diverticulitis is the most frequent. Colorectal cancer can present with colonic perforation, and colonoscopy can also progress to iatrogenic perforation [2, 3]. Moreover, infectious colitis, inflammatory bowel disease, ischemia, and trauma can cause colonic perforation [4–6].

Different surgical methods can be used according to the cause and severity of colonic perforation. Primary resection with immediate anastomosis can be safely performed for patients with uncomplicated or purulent peritonitis [7]. Although primary repair can be performed for small perforations, stoma formation has also been considered an option for patients with serious septic condition [8]. Several studies have reported that primary resection with anastomosis for fecal peritonitis is also feasible [9, 10], but another showed a 29.7 % rate of anastomotic leakage due to severe bowel wall edema or inflammation resulting from fecal peritonitis [11]. Small perforation has been considered safe for small perforations. Controversies regarding the proper surgical management for fecal peritonitis remain.

Even after immediate surgery for colonic perforation, various complications persist, including wound infection or intra-abdominal abscesses, cardiac or pulmonary problems, and renal failure. Unfortunately, in severe cases, patients may die of multi-organ failure with septic shock [12]. After recovering from the disease, patients may develop intestinal obstruction, enterocutaneous fistula, or incisional hernia. Despite improvements in antibiotics and postoperative intensive care, morbidity and mortality rates are still high after emergency surgery for colonic perforation [13]. These complications are related to secondary peritonitis due to bacterial or fecal contamination from colonic perforation, and the surgical outcomes are worse in cases of fecal peritonitis than in cases of purulent peritonitis [14].

We investigated surgical outcomes in terms of morbidity with early and late complications and mortality of patients, associated with fecal contamination resulting from the colonic perforation. The prognostic factors influencing the morbidity and mortality rates were also analyzed.

Materials and methods

The study was performed by retrospectively reviewing medical records of prospectively collected information from 152 patients who had undergone emergency surgery for colonic perforation between January 2005 and December 2011 in our institute. This study was reviewed and approved by the Institutional Review Board of the Seoul National University Hospital.

The patients' sex, age, body mass index (BMI), Charlson comorbidity scores (CSSs), American Society of Anesthesiologists (ASA) classification, full history taking, physical examination, symptom duration, vital sign including blood pressure, C-reactive protein (CRP) level, operation name, operation time, blood loss (measurement using anesthesia record), intra-operative transfusion, cause of perforation, perforation site, perforation size, perforation with or without fecal contamination, length of hospital stay, early and late postoperative complications, and mortality rates were investigated. The severity of peritonitis was assessed using the Mannheim peritonitis index (MPI) [15]. Symptom duration was defined as the time between the start of abdominal pain and the beginning time of the surgery. Systemic hypotension, which is presented at severe sepsis, was defined as a systolic blood pressure <90 mmHg or a reduction of systolic blood pressure by ≥40 mmHg from baseline. Organ failure, presented at preoperative periods, was categorized as either renal or pulmonary failure. Cases with urine output of at least 0.5 mL/[kg·h] within 2 h, despite adequate fluid treatment, and those with creatinine level higher than 0.5 mg/dL were considered to have renal failure. Cases with a PaO_2/FiO_2 ratio <300, and those requiring ventilator support, were considered to have pulmonary failure. CCS was a useful tool that is a weighted score for predicting mortality risk [16].

Patients were categorized into two groups: those with and without fecal contamination. Fecal contamination was defined as any case in which fecal materials oozed out grossly from the intra-peritoneal cavity during the operation. In addition, fecal contamination was defined as the presence of fecal material inside the peritoneal cavity which can be confirmed by laparotomy or laparoscopy. Cases in which there was spillage during the surgery were excluded from the fecal contamination group. We performed intra-peritoneal lavage with saline for all colonic perforation patients, and in particular, patients with fecal contamination underwent intra-peritoneal lavage with a large volume of saline (>10 L). Complications occurring within 30 days after the surgery were defined as "early complications," and those occurring after 30 days were defined as "late complications." Mortality was defined as death in the hospital within 30 days after surgery.

Treatment protocol for patients with abdominal pain

When a patient was hospitalized owing to abdominal pain, a physical examination was performed after taking a complete history. At this point, if acute abdomen was suspected, basic radiological imaging and routine laboratory tests (e.g., complete blood cell count, C-reactive protein, and electrolytes) were performed. If pneumoperitoneum was detected among the radiological findings, abdominal computed tomography was performed immediately to evaluate the perforation site and decide whether or not to operate. However, when the cause of acute abdomen was unclear, the patient was admitted, physical examinations were performed, and vital signs were monitored closely for changes; if there was any change, an evaluation was performed to determine the need for operation. We have been using a Jackson-Pratt (JP) drain, which is a closed-suction drain. The JP drain was inserted, dependent upon the position, to the pelvis, right upper quadrant, or left upper quadrant. Preoperative and postoperative blood cultures and postoperative drain cultures were mainly performed in our institute instead of intra-operative cultures. The broad-spectrum antibiotics such as piperacillin/tazobactam or dual therapy such as ceftriaxone and metronidazole have mostly been used before colon perforation surgery in our institute.

For the duration of antibiotics use, if postoperative vital signs are stable, and inflammation level (as determined using C-reactive protein) decreases, discontinuation of antibiotics would be considered. If bacteria are isolated from culture, bacterial detection is tested through follow-up culture every 4–5 days, and if patient vital signs are stable and bacteria are not detected, discontinuation of the use of antibiotics is considered.

Statistical analysis

Statistical analysis was performed by using the SPSS version 21.0 statistical software package (IBM Corporation, Armonk, NY, USA). Categorical variables were compared using the Pearson χ^2 test or Fisher exact test, and continuous variables were compared using the Student's *t* test, Mann-Whitney *U* test, and analysis of variance. Prognostic factors were analyzed using logistic regression. The variables associated with early complication, late complication, and mortality with a $p<0.1$ were introduced into a logistic regression to determine the independent risk factors. A $p<0.05$ was considered to indicate statistical significance.

Results

Patient characteristics and surgical procedures

The characteristics of the 152 patients who had undergone emergency surgery for colonic perforation are detailed in Table 1. There were slightly more men than women, and there were more elderly patients of >70 years of age (73 patients, 48.0 %). All patients had abdominal pain, and the mean symptom duration was 40.2±35.2 h. Elderly patients had significantly longer symptom duration than younger patients (48.4±37.1 vs. 32.6±31.7, $p=0.005$). Medical comorbidities were found in 77 patients (50.7 %), and cardiovascular disease ($n=54$, 35.5 %), especially hypertension ($n=34$, 22.4 %), was the most common. The mean C-reactive protein level and preoperative albumin level were not statistically significant. The most common cause of colonic perforation was related to procedures ($n=63$, 41.4 %) such as colonoscopy, endoscopic mucosal resection (EMR), endoscopic submucosal dissection (ESD), or colon stent insertion.

The sigmoid colon was the most common perforation site, and fecal contamination was observed in 41 (26.9 %) patients. Hartmann's procedure was most commonly performed in 52 (34.2 %) patients, and primary repair was also performed in 24 (15.8 %) patients who had a perforation <1 cm and with no fecal contamination. The mean number of drains used for surgery in all patients was 2.9, with 3.4 used by the fecal contamination group; this was significantly more than the 2.7 used by the fecal contamination group ($p=0.001$).

Table 1 Characteristics of patients with colonic perforation

	Total (N=152)
Gender	
Male	80 (52.6 %)
Female	72 (47.4 %)
Mean age (range), years	66.9±14.7 (18–96)
BMI (kg/m^2)	22.8±3.7
ASA classification	
I	68 (44.7 %)
II	45 (29.6 %)
III	39 (25.7 %)
Charlson comorbidity scores	
0, 1, and 2	71 (48.7 %)
≥3	81 (53.3 %)
Symptom duration (24 h)	78 (51.3 %)
C-reactive protein (mg/dL)	12.8±11.1
Systemic hypotension	26 (17.1 %)
Organ failure	49 (32.2 %)
MPI	24.4±7.9
Cause of colon perforation	
Procedure related	63 (41.4 %)
Colon cancer	35 (23.0 %)
Infection and inflammation	24 (15.8 %)
Ischemia	23 (15.1 %)
Trauma	7 (4.7 %)
Site of perforation	
A-colon	26 (17.1 %)
T-colon	9 (5.9 %)
D-colon	20 (13.2 %)
S-colon	87 (57.2 %)
Rectum	10 (6.6 %)
Surgical procedure	
Hartmann's operation	52 (34.2 %)
Total colectomy	25 (16.4 %)
Primary repair	24 (15.8 %)
Right hemicolectomy	19 (12.5 %)
Anterior resection	14 (9.2 %)
Colon segmental resection	8 (5.3 %)
Low anterior resection	5 (3.3 %)
Left hemicolectomy	3 (2.0 %)
Colostomy	2 (1.3 %)
Stoma creation	93 (61.2 %)
Fecal contamination	41 (26.9 %)
Operation time (min)	147.3±62.3
Blood loss (mL)	427.8±871.9
Intra-operative transfusion)	48 (31.6 %)
Perforation size (cm)	1.62±1.32
Length of stay (day)	25.9±52.5

BMI body mass index, *MPI* Mannheim peritonitis index, *ASA classification* American Society of Anesthesiologists classification

The total amount of irrigation in patients was 9.1 L, excluding 26 patients whose irrigation amounts were unknown (fecal contamination group, $n=6$; no fecal contamination group, $n=20$). The mean irrigation amounts of the fecal contamination group and no fecal contamination group were 12.5 and 7.8 L, respectively, which were statistically significant ($p<0.001$).

The mean duration of antibiotics use by patients was 13 days, in which the fecal contamination group and no fecal contamination group were administered antibiotics for 20 and 10 days, respectively. Hence, the fecal contamination group used antibiotics for a longer time, which was statistically significant ($p<0.001$).

Surgical outcomes with morbidity and mortality

Early postoperative complications occurred in 83 (54.6 %) patients, and of these complications, wound infection was the most frequent. Among these patients, 34 patients required secondary repair. Intra-abdominal abscesses were treated with percutaneous drainage and concomitant antibiotic treatment (Table 2). Of 130 patients, 44 (33.8 %) had late postoperative complications, excluding those who had died and those who were lost to follow-up, during 14.3 months (range, 1–97 months) of median follow-up period. Small bowel obstruction (SBO) was the most common late complication, and all patients' conditions improved with conservative management. Incisional hernia was the second most frequent late complication, and all patients with this complication underwent hernia repair and were followed up without recurrences. One patient who was admitted to the intensive care unit (ICU) for 6 months was diagnosed with acalculous cholecystitis when being admitted to the ICU; this patient underwent cholecystectomy without complications. One patient who underwent low anterior resection for an anastomosis stricture was treated with balloon dilatation.

Sixteen (10.6 %) of the 152 patients died, and 9 (40.9 %) patients died of septic shock, which was the most common cause of mortality. In all nine patients, the sepsis did not resolve since the preoperative periods. Of the total of 152 patients, cultures were performed for 87 patients (fecal contamination group, $n=29$; no fecal contamination group, $n=58$), 37 of whom had cultures positive for bacteria (fecal contamination group, $n=14$ [48.3 %]; no fecal contamination group, $n=23$ [39.7 %]). As stated in the results of the study, 9 of those 37 patients died from postoperative septic shock.

Patient characteristics and surgical outcomes according to fecal contamination

Patient characteristics, surgical procedures, and outcomes are described according to the presence or absence of fecal contamination (Table 3). Patients with fecal contamination had a higher preoperative organ failure rate, and a higher MPI score than those without fecal contamination. Compared to patients without fecal contamination, patients with fecal contamination had a higher rate of diverting colostomy and diverting ileostomy, had significantly larger perforation sizes and longer operating times, and had significantly more frequent early complications, although late complication and mortality rates did not differ.

Prognostic factors for the early complications, late complications, and mortality

Univariate and multivariate analyses were performed on the factors influencing early complications, late complications, and mortality (Table 4). On multivariate analysis, the following were

Table 2 Detailed description of early complication, late complication, and causes of death

Early complication (*N*=83, 54.6 %)	*n* (%)	Late complication (*N*=44, 33.8 %)	*n* (%)	Mortality (*N*=16, 10.6 %)	*n* (%)
Wound infection	46 (53.5)	Small bowel obstruction	32 (72.7)	Septic shock	9 (56.3)
Intra-abdominal Abscess	15 (17.4)	Incisional hernia	7 (15.9)	ARDS	3 (18.8)
Ileus	13 (15.1)	Enterocutaneous fistula	3 (6.8)	UGI bleeding	2 (12.5)
Pneumonia	7 (8.1)	Intra-abdominal abscess	2 (4.5)	Stress induced cardiomyopathy	1 (6.2)
Acute renal failure	5 (5.8)	Pseudomembranous colitis	1 (2.3)	Cerebral infarction	1 (6.2)
Pleural effusion	4 (4.7)	Acalculous cholecystitis	1 (2.3)		
Cerebral infarction	3 (3.5)	Anal stricture	1 (2.3)		
Stress induced cardiomyopathy	3 (3.5)	Wound infection	1 (2.3)		
Urinary retention	2 (2.3)	Retrograde ejaculation	1 (2.3)		
UGI bleeding	2 (2.3)				
Pneumothorax	2 (2.3)				
Pulmonary thromboembolism	1 (1.2)				
Deep vein thrombosis	1 (1.2)				

UGI upper gastrointestinal, *ARDS* acute respiratory distress syndrome

Table 3 Characteristics of patients depending on the presence or absence of fecal contamination

	Fecal contamination (*n*=41)	No fecal contamination (*n*=111)	*p*
Gender			0.832
Male	21 (51.2 %)	59 (53.2 %)	
Female	20 (48.8 %)	52 (46.8 %)	
Mean age (range), years	69.5±16.1 (18–92)	65.8±14.1 (37–96)	0.171
BMI (kg/m^2)	21.9±3.9	21.5±3.5	0.445
ASA classification			0.216
I	14 (34.1 %)	54 (48.6 %)	
II	13 (31.8 %)	32 (28.8 %)	
III	14 (34.1 %)	25 (25.6 %)	
Charlson comorbidity scores			0.059
0, 1, and 2	14 (34.1 %)	57 (51.4 %)	
≥3	27 (65.9 %)	54 (48.6 %)	
Symptom duration (>24 h)	23 (56.1 %)	55 (49.5 %)	0.473
C-reactive protein (mg/dL)	13.9±11.7	12.3±10.9	0.489
Preoperative albumin (g/dL)	3.25±0.50	3.39±0.73	0.252
Systemic hypotension	9 (22.0 %)	17 (15.3 %)	0.335
Organ failure	22 (53.7 %)	27 (24.3 %)	0.001
MPI	31.3±5.1	21.9±7.2	<0.001
Cause of colon perforation			0.128
Procedure related	12 (29.3 %)	51 (45.9 %)	
Colon cancer	10 (24.4 %)	25 (22.5 %)	
Infection and inflammation	6 (14.6 %)	17 (15.3 %)	
Ischemia	11 (26.8 %)	12 (10.8 %)	
Trauma	2 (4.9 %)	6 (5.4 %)	
Bowel preparation			<0.001
No	38 (92.7 %)	71 (64.0 %)	
Yes	3 (7.3 %)	40 (36.0 %)	
Site of perforation			0.604
A-colon	6 (14.6 %)	20 (18.0 %)	
T-colon	2 (4.8 %)	7 (6.3 %)	
D-colon	7 (17.1 %)	13 (11.7 %)	
S-colon	22 (53.7 %)	62 (55.9 %)	
Rectum	4 (9.8 %)	9 (8.1 %)	
Operation time (min)	168.8±49.9	144.8±66.1	0.036
Blood loss (mL)	460.0±435.2	427.8±871.9	0.764
Intra-operative transfusion (units)	1.6±2.2	1.2±3.2	0.336
Perforation size (cm)	2.1±1.3	1.5±1.3	0.020
Length of stay (day)	38.9±49.2	26.8±57.1	0.231
Stoma creation	36 (87.8 %)	57 (51.4 %)	<0.001
Early complication	34 (82.9 %)	55 (49.5 %)	0.001
Late complication (*n*=130)	11/32 (46.2 %)	33/98 (39.3 %)	0.942
30-day mortality	7 (17.1 %)	9 (8.1 %)	0.110

MPI Mannheim peritonitis index, *ASA classification* American Society of Anesthesiologists classification

independent risk factors for early complications: symptom duration over 24 h (p=0.005), preoperative renal failure (p=0.013), intra-operative transfusion (p=0.003), and intra-peritoneal fecal contamination (p=0.037). There were no prognostic factors for late complications on multivariate analysis. Risk factors of mortality included age over 70 years (p=0.039), ASA grade≥III (p=0.025), systemic hypotension (p=0.026), preoperative renal failure (p=0.044), and intra-operative transfusion (p=0.005).

Table 4 Prognostic factors for early complication, late complication, and mortality after univariate and multivariate analyses

	Early complication				Late complication		Mortality			
	Univariate analysis		Multivariate analysis		Univariate analysis		Univariate analysis		Multivariate analysis	
	Patients with early complication *n* (%)	*p*	Adjusted OR (95 % CI)	*p*	Patients with late complication *n* (%)	*p*	Patients with mortality *n* (%)	*p*	Adjusted OR (95 % CI)	*p*
Sex		0.123				0.123		0.058		
Male	51/80 (63.8)				20/64 (31.3)		12/80 (15.0)			
Female	37/72 (51.4)				24/66 (36.4)		4/72 (5.6)			
Age		0.059				0.371		0.001	1	0.039
<70 years	40/79 (50.6)				23/75 (30.7)		2/79 (2.5)		6.32 (1.10–36.33)	
≥70 years	48/73 (57.9)				21/55 (38.2)		14/73 (19.2)			
ASA		0.041				0.830		<0.001	1	0.025
I and II	60/113 (53.1)				35/102 (34.3)		6/113 (5.3)		4.76 (1.22–18.59)	
III	28/39 (71.8)				9/28 (32.1)		10/39 (25.6)			
Charlson comorbidity score		0.093				0.321		0.004		
0, 1, and 2	36/71 (50.7)				20/67 (29.9)		2/71 (2.8)			
≥3	52/81 (64.2)				24/63 (38.1)		14/81 (17.3)			
BMI		0.130				0.252		0.669		
<25	78/129 (60.5)				35/110 (31.8)		13/129 (10.1)			
≥25	10/23 (43.5)				9/20 (45.0)		3/23 (13.0)			
Symptom duration		<0.001		0.005		0.170		0.011		
<24 h	32/74 (43.2)		1		20/70 (28.6)		3/74 (4.1)			
≥24 h	56/78 (71.8)		2.91 (1.37-6.18)		24/60 (40.0)		13/78 (13.1)			
Systemic hypotension		0.200				0.306		0.003	1	0.026
No	70/126 (55.6)				36/112 (32.1)		9/126 (7.1)		4.77 (1.20–18.89)	
Yes	18/26 (69.2)				8/18 (44.4)		7/26 (26.9)			
Malignancy		0.152				0.091		0.771		
No	49/92 (53.3)				23/81 (28.4)		9/92 (9.84)			
Yes	39/60 (65.0)				21/49 (42.9)		7/60 (11.7)			
Ischemic cause		0.092				0.659		0.001		
No	71/129 (55.0)				40/116 (34.5)		7/120 (5.8)			
Yes	17/23 (73.9)				4/14 (28.6)		9/32 (28.1)			
Renal failure		<0.001		0.013		0.475		<0.001	1	0.044
No	60/120 (50.0)		1		38/108 (35.2)		38/108 (35.2)		3.87 (1.04–14.46)	
Yes	28/32 (87.5)		4.47 (1.37–14.57)		6/22 (27.3)		6/22 (27.3)			
Respiratory failure		0.046				0.969		0.257		
No	75/136 (55.1)				40/118 (33.9)		13/136 (9.6)			
Yes	13/16 (81.3)				4/12 (33.3)		3/16 (18.8)			
MPI		<0.001				0.517		0.002		

Table 4 (continued)

	Early complication				Late complication		Mortality			
	Univariate analysis		Multivariate analysis		Univariate analysis		Univariate analysis		Multivariate analysis	
	Patients with early complication *n* (%)	*p*	Adjusted OR (95 % CI)	*p*	Patients with late complication *n* (%)	*p*	Patients with mortality *n* (%)	*p*	Adjusted OR (95 % CI)	*p*
<26	36/83 (43.4)				24/76 (31.6)		3/83 (3.6)			
≥26	52/69 (75.4)				20/54 (37.0)		13/69 (18.8)			
Intra-operative transfusion		<0.001		0.003		0.439		<0.001		0.005
No	48/104 (46.1)		1		31/97 (32.0)		3/104 (2.9)		1	
Yes	40/48 (83.3)		3.97 (1.58–9.98)		13/33 (39.4)		13/48 (27.1)		8.97 (1.96–41.01)	
Fecal contamination		0.001		0.037		0.942		0.110		
No	55/111 (49.5)		1		33/98 (33.7)		9/111 (17.1)			
Yes	33/41 (80.5)		2.78 (1.06–7.23)		11/32 (34.4)		7/41 (8.1)			

BMI body mass index, *OR* odds ratio, *CI* confidence interval, *ASA* American Society of Anesthesiologists classification, *MPI* Mannheim peritonitis index

Discussion

This study aimed to investigate early complications, late complications, and mortality after surgical treatment for colonic perforation and analyzed effects of fecal contamination on surgical outcomes, as well as other prognostic factors for those surgical outcomes. Our results found that the rates of early and late complications were 54.6 and 33.8 %, respectively, and the mortality rate was 10.6 %. The present study showed that symptom duration over 24 h, preoperative renal failure, intra-operative transfusion, and fecal contamination are associated with early complications. There were no significant prognostic factors for late complication. Older age (>70 years), high ASA grade (≥III), systemic hypotension, preoperative presence of renal failure, and the requirement for intra-operative transfusion significantly increased mortality rates. When fecal contamination was present, the early complication rate increased but there were no differences in the rates of late complication and mortality.

The prognostic impact of fecal contamination has been unclear, and few studies have evaluated the surgical outcomes of fecal peritonitis. In this study, the early complication rate in the presence of fecal peritonitis was significantly high, but it had no impact on late complications or mortality rates. These results indicate that fecal contamination may not significantly influence morbidity or mortality in cases of colonic perforation. Intra-peritoneal massive irrigation is frequently performed in cases of fecal contamination and has been considered most important to reduce morbidity and mortality rates after surgery. Several recent studies have reported that laparoscopic lavage is feasible for perforated diverticulitis with purulent peritonitis (Hinchey grade III) and is associated with a low mortality rate or a low recurrence risk [17, 18]. In addition, laparoscopic lavage was safely performed for fecal peritonitis (Hinchey grade IV) in some studies [19, 20]. However, another study showed that laparoscopic lavage for patients with fecal peritonitis failed and required a subsequent Hartmann's procedure [21]. Intra-peritoneal massive irrigation played an important role in patients with fecal contamination associated with dilute bacterial mass [22]. One experimental study reported that microbial adherence to the serosal mesothelial surface was a virulence factor in a rat model of fecal peritonitis, and this contamination cannot be treated by lavage [23]. Despite intra-operative lavage, aerobic/anaerobic microbes could not be removed completely, as the feces would still adhere and cause postoperative morbidity or mortality. In addition, intra-peritoneal lavage with an insufficient volume of saline did not completely remove the residual microbes, thus promoting the progression of peritonitis [24]. Thus, for patients with fecal contamination, it is necessary to perform intra-peritoneal lavage with sufficient volume of saline for fecal contamination, as well as provide postoperative supportive care with broad-spectrum antibiotics [25].

Colonic perforation can result in a life-threatening peritonitis with serious complications such as septic shock or multi-organ failure. Despite improvements in the management of septic condition with supportive care, including antibiotics, immediate surgery is still critical to achieve better outcomes. However, even after undergoing surgery, patients with colorectal perforation may encounter high rates of morbidity and mortality [1, 26]. In this study, the morbidity and mortality rates were similar to those in other reports [2, 12], and patients with colonic perforation still presented with poor surgical outcomes. These morbidity and mortality rates were also remarkably higher than those after elective colorectal surgery [27]. One of the reasons why morbidity and mortality rates increase when patients are operated for colon perforation is severe co-morbidities, such as cardiovascular disease, cerebrovascular incidents, and diabetes mellitus. In this study, 50.7 % of enrolled patients had co-morbidities. Particularly, 17 patients died out of the 23 patients with ischemic colitis, thus a mortality rate of 73.9 %. Ischemic colitis is frequently presented with several co-morbidities. A high ASA grade (≥III) is a significant factor for mortality. The presence of a high ASA grade and ischemic colitis seem to be correlated. In our previous study, we reported that preoperative systemic hypotension is the most important risk factor for mortality in patients who had undergone an operation for ischemic colitis [28]. Preoperative systemic hypotension occurred in 26 (17.1 %) patients in this study, and 9 patients (40.9 %) out of 22 patients did not recover from the sepsis and died. On multivariate analysis, we found that preoperative systemic hypotension was also an important risk factor for mortality. In fact, some reports have shown that early quantitative resuscitation improves survival in septic shock patients with systemic hypotension [29, 30]. The early identification of systemic hypotension and sepsis was important for patients with colon perforation, and rapid surgical treatment is required for patients with systemic hypotension due to the septic condition.

Our multivariate analysis indicated that renal failure and intra-operative transfusion influenced early complications and mortality rates. Sepsis and septic shock have been reported as important leading causes of acute kidney injury in critically ill patients [31], reflecting progression sepsis and poor general condition. Intra-operative transfusion is commonly associated with increased postoperative morbidity and mortality rates [32, 33], although the mechanisms underlying the association of intra-operative transfusion with poor surgical outcomes are unclear. One possible cause is transfusion-related immunomodulation that stimulates immunity, causing alloimmunization of the host [34]. In addition, during preoperative examinations, the presence of anemia or blood loss that requires transfusion could be a risk factor [35]. Symptom duration was also a significant factor for early complications in our study, and some studies have reported that symptom duration was a strong prognostic factor, since treatment delay was caused by late hospitalization in elderly patients [36], which may have been owing to their low sensitivity to the panperitonitis symptoms. Further, if patients had a longer duration of symptoms, they had a higher risk for sepsis and fecal peritonitis. In the present study, age was a significant prognostic factor for mortality, and elderly patients had a higher mortality rate. Some studies have suggested that elderly patients have a higher mortality rate than younger patients, which is consistent with our findings [37, 38]. MPI score has been reported as a prognostic factor for morbidity and mortality [39], although our results on this were contradictory. Some studies have also reported that the MPI score was clinically convenient for calculation but that the items were too simple to comprehensively assess individual patient conditions [40]. More comprehensive systems, such as the Acute Physiology and Chronic Health Evaluation II (APACHE II) or Simplified Acute Physiology Score (SAPS II), may provide comprehensive data, as such scoring systems provide >10 types of laboratory data [40]. In this study, scoring systems other than MPI were not used because this was a retrospective study. There has been no consensus on the ideal and generally accepted scoring system, and the new scoring system that can be used for colon perforation needs to be developed in further large-scale studies.

This study had some limitations owing to its retrospective design. The causes of colonic perforation were heterogeneous, and the surgical procedures performed varied. However, this study was unique in that surgical outcomes for colonic perforation were evaluated according to fecal contamination, and the results represent the surgeons' efforts to improve the outcomes. Further prospective randomized study is necessary for the proper management of fecal contamination to achieve better outcomes after surgery for colonic perforation. Although the presence, location, and extent of intra-abdominal adhesions may have contributed to fluid location and postoperative sepsis, the presence or absence of intra-abdominal adhesions was not clearly investigated, which is a limitation of this study. However, when there was an adhesion due to surgical history or intra-abdominal adhesion during surgery due to formation of an intra-abdominal abscess cavity, adhesiolysis was performed for all of small bowel from the Treiz ligament to the ileocecal valve. This will be reflected in the follow-up study.

In conclusion, the early complication, late complication, and mortality rates were high in patients who underwent surgical treatment for colonic perforation. The frequency of early complication may increase in the presence of fecal contamination caused by colonic perforation. However, when early complications are well managed, the contamination does not have a significant impact on late complication or mortality rates. Therefore, in the presence of fecal contamination, proper management of early complications by using active postoperative treatments can help improve long-term surgical outcomes.

Conflict of interest The authors declare that they have no conflicts of interest related to the publication of this article.

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