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Do the Severity of Peritonitis and Stoma Creation Influence the Occurrence of Incisional Surgical Site Infections in Patients With Colorectal Perforation?

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Objective: To identify the risk factors for incisional surgical site infection (SSI) in patients undergoing emergency surgery for colorectal perforation.

Summary of Background Data: Emergency surgery for colorectal perforation carries an especially high risk of incisional SSI. Although the risk factors of incisional SSI after colorectal surgery have been analyzed, no study has focused exclusively on patients with colorectal perforation.

Methods: Patients with colorectal perforation who underwent emergent surgery from 2010 to 2015 were enrolled. The factors associated with the occurrence of postoperative incisional SSI were evaluated.

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Results: We enrolled 108 patients with colorectal perforation who underwent an emergency operation. Of these, 13 patients who died within 30 days after surgery were excluded. The mean age of the 95 study patients was 70 ± 13 years; 48 (51%) patients were male. The incisional SSI group comprised 26 patients (27%). Multivariate logistic regression analysis showed that stoma creation [odds ratio: 11.34; 95% confidence interval: 2.06–214.14] was an independent risk factor for incisional SSI. However, none of the clinical indicators of severe peritonitis and sepsis, including body temperature, systolic blood pressure, heart rate, preoperative white blood cell count, and C-reactive protein, were associated with the occurrence of incisional SSI.

Conclusions: Stoma creation was an independent risk factor for postoperative incisional SSI. Therefore, in this patient population, meticulous postoperative wound management is essential.

Key words: Peritonitis – Risk factors – Surgical site infection – Wound infection

The rate of surgical site infection (SSI) is higher in colorectal surgery than in gastrointestinal surgery. It was reported to be 9%–41%.[1–5] Moreover, SSI causes longer hospital stay and higher inpatient costs.[6–9] Thus, determining the risk factors for SSI could improve intraoperative and postoperative wound management in patients at risk.

The guidelines of the Centers for Disease Control and Prevention (CDC) divide SSI into 3 types: incisional, deep, and organ/space infections.[10] In the setting of colorectal surgery, the risk factors for the 3 types differ.[11] Although the rate of incisional SSI is higher in emergency than in elective colorectal surgery,[12] no study has focused exclusively on patients who underwent emergency surgery for colorectal perforation. Colorectal perforation causes the widespread dissemination of bacteria throughout the intraabdominal space. Surgical treatment of colorectal perforation can expose the ascites to fecal contamination, which in turn contaminates the incision. Similarly, in patients who underwent stoma creation, the wound is adjacent to the infective origin and is vulnerable to infection postoperatively. Thus, patients with colorectal perforation are at extremely high risk of incisional SSI. In this study, we sought to identify the risk factors for incisional SSI in patients undergoing emergency surgery for colorectal perforation.

Materials and Methods

Patients

Patients with colorectal perforation who underwent emergency surgery at our single center from 2010 to 2015 were enrolled consecutively in this study. Patients with a perforated appendicitis were excluded, as were patients who died following surgery. The primary outcome was the occurrence of a postoperative incisional SSI.

The study patients were divided into SSI and non-SSI groups. The following patient characteristics were considered as potential risk factors and compared between the 2 groups: age, sex, body mass index (BMI), comorbidities, preoperative data [heart rate, body temperature, systolic blood pressure, white blood cell (WBC) count, C-reactive protein (CRP), and serum creatinine and albumin], etiology of the perforation, the perforation site, stoma creation, operation time (minutes), and amount of intraoperative blood loss (mL).

The study protocol was approved by the Institutional Review Board of Kobe City Medical Center General Hospital. Informed consent was waived because this study was conducted retrospectively.

Diagnosis

Colorectal perforation was diagnosed according to the following criteria: (a) the presence of symptoms that indicate peritonitis, such as severe abdominal pain; (b) the presence of peritoneal irritation signs, such as rebound tenderness and abdominal guarding; and (c) the presence of free air on preoperative computed tomography. All perforations were diagnosed by 2 or more surgeons and radiologists in our institution preoperatively and confirmed intraoperatively.

The incisional wound was examined by a doctor and a nurse once a day and by the members of SSI surveillance team of our center once a week until the patient was discharged from the hospital. After

discharge, the wound was examined once a week until 30 days after surgery. SSI was diagnosed based on the definition included in the guidelines of the CDC.[13]

Statistical analyses

Continuous variables are presented as the mean ± standard deviation or median (interquartile range), and categoric variables as number and percentage. The association between SSI and clinical characteristics was assessed using the χ^2 and Mann–Whitney U tests. Variables with significant associations with SSI in the univariate analyses were included in the multivariate logistic regression model. To ensure robustness, we added variables that were clinical indicators of severe peritonitis and sepsis: body temperature, systolic blood pressure, heart rate, WBC count, and CRP. In the multivariate analysis, all continuous variables were clinically dichotomized: preoperative WBC count (≤4,000, >12,000, or 4,000 to ≤12,000/μL) and preoperative body temperature (≤6°C, >38°C, or 36°C to ≤38°C) in accordance with the criteria for systemic inflammatory response syndrome;[14] preoperative serum creatinine level (≥1.5 or <1.5 mg/dL), and preoperative heart rate (≤69, ≥110, or 70 to <109 beats/min) in accordance with the Acute Physiology and Chronic Health Evaluation II (APACHE II) scoring system;[15] and preoperative systolic blood pressure (≤89 mmHg or >90 mmHg) in accordance with the Physiologic and Operative Severity Score for the enUumeration of Mortality (POSSUM).[16] The effect of the associations was expressed as the odds ratio (OR) and 95% confidence interval (CI). All statistical analyses were conducted by one of the physicians participating in the study (TY), under the supervision of the chief statistician of our institution (TM), using JMP, version 10 (SAS Institute Inc., Cary, NC, USA). All reported *P* values are 2-sided. A *P* value <0.05 was considered to indicate statistical significance.

Results

Patient selection

The 108 consecutive patients enrolled in this retrospective study underwent emergency operation for colorectal perforation during the study period. After the exclusion of 13 patients because they died within 30 days after surgery (none had incisional SSI at the time of death), 95 patients were analyzed.

Table 1 Clinical characteristics of the study patients (n = 95)[a]

Variable	Value
Age, years	70 ± 13
Males	48 (50.5)
BMI, kg/m^2	21.8 ± 4.7
Chemotherapy	6 (6.3)
Steroid use	20 (21.1)
Diabetes mellitus	5 (5.3)
Body temperature >38.0°C or <36.0°C	30 (31.6)
Systolic blood pressure, mmHg	128 ± 29
Heart rate, beats/min	96 ± 19
WBC count >12,000 or <4,000 per μL	50 (52.6)
CRP, mg/dL	12.4 ± 11.0
Alb, mg/dL	2.9 ± 0.8
Cr, mg/dL	1.1 ± 1.2

[a]Data presented as mean ± standard deviation, or n (%).

Alb, albumin; BMI, body mass index; Cr, creatinine; CRP, C-reactive protein; WBC, white blood cell.

Patient characteristics

The characteristics of the 95 patients are presented in Tables 1 and 2. The mean age at surgery was 70 ± 13 years; 48 (51%) patients were male. Iatrogenic perforations included those resulting from colonoscopy and radiographic contrast enema. Inflammatory diseases included cytomegalovirus-induced colitis, ulcerative colitis, radiation therapy-induced colitis, and Behçet's disease. Stoma creation was performed in 72 patients. Among them, colostomy

Table 2 Operative factors of the study patients (n = 95)[a]

Variable	Value
Cause of perforation	
Diverticulum	37 (38.9)
Cancer	15 (15.8)
Fecal impaction	13 (13.7)
Iatrogenic	11 (11.6)
Inflammatory disease	4 (4.2)
Trauma	2 (2.1)
Rectal prolapse	1 (1.1)
Idiopathic	12 (12.6)
Perforation site	
Cecum	7 (7.4)
Ascending colon	3 (3.1)
Transverse colon	7 (7.4)
Descending colon	3 (3.2)
Sigmoid colon	62 (65.3)
Rectum	13 (13.7)
Stoma creation	72 (75.8)
Colostomy	65
Ileostomy	7
Duration of surgery, min	177 ± 55
Blood loss, mL	200 [75–400]

[a]Data presented as mean ± standard deviation, median [interquartile range], or n (%).

Table 3 Comparison of the clinical characteristics of the patients with and without incisional SSI[a]

Variable	SSI (n = 26)	No SSI (n = 69)	*P* value
Age (years)	71 ± 12	70 ± 14	0.72
Males	14 (53.8)	34 (49.3)	0.69
Body mass index (kg/m^2)	22.3 ± 4.0	21.6 ± 4.9	0.46
Chemotherapy	3 (11.5)	3 (4.3)	0.20
Steroid use	7 (31.3)	13 (18.8)	0.39
Diabetes mellitus	2 (7.7)	3 (4.3)	0.55
Body temperature >38.0°C or <36.0°C	8 (30.8)	22 (31.9)	0.91
Systolic blood pressure (mmHg)	124 ± 33	130 ± 27	0.43
Heart rate (beats/min)	101 ± 19	94 ± 19	0.07
WBC count >12,000/μL or <4,000/μL	13 (50.0)	37 (53.6)	0.75
CRP (mg/dL)	15.2 ± 12.7	11.3 ± 10.1	0.19
Alb (mg/dL)	2.7 ± 0.6	2.9 ± 0.8	0.12
Cr (mg/dL)	1.2 ± 0.8	1.1 ± 1.3	0.03*

*$P < 0.05$.

[a]Data presented as mean ± standard deviation, or n (%).

Alb, albumin; BMI, body mass index; Cr, creatinine; CRP, C-reactive protein; SSI, surgical-site infection; WBC, white blood cell.

Table 4 Comparison of the operative characteristics of the patients with and without incisional SSI[a]

Variable	SSI (n = 26)	No SSI (n = 69)	*P* value
Cause of perforation			0.30
Diverticulum	7 (26.9)	30 (43.5)	
Cancer	5 (46.2)	10 (14.5)	
Fecal impaction	3 (11.5)	10 (14.5)	
Iatrogenic	3 (11.5)	8 (11.6)	
Inflammatory disease	0	4 (5.8)	
Trauma	1 (3.8)	1 (1.4)	
Rectal prolapse	0	1 (1.4)	
Idiopathic	7 (26.9)	5 (7.2)	
Perforation site			0.14
Cecum	0	7 (10.1)	
Ascending colon	0	3 (4.3)	
Transverse colon	4 (15.4)	3 (4.3)	
Descending colon	0	3 (4.3)	
Sigmoid colon	17 (65.4)	45 (65.2)	
Rectum	5 (19.2)	8 (11.6)	
Stoma creation	25 (96.2)	47 (68.1)	0.004*
Duration of surgery (min)	188 ± 63	174 ± 52	0.22
Blood loss (mL)	300 [99–506]	176 [29–359]	0.06

[a]Data presented as mean ± standard deviation, median [interquartile range], or n (%).

was performed in 65 patients, and ileostomy was performed in 7 patients.

Risk factors for incisional SSI

Incisional SSI occurred in 26 patients (27%). The postoperative hospital stay was significantly longer in this group than in the SSI-negative group (37 versus 15 days, respectively; $P < 0.001$). The characteristics of the 2 groups are compared in Tables 3 and 4. Higher preoperative serum creatinine levels ($P = 0.03$) and stoma creation ($P = 0.004$) were significantly associated with the development of an incisional SSI. After adjusting for potential risk factors for SSI (body temperature, systolic blood pressure, heart rate, preoperative WBC count, CRP, serum creatinine level, and stoma creation), stoma creation (OR: 11.34; 95% CI: 2.06–214.14) was identified an independent risk factor for incisional SSI in patients with colorectal perforation (Table 5). None of the preoperative clinical indicators of severe peritonitis and sepsis (body temperature, systolic blood pressure, heart rate, preoperative WBC count, and CRP) were associated with the occurrence of incisional SSI.

Discussion

The present study determined that stoma creation is an independent risk factor for the development of incisional SSI after surgery for colorectal perforation. Previous studies identified body mass index, steroid use, preoperative radiation, stoma creation, and intraoperative hypotension as risk factors for incisional SSI after colorectal surgery.[1,2,5] Konishi *et al* identified stoma creation as a risk factor for incisional SSI in patients who underwent rectal surgery in their retrospective analysis of 217 patients;[1] their results are consistent with our own. However, the aforementioned studies included only elective colorectal surgeries, whereas few studies

Table 5 Multiple logistic regression analysis of the risk factors of incisional SSI after surgery for colorectal perforation

Variable	Odds ratio	95 % CI	*P* value
Body temperature >38.0°C or <36.0°C	1.30	0.439–4.124	0.64
Systolic blood pressure ≤89 mmHg	2.20	0.372–12.964	0.38
Heart rate ≤69 beats/min, or ≥110 beats/min	1.91	0.619–5.830	0.26
WBC count >12,000 or <4,000/μL	1.63	0.601–4.578	0.34
CRP >10 mg/dL	1.67	0.575–4.996	0.35
Cr ≥1.5 mg/dL	1.32	0.343–5.816	0.70
Stoma creation	11.34	2.056–214.142	0.003*

*$P < 0.05$.

CI, confidence interval; Cr, serum creatinine; CRP, C-reactive protein; SSI, surgical site infection; WBC, white blood cell.

have investigated the risk factors associated with emergency colorectal surgery. In their analysis of 78 patients who underwent emergency colorectal surgery, Watanabe *et al* reported that obesity and surgical incision classes III–IV (class I, clean surgical wound; class II, clean-contaminated wound; class III, contaminated wound; and class IV, contaminated-infected surgical wound)[13] were associated with an increased rate of incisional SSI.[3] That study included patients with many types of colorectal diseases, while we focused on the risk of incisional SSI in emergency surgery for colorectal perforation.

Stoma creation is a frequent component of surgery performed for colorectal perforation; indeed, 76% of our patients required a stoma. The incision site for a stoma is near the infective origin, which can lead to fecal contamination of the wound. In this study, the multivariate analysis included the preoperative indicators of severe peritonitis (body temperature, blood pressure, heart rate, WBC, and CRP), as they can increase the risk of intraoperative wound contamination caused by a contaminated ascites. Nonetheless, only stoma creation was significantly associated with incisional SSI. Though this result could mean just the association between stoma creation and occurrence of incisional SSI, we considered that it suggested that the main cause of incisional SSI in patients with stoma was not intraoperative wound contamination by a contaminated ascites, but postoperative fecal contamination from the stoma before incisional wound healing.

In a previous report, we demonstrated the effectiveness of a preventive incisional SSI bundle in the prevention of incisional SSI in patients with colorectal perforation undergoing stoma creation.[17] In the present study, cyanoacrylate tissue adhesive (Dermabond; Ethicon, Inc., Somerville, NJ, USA) was used as a wound dressing during stoma creation because it provides an effective barrier against microorganism penetration. Although this approach has not been rigorously analyzed in clinical studies, its *in vitro* effectiveness was reported by Bhenede *et al*.[18] Our results emphasize the importance of meticulous postoperative wound management to prevent incisional SSI due to fecal contamination of the wound from a stoma in a patient with colorectal perforation.

Our study had several limitations. First, the study was conducted at a single center and was based on a small number of patients. A large-scale multicenter study is needed to confirm our findings. Second, stratifying the study patients based on a risk score system, such as the APACHE II score, the Mannheim peritonitis index, or the POSSUM score, would have better supported our conclusion that the severity of peritonitis and intraoperative wound contamination caused by contaminated ascites is not associated with an incisional SSI. However, we were unable to retrospectively obtain data on several parameters needed to use these risk scores, such as the respiratory rate, respiratory history, and the preoperative duration of peritonitis (which is difficult to determine in patients with impaired consciousness). Finally, operative and postoperative management was performed by different clinicians, resulting in an inconsistent quality of care.

Conclusion

Stoma creation was an independent risk factor for postoperative incisional SSI. Therefore, in this patient population, meticulous postoperative wound management is essential.

Acknowledgments

The authors declare that they have no competing interests.

TY designed the study, acquired the data, analyzed and interpreted the data, and drafted and revised the manuscript. TM offered statistical advice. HK helped to acquire the data. JK revised the result section and helped to conduct statistical analysis. MK, HH, and SK revised the materials and methods and the discussion section. All authors read and approved the final manuscript.

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