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ORIGINAL ARTICLE

Risk Factors for Surgical Site Infections After Elective Gastrectomy

Kazuhiro Migita · Tomoyoshi Takayama · Sohei Matsumoto · Kohei Wakatsuki · Koji Enomoto · Tetsuya Tanaka · Masahiro Ito · Yoshiyuki Nakajima

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Abstract
Objective The aim of this study was to identify the risk factors for surgical site infections (SSIs) after elective gastrectomy.
Methods This study reviewed the medical records of 842 patients who underwent elective gastrectomy. Multivariate analyses were performed to determine the risk factors for SSIs.
Results Superficial incisional, deep incisional, and organ/space SSIs were detected in 50 (5.9%) patients, 2 (0.2%) patients, and 90 (10.7%) patients, respectively. A multivariate analysis demonstrated that female gender (p=0.0332) and allogenic blood transfusion (p=0.0266) were independent predictors for superficial incisional SSIs, while a male gender (p=0.0355), corticosteroid therapy (p=0.037), total gastrectomy (p<0.0001), and a duration of operation ≥300 min (p=0.0062) were independent predictors for organ/space SSIs. The median length of postoperative hospital stay was significantly longer in patients with organ/space SSIs in comparison to those without SSIs (p<0.0001) and with superficial incisional SSIs (p<0.0001). The patients with organ/space SSIs had a significantly higher re-operation rate in comparison to those without SSIs (p<0.0001).
Conclusions The risk factors both for incisional SSIs and for organ/space SSIs are strongly associated with surgical results. Meticulous surgical techniques are therefore required to prevent SSIs.

Keywords Surgical site infection · Gastrectomy · Short-term outcome

Introduction

Gastrectomy is one of the most common surgical procedures in gastrointestinal surgery in Japan. Although advances in surgical techniques and devices and improvements in perioperative management have resulted in reduced mortality after gastrectomy, postoperative morbidity remains a clinically significant problem.[1]

Surgical site infections (SSIs) are the leading cause of nosocomial infectious complications among surgical patients, accounting for 38% of all such infections.[2] SSIs are also responsible for the prolonged duration of hospital stays, increased hospital costs, and decreased patient's quality of life.[2–4] Furthermore, they remain a substantial cause of mortality. It is therefore important to clarify the risk factors to reduce SSIs. Although these issues have been well studied in various types of gastrointestinal surgery, particularly colorectal surgery,[3, 5–8] there is so far little information available on the risk factors for SSIs after gastrectomy. This study, therefore, investigated the incidence and the characteristics of SSIs after elective gastrectomy. This investigation also attempted to identify the risk factors for SSIs in this group.

K. Migita (✉) · T. Takayama · S. Matsumoto · K. Wakatsuki · K. Enomoto · T. Tanaka · M. Ito · Y. Nakajima
Department of Surgery, Nara Medical University,
840 Shijo-Cho,
Kashihara, Nara 634-8522, Japan
e-mail: kmigita@naramed-u.ac.jp

Patients and Methods

A total of 868 patients underwent elective gastrectomy at Nara Medical University from January 2001 to December 2010. Twenty-five patients who underwent an additional

surgical procedure for another disease at the time of gastrectomy were excluded; these included colorectal cancer in seven patients, esophageal carcinoma and hepatocellular carcinoma in four each, ovarian tumors in three, pancreatic cancer, renal cell carcinoma, and abdominal aortic aneurysm in two each, and intraductal papillary mucinous neoplasm of the pancreas in one. One patient whose intraoperative data were not available was also excluded. Therefore, 842 patients remained and were analyzed in this study. All patients were followed up for at least 30 days after gastrectomy in order to monitor for the incidence of SSIs.

Data

The perioperative patient characteristics and surgical variables demonstrated to be risk factors for SSIs in previous studies were obtained retrospectively from the medical records and evaluated as risk factors for the incidence of SSIs. The patient characteristics included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score (<3 versus ≥3), presence of cardiovascular disease, diabetes mellitus, renal failure, corticosteroid therapy in the past 30 days for a chronic condition, serum albumin (≥3.5 versus <3.5 g/dl), diagnosis (cancer versus others), and preoperative chemotherapy within 30 days prior to gastrectomy.

The surgical variables included the type of procedure (partial versus total gastrectomy) and approach (open versus laparoscopic), the duration of the operation, blood loss, perioperative allogenic blood transfusion, the type and duration of prophylactic antibiotics administered, type of cutaneous closure (suture with non-absorbable materials versus external metal staples versus buried suture with absorbable materials), intra-abdominal suture material (non-absorbable versus absorbable), extent of lymph node dissection (D0, D1 versus D2 or more), and combined organ resection. Partial gastrectomy included distal and pylorus-preserving gastrectomy, and local resection. Total gastrectomy included total gastrectomy and total resection of the gastric remnant. The extent of lymph node dissection was defined according to the Japanese Classification of Gastric Carcinoma.[9] Intravenous prophylactic antibiotics were given to all patients. The initial dose was administered 30 min before the skin incision. During surgery, an additional dose was administered every 3 h. The type and duration of prophylactic antibiotics administered were not standardized during this study period. SSI was defined based on Centers for Disease Control and Prevention (CDC) criteria,[2] and the definition included superficial incisional, deep incisional, and organ/space SSIs. Data regarding the bacterial cultures were also obtained.

The outcome parameters were also considered in this study, including the length of postoperative hospital stay, re-operation under general anesthesia, and 30-day mortality. The patients who had both incisional SSIs and organ/space SSIs were included in the group of organ/space SSIs.

Statistical Analysis

All patients were divided into two groups according to whether they had postoperative SSIs. The categorical variables were presented as numbers and percentages, and the groups were compared using the chi-square test or Fisher's exact test. Continuous variables were expressed as the median with range, and groups were compared using the Mann–Whitney U test. Moreover, some continuous variables were converted to dichotomous variables for convenience, including the duration of operation (<300 versus ≥300 min) and blood loss (<300 versus ≥300 g). All variables with a p value <0.2 in the univariate analysis were entered into a multivariate analysis. The multivariate analysis was performed using a logistic regression model to investigate the factors associated with the incidence of SSIs. A p value <0.05 was considered to be statistically significant.

Results

Incidence and Characteristics of SSIs

One hundred thirteen of the 842 patients included in this study (15.8%) had SSIs; 50 (5.9%) were classified as superficial incisional SSIs, 2 (0.2%) as deep incisional SSIs, and 90 (10.7%) as organ/space SSIs. Nine patients had both superficial incisional SSIs and organ/space SSIs. The study investigated the risk factors for superficial incisional SSIs and for organ/space SSIs. It was not possible to evaluate the risk factors for deep incisional SSIs because there were only a few patients with these infections. The superficial incisional SSIs were diagnosed at a median of 8 days after gastrectomy (range, 3–23 days). The organ/space SSIs were diagnosed at a median of 8 days after gastrectomy (range, 3–25 days). Forty eight of the 90 organ/space SSIs (53.3%) were intra-abdominal abscesses due to pancreatic fistula, 28 (31.1%) were abscesses resulting from anastomotic leakage, and 3 (3.3%) resulted from bile leakage. The cause of organ/space SSIs was unknown in 11 patients (12.2%).

Pus from the infection site was obtained from 14 of 50 patients with superficial incisional SSIs. Sixteen isolates were recovered from 13 surgical sites. These included methicillin-resistant *Staphylococcus aureus* (n=4), *Pseudomonas aeruginosa* (n=4), *Enterobacter cloacae* (n=4), *Enterococcus faecalis* (n=1), *Morganella morganii* (n=1), *Escherichia coli* (n=1), and *Proteus vulgaris* (n=1). Pus from the infection site was also obtained from 71 of 90 patients with organ/space SSIs. A total of 73 species of microbes were isolated from 59

sites. These included *P. aeruginosa* (*n*=11), *E. cloacae* (*n*=10), methicillin-resistant *S. aureus* (*n*=9), *E. coli* (*n*=7), α-*Streptococcus* (*n*=4), *Klebsiella oxytoca* (*n*=4), *Candida albicans* (*n*=4), methicillin-sensitive *S. aureus* (*n*=3), *Klebsiella pneumoniae* (*n*=3), *Prevotella buccae* (*n*=3), *Streptococcus* spp. (*n*=2), *E. faecalis* (*n*=2), *Prevotella melaninogenica* (*n*=2), *Bacteroides* spp. (*n*=2), *Enterobacter aerogenes* (*n*=1), *Aeromonas hydrophila* (*n*=1), *Fusobacterium nucleatum* (*n*=1), *M. morganii* (*n*=1), *Proteus penneri* (*n*=1), *Prevotella loescheii* (*n*=1), and *Stenotrophomonas maltophilia* (*n*=1).

Risk Factors for Superficial Incisional SSIs

Table 1 shows the patient characteristics and the incidence of superficial incisional SSIs. No parameter was significantly associated with the incidence of superficial incisional SSIs. The relationship between surgical variables and the incidence of superficial incisional SSIs is summarized in Table 2. The rate of superficial incisional SSIs was significantly higher in patients who received allogenic perioperative blood transfusion than in those who did not (10.7%, 4.5%, respectively, p=0.0024). There were no significant differences between the groups in terms of the type of procedure and approach, the duration of the operation, blood loss, the type and duration of prophylactic antibiotics administered, type of cutaneous closure, extent of lymph node dissection, and combined organ resection.

Table 3 shows the results of the multivariate analysis for the risk factors of superficial incisional SSIs. Female gender (p=0.0332) and allogenic blood transfusion (p=0.0266) were found to be significantly associated with an increased risk for superficial incisional SSIs.

Risk Factors for Organ/Space SSIs

Table 4 shows the patient characteristics and the incidence of organ/space SSIs. The group that experienced organ/space SSIs was more likely to be male (p=0.0163). The surgical variables and the incidence of organ/space SSIs are compared in Table 5. Total gastrectomy (p<0.0001), open gastrectomy (p<0.0001), allogenic blood transfusion (p<0.0001), lymph node dissection of D2 or more (p=0.0001), and combined organ resection (p<0.0001) were significantly associated with the incidence of organ/space SSIs. Furthermore, the patients with organ/space SSIs had a longer duration of operation (p<0.0001) and more blood loss (p<0.0001) than those without them.

Table 6 shows the results of the multivariate analysis for the risk factors of organ/space SSIs. Male gender (p=0.0355), corticosteroid therapy (p=0.037), total gastrectomy (p<0.0001), and duration of operation ≥300 min (p=0.0062) were identified as independent factors predicting the incidence of organ/space SSIs.

As pancreatic fistulae and anastomotic leakage were the major causes of organ/space SSIs, we analyzed the risk factors for these complications. Total gastrectomy (p=0.0001), a duration of operation ≥300 min (p=0.032), and lymph node dissection of D2 or more (p=0.005) were independent predictors of a pancreatic fistula, while total gastrectomy (p=0.0121) was the only factor predicting anastomotic leakage (Table 7).

Table 1 Clinical characteristics of the patients with superficial incisional SSI

Variables	Total *N*	SSI (−) (%)	SSI (+) (%)	*p* value
Age (years)[a]		67 (24–89)	68 (31–83)	0.3635
Sex				0.0589
Male	596	567 (95.1)	29 (4.9)	
Female	246	225 (91.5)	21 (8.5)	
BMI				0.883
<25	672	633 (94.2)	39 (5.8)	
≥25	170	159 (92.8)	11 (7.2)	
ASA score				0.7799
<3	759	715 (94.2)	44 (5.8)	
≥3	83	77 (92.8)	6 (7.2)	
Cardiovascular disease				0.4316
Absent	520	486 (93.5)	34 (6.5)	
Present	322	306 (95)	16 (5)	
Diabetes mellitus				0.4504
Absent	698	659 (94.4)	39 (5.6)	
Present	144	133 (92.4)	11 (7.6)	
Renal failure				
Absent	815	768 (94.2)	47 (5.8)	0.2122
Present	27	24 (88.9)	3 (11.1)	
Corticosteroid therapy				
Absent	824	775 (94.1)	49 (5.9)	>0.9999
Present	18	17 (94.4)	1 (5.6)	
Serum albumin (g/dl)				0.0705
≥3.5	773	731 (94.6)	42 (5.4)	
<3.5	69	61 (88.4)	8 (11.6)	
Diagnosis				0.7153
Cancer	808	759 (93.9)	49 (6.1)	
Others	34	33 (97.1)	1 (2.9)	
Preoperative CTx				0.1973
Not performed	799	754 (94.4)	45 (5.6)	
Performed	43	38 (88.4)	5 (11.6)	

SSI surgical site infection, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *CTx* chemotherapy

[a] Values are expressed as median with range

Table 2 Surgical variables and superficial incisional SSI

Variables	Total *N*	SSI (−) (%)	SSI (+) (%)	*p* value
Procedure				0.3563
Partial gastrectomy[a]	547	511 (93.4)	36 (6.6)	
Total gastrectomy[b]	295	281 (95.3)	14 (4.7)	
Approach				0.1343
Open	623	581 (93.3)	42 (6.7)	
Laparoscopic	219	211 (96.3)	8 (3.7)	
Duration of operation (min)[c]		275 (45–631)	281 (40–455)	0.5386
Duration of operation (min)				>0.9999
<300	521	490 (94)	31 (6)	
≥300	321	302 (94.1)	19 (5.9)	
Blood loss (g)[c]		270 (10–2907)	410 (10–1406)	0.415
Blood loss (g)				0.2305
<300	448	426 (95.1)	22 (4.9)	
≥300	394	366 (92.9)	28 (7.1)	
Transfusion				0.0024
Not performed	645	616 (95.5)	29 (4.5)	
Performed	197	176 (89.3)	21 (10.7)	
Type of prophylactic antibiotics				0.2196
First-generation cephem	785	741 (94.4)	44 (5.6)	
Others	57	51 (89.5)	6 (10.5)	
Duration of prophylactic antibiotics				0.6085
Pre- and intraoperatively	193	184 (95.3)	9 (4.7)	
1–3 days	450	423 (94)	27 (6)	
4 days or longer	199	185 (93)	14 (7)	
Cutaneous closure				0.4689
Suture (non-absorbable materials)	603	564 (93.5)	39 (6.5)	
External metal staples	148	140 (94.6)	8 (5.4)	
Buried suture (absorbable materials)	91	88 (96.7)	3 (3.3)	
Lymph node dissection				0.5879
D0, D1	534	500 (93.6)	34 (6.4)	
D2 or more	308	292 (94.8)	16 (5.2)	
Combined organ resection				0.7145
Not performed	630	591 (93.8)	39 (6.2)	
Performed	212	201 (94.8)	11 (5.2)	

SSI surgical site infection

[a]Including distal and pylorus-preserving gastrectomy, and local resection

[b]Including total gastrectomy and total resection of the gastric remnant

[c]Values are expressed as median with range

Postoperative Hospital Stay and 30-Day Mortality

The median length of the postoperative hospital stay of patients without SSIs, with superficial incisional SSIs, and with organ/space SSIs was 19 days (range, 6–107 days), 23 days (range, 10–63 days), and 47 days (range, 16–278 days), respectively. The median length of postoperative hospital stay was significantly longer in patients with organ/space SSIs in comparison to those without SSIs ($p<0.0001$) and with superficial incisional SSIs ($p<0.0001$). The patients with superficial incisional SSIs had a significantly longer postoperative hospital stay than those without SSIs ($p=0.0374$).

All incisional SSIs were treated by opening the incisions. Among the 90 organ/space SSIs, 69 were treated conservatively, and 13 were successfully managed by image-guided percutaneous drainage. Eight organ/space SSIs required drainage by laparotomy due to uncontrolled peritonitis.

The rates of re-operation under general anesthesia in patients without SSIs, with superficial incisional SSIs, and with organ/space SSIs were 0.7% (5 of 711 patients), 2.4% (1 of 41 patients), and 8.9% (8 of 90 patients), respectively. The rates of re-operation were significantly higher in the patients with organ/space SSIs than in those without SSIs ($p<0.0001$).

Although the 30-day mortality rate was 2.2% (2 of 90 patients) in patients with organ/space SSIs, there was no 30-

Table 3 Multivariate analysis of the risk factors of superficial incisional SSI

Variables	Odds ratio (95% CI)	*p* value
Sex	1.9 (1.052–3.43)	0.0332
Female		
Serum albumin	1.493 (0.634–3.518)	0.3592
<3.5 g/dl		
Preoperative CTx	1.8 (0.661–4.899)	0.2497
Performed		
Approach	1.462 (0.643–3.325)	0.3649
Open		
Transfusion	2.088 (1.089–4.003)	0.0266
Performed		

Factors with a *p* value <0.2 in the univariate analysis were included in the multivariate analysis

SSI surgical site infection, *CI* confidence interval, *CTx* chemotherapy

day mortality in those without organ/space SSIs. The two deaths occurred due to anastomotic leakage following total gastrectomy.

Discussion

SSIs are divided into superficial incisional, deep incisional, and organ/space SSIs, according to the CDC classification.[2] Therefore, this study investigated the risk factors for incisional and organ/space SSIs separately and identified distinct risk factors associated with these two complications. Multivariate analyses demonstrated that male gender, corticosteroid therapy, total gastrectomy, and duration of operation ≥300 min were independent predictors for the incidence of organ/space SSIs, while a female gender and allogenic blood transfusion were independent risk factors for superficial incisional SSIs. Previous studies have reported several risk factors for SSIs after gastrectomy, such as advanced age,[10] a BMI of 25 or above,[11] diabetes mellitus,[6] open gastrectomy,[6, 10] a longer duration of operation,[6, 10, 12] and a "contaminated" or "dirty-infected" wound.[10] However, most of these studies did not describe incisional SSIs and organ/space SSIs separately. The development of SSIs depends on complex interactions between the patient-related and procedure-related factors, intraoperative bacterial contamination, and compliance with the standard measures that should be implemented to prevent SSIs.[5] It is likely that the risk factors for incisional SSIs and organ/space SSIs differ significantly.[7] These two complications should therefore be dealt with separately.

SSIs, especially organ/space SSIs, exhibit a major impact on surgical outcomes. The patients with organ/space SSIs in the current study had a significantly longer duration of postoperative hospital stay than those without SSIs and those with incisional SSIs. Furthermore, the re-operation rates were significantly higher in patients with organ/space SSIs in comparison to those without SSIs. Organ/space SSIs can also cause the 30-day mortality. Although the patients with superficial incisional SSIs had a longer duration of postoperative hospital stay in comparison to those without SSIs, superficial incisional SSIs did not lead to higher re-operation rates or 30-day mortality. These results indicate that prevention and management of SSIs, particularly organ/space SSIs, are important.

This study found total gastrectomy to be a risk factor strongly associated with the incidence of organ/space SSIs.

Table 4 Clinical characteristics of the patients with organ/space SSI

Variables	Total *N*	SSI (-) (%)	SSI (+) (%)	*p* value
Age (years)[a]		67 (24–89)	68 (44–88)	0.308
Sex				0.0163
Male	596	522 (87.6)	74 (12.4)	
Female	246	230 (93.5)	16 (6.5)	
BMI				0.9271
<25	672	601 (89.4)	71 (10.6)	
≥25	170	151 (88.8)	19 (11.2)	
ASA score				0.8141
<3	759	679 (89.5)	80 (10.5)	
≥3	83	73 (88)	10 (12)	
Cardiovascular disease				0.3488
Absent	520	469 (90.2)	51 (9.8)	
Present	322	283 (87.9)	39 (12.1)	
Diabetes mellitus				0.7427
Absent	698	625 (89.5)	73 (10.5)	
Present	144	127 (88.2)	17 (11.8)	
Renal failure				0.5198
Absent	815	729 (89.4)	86 (10.6)	
Present	27	23 (85.2)	4 (14.8)	
Corticosteroid therapy				0.1162
Absent	824	738 (89.6)	86 (10.4)	
Present	18	14 (77.8)	4 (22.2)	
Serum albumin (g/dl)				0.0935
≥3.5	773	695 (89.9)	78 (10.1)	
<3.5	69	57 (82.6)	12 (17.4)	
Diagnosis				0.1646
Cancer	808	719 (89)	89 (11)	
Others	34	33 (97.1)	1 (2.9)	
Preoperative CTx				0.3347
Not performed	799	716 (89.6)	83 (10.4)	
Performed	43	36 (83.7)	7 (16.3)	

SSI surgical site infection, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *CTx* chemotherapy

[a] Values are expressed as the median with range

Table 5 Surgical variables and organ/space SSI

Variables	Total *N*	SSI (-) (%)	SSI (+) (%)	*p* value
Procedure				<0.0001
Partial gastrectomy[a]	547	524 (95.8)	23 (4.2)	
Total gastrectomy[b]	295	228 (77.3)	67 (22.7)	
Approach				<0.0001
Open	623	540 (86.7)	83 (13.3)	
Laparoscopic	219	212 (96.8)	7 (3.2)	
Duration of operation (min)[c]		265 (40–631)	311 (150–616)	<0.0001
Duration of operation (min)				<0.0001
<300	521	482 (92.5)	39 (7.5)	
≥300	321	270 (84.1)	51 (15.9)	
Blood loss (g)[c]		252 (10–2795)	753 (25–2907)	<0.0001
Blood loss (g)				<0.0001
<300	448	426 (95.1)	22 (4.9)	
≥300	394	326 (82.7)	68 (17.3)	
Transfusion				<0.0001
Not performed	645	596 (92.4)	49 (7.6)	
Performed	197	156 (79.2)	41 (20.8)	
Type of prophylactic antibiotics				0.2851
First-generation cephem	785	704 (89.7)	81 (10.3)	
Others	57	48 (84.2)	9 (15.8)	
Duration of prophylactic antibiotics				0.7838
Pre- and intraoperatively	193	175 (90.7)	18 (9.3)	
1–3 days	450	400 (88.9)	50 (11.1)	
4 days or longer	199	177 (88.9)	22 (11.1)	
Intra-abdominal suture material				0.7657
Non-absorbable	507	451 (89)	56 (11)	
Absorbable	335	301 (89.9)	34 (10.1)	
Lymph node dissection				0.0001
D0, D1	534	494 (92.5)	40 (7.5)	
D2 or more	308	258 (83.8)	50 (16.2)	
Combined organ resection				<0.0001
Not performed	630	586 (93)	44 (7)	
Performed	212	166 (78.3)	46 (21.7)	

SSI surgical site infection

[a]Including distal and pylorus-preserving gastrectomy, and local resection

[b]Including total gastrectomy and total resection of the gastric remnant

[c]Values are expressed as median with range

Previous studies show that the rates of overall complications and mortality are significantly higher in total gastrectomy than in partial gastrectomy.[13–15] Total gastrectomy has a higher risk for anastomotic leakage than distal gastrectomy.[14, 16] Similarly, the present study showed that organ/space SSIs due to anastomotic leakage occurred more frequently in patients undergoing total gastrectomy than in those undergoing partial gastrectomy (6.8% versus 1.5%, $p<0.0001$). Furthermore, total gastrectomy was the only independent risk factor for anastomotic leakage. Ninety percent of the cases with anastomotic leakage following total gastrectomy in the present study were at esophagojejunostomy. Pancreatic fistula, in addition to anastomotic leakage, is a major cause of morbidity following gastrectomy.[1, 17] The present study found that organ/space SSIs due to pancreatic fistulae also occurred more frequently in patients undergoing total gastrectomy than in those undergoing partial gastrectomy (12.2% versus 2.2%, $p<0.0001$), and total gastrectomy was an independent risk factor for a pancreatic fistula following gastrectomy. An extended lymph node dissection (D2 or more) was another independent risk factor for this complication. Lymph node dissection along with the splenic artery is associated with this complication.[17, 18] The technical difficulties of esophagojejunostomy and the extent of lymph node dissection might therefore be related to the incidence of organ/space SSIs.

In addition to the surgical procedure, the patient-related factors are also associated with the incidence of organ/space

Table 6 Multivariate analysis of the risk factors associated with organ/space SSI

Variables	Odds ratio (95% CI)	*p* value
Sex	1.913 (1.045–3.504)	0.0355
Male		
Corticosteroid therapy	4.118 (1.089–15.578)	0.037
Present		
Serum albumin	1.204 (0.561–2.583)	0.6339
<3.5 g/dl		
Diagnosis	0.962 (0.118–7.846)	0.9712
Cancer		
Procedure	4.421 (2.467–7.92)	<0.0001
Total gastrectomy[a]		
Approach	2.333 (0.878–6.197)	0.0891
Open		
Duration of operation	2.129 (1.24–3.657)	0.0062
≥300 min		
Blood loss	1.483 (0.795–2.765)	0.2153
≥300 g		
Transfusion	1.515 (0.88–2.607)	0.1335
Performed		
Lymph node dissection	1.494 (0.876–2.55)	0.1406
D2 or more		
Combined organ resection	0.904 (0.494–1.654)	0.7434
Performed		

Factors with a *p* value <0.2 in the univariate analysis were included in the multivariate analysis

SSI surgical site infection, *CI* confidence interval

[a] Including total gastrectomy and total resection of the gastric remnant

SSIs. Corticosteroids are used clinically to treat a wide variety of diseases by suppressing inflammations and immune functions. The current study found that corticosteroid therapy was another independent risk factor for organ/space SSIs. The patients who received corticosteroid therapy had a 4.118-fold risk of organ/space SSIs in comparison to those who did not.

Previous reports showed that male patients experienced postoperative complications more frequently and had a significantly higher rate of hospital mortality than female patients following gastrectomy.[13, 19] Similarly, the present study found male gender to be an independent risk factor for organ/space SSIs. We found that male patients were more likely to have an ASA score ≥3 (11.2% versus 6.5%, p=0.0488) and that they had a higher prevalence of diabetes mellitus (19.5% versus 11.4%, p=0.0063) compared with female patients. The proportion of cancer patients was also higher in males than in females (97.3% versus 92.7%, p=0.0036). Furthermore, male patients had a significantly longer median duration of surgery (277 versus 259 min, p= 0.0105) and greater blood loss (317 versus 186 g, p< 0.0001) than female patients. These differences might have contributed to the higher incidence of organ/space SSIs in male patients.

On the other hand, a female gender was an independent predictor of superficial incisional SSIs in this study. Previous studies have reported that the amount of abdominal subcutaneous fat is an independent predictor of superficial incisional SSIs after intra-abdominal surgery and that this is a more useful predictor of superficial incisional SSIs when compared with the BMI.[20, 21] Female patients had significantly greater abdominal subcutaneous fat than male patients.[21] The greater amount of subcutaneous fat may be associated with the higher incidence of superficial incisional SSIs in female patients, although this could not be evaluated in the present study.

Allogenic blood transfusion was another risk factor for superficial incisional SSIs. Allogenic blood transfusion induces immunosuppression, and this immunosuppressive effect adversely affects the patient outcomes.[8, 22] The association between allogenic blood transfusion and an increase in postoperative infectious complications has previously been established in several studies.[7, 8, 22, 23] Transfusion is also associated with higher mortality rates and an increased length of hospital stay.[23, 24] However, the impact of allogenic blood transfusion on the incidence of SSIs still remains controversial. While many studies suggest that allogenic blood transfusion is a risk factor for the development of SSI,[7, 8, 23] others did not confirm any such independent association.[24, 25] This discrepancy may be due to covariate selection in the multivariate analyses and different inclusion criteria for the individual patients. The current results indicate that the modulation of host immunity is an important factor for the incidence of incisional SSIs after gastrectomy.

Given that both incisional and organ/space SSIs were strongly associated the surgical results, improvements in surgical techniques are required. One possible measure to reduce SSIs is the use of energy devices, such as ultrasonically activated coagulating shares. More recently, we introduced ultrasonically activated coagulating shares in open gastrectomy, as well as laparoscopic surgery, and now extend the use of these devices to all steps of the dissection, including nodes along with the splenic artery. Some reports have shown that the use of these devices reduces the length of the surgery, blood loss, lymphorrhea, the need for blood transfusion, and major postoperative complications, when compared with conventional monopolar electrosurgery for gastric surgery.[26, 27] The reduction of intraoperative hemorrhage and lymphorrea would keep the surgical fields more

Table 7 The results of the multivariate analysis of the risk factors associated with pancreatic fistulae and anastomotic leakage

Variables	Pancreatic fistula		Anastomotic leakage	
	Odds ratio (95% CI)	*p* value	Odds ratio (95% CI)	*p* value
Sex	1.923	0.1136	–	–
Male	(0.855–4.329)			
ASA score	–	–	1.88	0.2625
≥3			(0.623–5.669)	
Cardiovascular disease	–	–	2.05	0.1047
Present			(0.861–4.878)	
Diabetes mellitus	–	–	1.991	0.1216
Present			(0.833–4.759)	
Renal failure	–	–	3.291	0.1208
Present			(0.731–14.822)	
Preoperative CTx	–	–	1.792	0.3955
Performed			(0.467–6.884)	
Procedure	4.73	0.0001	3.47	0.0121
Total gastrectomy[a]	(2.126–10.527)		(1.312–9.176)	
Approach	2.922	0.1389	5.205	0.1406
Open	(0.706–12.09)		(0.58–46.7)	
Duration of operation	2.172	0.032	2.29	0.0746
≥300 min	(1.069–4.413)		(0.921–5.696)	
Blood loss	1.579	0.2791	1.653	0.3592
≥300 g	(0.691–3.608)		(0.564–4.843)	
Transfusion	1.127	0.7404	1.802	0.1709
Performed	(0.555–2.289)		(0.775–4.19)	
Intra-abdominal suture material	0.603	0.1343	–	–
Non-absorbable	(0.311–1.169)			
Lymph node dissection	2.87	0.005	–	–
D2 or more	(1.375–5.989)			
Combined organ resection	0.622	0.245	0.665	0.4203
Performed	(0.28–1.384)		(0.247–1.794)	

Factors with a p value <0.2 in the univariate analysis were included in the multivariate analysis.

CI confidence interval, *ASA* American Society of Anesthesiologists, *CTx* chemotherapy

[a]Including total gastrectomy and total resection of the gastric remnant

clearly visible, thus contributing to avoiding injury to the pancreas during lymph node dissection. A prospective randomized control trial is required to determine whether these devices can reduce the incidence of incisional and organ/space SSIs in gastrectomy.

Another possible measure to prevent SSIs is the use of laparoscopy. Laparoscopic gastrectomy had a lower rate of organ/space SSIs, although this was not significant in the multivariate analysis of this study. At our institution, the number of patients undergoing laparoscopic gastrectomy is increasing every year. In accordance with previous studies,[6, 10] the use of laparoscopy might contribute to reducing SSIs after gastrectomy with increasing experience.

With regard to leakage of an esophagojejunal anastomosis made using a circular stapler, technical errors are strongly associated with this complication.[28] In most cases, the postoperative leakage is likely due to an incomplete anastomosis. Therefore, we recommend a detailed observation of the anastomosis site and doughnuts and that an incomplete anastomosis should be repaired by suturing or re-anastomosis during the operation to avoid postoperative anastomotic leakage.

In conclusion, this study demonstrated that the risk factors for incisional SSIs and organ/space SSIs were quite different. However, the risk factors for both complications are strongly associated with the surgical results. Meticulous surgical techniques are therefore required to prevent SSIs.

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