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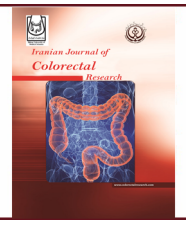

Preoperative Risk Factors Contributing to Surgical Site Infections After Elective and Emergent Colorectal Surgery

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Abstract

Background: Surgical site infections (SSIs) are associated with an increased hospital stay and a significant healthcare burden. Recognition of risk factors might help prevent it.
Methods: Patients referring to the colorectal department of Imam Khomeini Hospital Complex for elective or emergent surgery were evaluated from January 2018 to 2019. All variables known to be associated with SSI were investigated.
Results: Total number of 473 patients with a mean age of 55.6±13.9 years (range 18-88 years) and a male to female ratio of 1.4 were evaluated. Overall, 103 patients developed SSI within 30 days after surgery, representing an incidence rate of 21.7%. Seventy-seven percent of patients with SSI were in the age group under 65 years; 42% were female, and 58% were male. There were 89 cases of superficial (86%), 11 cases of deep (10%), and 3 cases of organ/space surgical site infection (3%). The risk factors significantly associated with SSI development were diabetes mellitus, operation on the rectum, emergency surgery, history of neoadjuvant chemotherapy, laparoscopy approach changed to laparotomy approach, colostomy/ileostomy implantation or closure, blood transfusion after surgery, anastomotic leakage, and surgery lasting more than 200 minutes. After multivariate analysis, neoadjuvant chemoradiotherapy, emergent surgery, operation on the rectum, postoperative blood transfusion, and prolonged operation to discharge periods were significantly associated with a remarkably higher SSI risk.
Conclusion: SSI is a devastating condition that compromises surgical outcomes. Preventive measures should be applied in every surgical facility to prevent SSI and minimize its complications.

Keywords: Surgical site infection, Colorectal surgery, Risk factor, Chemo-radiation, Hospital stay

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Introduction

Surgical site infection (SSI) is the second most common nosocomial infection in patients undergoing surgical procedures, affecting around 30% of patients (1). SSI is linked to an increased mortality rate (3%), prolonged hospital stay, and readmission (2, 3). Moreover, it counts as the third most expensive type of healthcare-acquired infection (3). SSI mainly occurs within 30 days following the operation and can manifest with a wide range of clinical features. Centers for Disease Control and Prevention (CDC) categorizes SSIs as (i) incisional, which is subdivided into superficial (skin and subcutaneous tissue involvement) and deep (deep soft tissue involvement including fascia and muscles), and (ii) organ/space (any part of the anatomy that has been manipulated or opened during surgery, other than the surgical incision) (4). There are various factors associated with the risk of SSIs, divided into three categories: (i) patient factors like old age, decreased immunity, obesity, diabetes mellitus, malnutrition, peripheral vascular disease, anemia, and recent surgery; (ii) local factors such as improper skin preparation before surgery, contamination of equipment, long operating time, local necrosis, hypoxia, and low body temperature; and (iii) microbial factors including prolonged hospitalization, toxin secretion, and resistance to microbial clearance (5, 6). Due to the multiplicity of microbes in the colon and rectum, the wound of these anatomical parts is often not clean; thus, colorectal surgery is more prone to SSI than other surgeries (7). The overall prevalence of SSI in colorectal surgery is up to 35% (8).

So far, many studies have examined the factors related to SSI, but it seems that due to the importance of this issue, the high prevalence, and the enormous burden on medical expenses, more investigations are still needed. Therefore, we evaluated SSI incidence in patients undergoing colorectal surgery and examined the related risk factors.

Materials and Methods

This cross-sectional study was performed from January 2018 to January 2019 in two surgical wards of a tertiary referral center—the Imam Khomeini Hospital, affiliated with Tehran University of Medical Sciences, Tehran, Iran. The Ethics Committee of Tehran University of Medical Sciences approved the study protocol, and this study was performed in accordance with the ethical standards laid down in the Declaration of Helsinki 2013. Before surgery, written informed consent was obtained from all patients. All operations were supervised or done by one attending surgeon. The inclusion criteria were as follows: 1) age ≥18 years; 2) Patients who underwent elective or emergency surgery in the colorectal surgery department of Imam Khomeini Hospital during the study period; and 3) Patients who were hospitalized for at least two weeks. The first surgery was included in the study in case of reoperation less than 30 days after the previous surgery. Exclusion criteria were as follows: 1) A lack of sufficient information; 2) Vascular surgery, urology, or transplant; and 3) Follow-up in less than two weeks.

Essential characteristics of enrolled patients consisted of age, sex, body mass index (BMI), history of smoking and opium use, previous history of diabetes mellitus, hypertension, underlying colorectal diseases such as Crohn's disease (CD) or ulcerative colitis (UC), chronic renal or hepatic or cardiac failure, immunosuppressive medications, and preoperative blood values (albumin, hemoglobin [Hb], white blood cell [WBC]). In addition, operative characteristics such as operation duration (200 minutes cut-off point), previous laparotomy history, bowel preparation, surgery type (elective/emergency), surgical wound type (CDC classification: clean, clean/contaminated, contaminated, or dirty), perioperative blood products transfusion, carcinoembryonic antigen (CEA), pathology outcome (divided into 0 to 5 according to tumor staging system), surgery site (right colon, transverse colon, left colon, or rectum), admission to operation period, operation to discharge period, intensive care unit (ICU) admission, ostomy site (colostomy, ileostomy), surgical approach (open/laparoscopic/laparoscopic-open/other), and history of chemoradiotherapy within 12 weeks of operation were obtained from all patients. All the information was collected by referring to patients' medical records, checked through a checklist and examination by a surgeon, and recorded in an SPSS file designed for further analysis.

Preoperative preparation such as bowel preparation using an oral laxative or mechanical bowel preparation, skin preparation, hair removal, and antiseptic soap was the same for all elective surgeries. All patients received prophylactic antibiotics (cefazolin 2 gr+metronidazole 500 mg, intravenous infusion 30 min before incision) based on local resistance profiles and the surgeon's discretion. In the event of penicillin or cephalosporin allergy, gentamicin 3 mg/kg was administered with metronidazole 500 mg. In case of a contaminated wound or dirty/infected wound (defined by CDC), prophylaxis was given for 24 h. In the event of a prolonged duration of operation (>200 minutes cut-off point), patients received a booster dose of cefazolin 1 gr. Other perioperative care was standard for all cases. Hypothermia and hypoxia were prevented by closely monitoring the patients during the procedure. Abdominal wall closure was performed using polydioxanone (PDS) monofilament absorbable sutures for the fascia; absorbable or non-absorbable sutures were used for the skin. The skin was closed primarily in all operations unless intra-abdominal abscess or leakage of colonic contents occurred.

The primary outcome was SSI occurrence during 30 days post-operation, as defined by the CDC (deep-superficial incision infection or organ/space infection) (8). Once the SSI occurred, a sample was obtained from the wound secretion, the pus drained, the wound fluid, or the suspected catheter. Also, blood and wound cultures were checked. All patients were followed via standard telephone interviews or records of readmission if the patient was discharged from the hospital less than 30 days post-operation. Other outcomes were duration of postoperative stay, mortality, morbidity, and total hospital stay.

Data were analyzed using Statistical Package for the Social Science (SPSS) version 24. Quantitative data were provided as the mean±standard deviation (SD), while the frequency was used to describe qualitative data. The chi-squared test and Fisher's exact test were used to compare categorical variables. P values<0.05 were considered significant. For quantitative data, if the normal distribution was established, a t-test was used, and if the distribution was not normal, the corresponding non-parametric test (Mann-Whitney U test) was used. The Hosmer and Lemeshow test was used to assess the logistic regression. Statistically significant variables in univariable logistic regression were included in multivariable logistic regression model analysis to recognize the independent risk factors of SSI within 30 postoperative days. A stepwise backward method was selected for variable selection (P<0.05; permanence P<0.1).

Results

In total, 473 patients referring to Imam Khomeini Hospital Complex for colorectal surgery were enrolled in this study. The mean age was 55.6±13.9 years (range 18-88 years); 41.6% were female, and 58.4% were male. During this study, none of the patients died. All demographic characteristics are exhibited in Table 1. One hundred and three patients developed SSI within 30 days after surgery,

Table 1: Study population characteristics

Variables	Surgical Site Infection		P value
	Yes N (%)*	No N (%)	
Age group (years)			
<65	79 (77%)	257 (69%)	0.14
≥65	24 (23%)	113 (31%)	
.Gender			
Female	43 (42%)	154 (42%)	0.98
Male	60 (58%)	216 (58%)	
BMI (kg/m^2)			
<25	43 (42%)	177 (48%)	0.46
25-30	44 (43%)	144 (39%)	
>30	16 (15%)	49 (13%)	
Preoperative WBC count (/µl)			
<11,000	90 (89%)	342 (92%)	0.09
≥11,000	13 (11%)	28 (8%)	
Preoperative Hb (g/dl)			
<10	20 (19%)	52 (14%)	0.22
≥10	83 (81%)	218 (86%)	
Preoperative CEA			
≤2.5	56 (54%)	219 (59%)	0.44
>2.5	47 (46%)	151 (41%)	
Preoperative albumin (g/l)			
<3	9 (9%)	12 (3%)	0.93
≥3	94 (91%)	358 (97%)	
Diabetes mellitus			
No	78 (76%)	330 (89%)	0.003
Yes	25 (24%)	40 (11%)	
.Predisposing factor			
None	4 (4%)	3 (1%)	0.42
Ulcerative colitis	4 (4%)	7 (2%)	
Crohn	1 (1%)	3 (1%)	
Cancer	92 (89%)	330 (89%)	
Other	2 (2%)	27 (7%)	
Opioid history			
Yes	4 (4%)	10 (3%)	0.53
No	99 (96%)	360 (97%)	
Smoking history			
Yes	6 (6%)	15 (4%)	0.43
No	97 (94%)	355 (96%)	

Obstruction			
No	88 (85%)	335 (91%)	0.46
Complete	9 (9%)	9 (2%)	
Partial	7 (6%)	26 (7%)	
Neoadjuvant chemoradiotherapy			
Yes	65 (71%)	198 (60%)	0.02
No	27 (29%)	132 (40%)	
Metastasis			
None	89 (97%)	321 (97%)	0.62
Liver	2 (2%)	5 (2%)	
Lung	0	4(1%)	
Other	1 (1%)	0 (0%)	
Operation type			
Emergency	12 (12%)	7 (2%)	<0.001
Elective	91 (88%)	363 (98%)	
Operative approach			
Laparotomy	78 (76%)	292 (79%)	0.01
Laparoscopy	9 (9%)	41 (11%)	
Laparoscopy converted to laparotomy	13 (13%)	19 (5%)	
Other	3 (2%)	18 (5%)	
Operation purpose			
Curative	97 (94%)	354 (97%)	0.21
Palliative	6 (6%)	16 (3%)	
Operation site			
Colon	36 (35%)	134 (36%)	0.16
Rectum	41 (40%)	172 (46%)	
Both	26 (25%)	64 (18%)	
Surgery consistent ostomy creation or closure			
None	31 (30%)	148 (40%)	<0.01
Ileostomy	57 (55%)	204 (55%)	
Colostomy	15 (15%)	18 (5%)	
Synchronous operation			
None	88 (85%)	308 (83%)	0.43
Liver metastatectomy	1 (1%)	8 (2%)	
Omentectomy	1 (1%)	9 (3%)	
Hystro-ophorectomy	1 (1%)	4 (1%)	
Other	12 (12%)	41 (11%)	
Blood transfusion			
No	84 (81%)	345 (93%)	0.001
Yes	19 (19%)	25 (7%)	
Post-operation anastomosis leakage			
No	96 (93%)	363 (98%)	0.015
Yes	7 (7%)	7 (2%)	
Post-operation fever			
No	92 (89%)	356 (96%)	0.008
Yes	11 (11%)	14 (4%)	
Pathology stage			
Stage 1	30 (33%)	100 (30%)	0.55
Stage 2	33 (36%)	115 (35%)	
Stage 3	27 (30%)	85 (26%)	
Stage 4	2(1%)	30 (22%)	
ICU stay (days)			
≤2	65 (63%)	258 (70%)	0.14
>2	38 (37%)	122 (30%)	
Admission to operation period (days)			
≤6	56 (54%)	246 (66%)	0.05
>6	47 (46%)	124 (34%)	
Operation duration (minutes)			
≤200	52 (50%)	235 (63%)	0.01
>200	51 (50%)	135 (37%)	
Operation to discharge period (days)			
≤7	43 (42%)	306 (83%)	<0.001
>7	60 (58%)	64 (17%)	

BMI: body mass index, WBC: white blood cell, CEA: carcinoembryonic antigen, ICU: intensive care unit

and the incidence rate of SSI was estimated to be 21.7%. Seventy-seven percent of patients with SSI were in the age group under 65 years; 42% were female, and 58% were male. There were 89 cases of superficial (86%), 11 cases of deep (10%), and 3 cases of organ/space surgical site infection (3%). There was no statistically significant difference between patients with SSI and those without SSI regarding age, gender, BMI, length of preoperative stay, predisposing factors such as CD, UC, cancer, metastasis, smoking, and opioid history. The most common comorbidity was diabetes mellitus (DM), and 24% (n=20) of patients with SSI had a history of DM, which showed a significant association with SSI (P=0.003). There was no significant relationship between developing SSI and preoperative CEA, Hb, and albumin values, except for WBC count, which showed higher SSI occurrence in patients with higher WBC counts (≥11,000/µl, P=0.009).

The SSI incidence varied significantly based on the site of surgery, of which rectum surgery with 39.6% had a higher incidence than colon surgery (34.6%). Moreover, there was a strong correlation between the type of surgery (elective/emergency) and developing SSI, and the incidence of SSI was higher in patients who had undergone emergent surgery (60.0 vs. 19.6%; P<0.001). In patients with a history of neoadjuvant chemotherapy (n=270), 25.5% (n=69) developed SSI (P=0.02), which shows a significant correlation between a weakened immune system and developing SSI. There was no significant relationship between developing SSI and partial/complete obstruction symptoms.

Regarding the approach of operation, patients who first underwent laparoscopy and then converted to laparotomy had a higher SSI incidence than other approaches (P=0.01). There was significantly lower SSI incidence in patients with preoperative bowel preparation by mechanical bowel preparation versus no preparation (P<0.001). Also, patients with skin preparation and hair removal showed lower SSI incidence (P<0.001). In patients with colostomy/ileostomy, 24.7% developed SSI, of which patients with an ileostomy had higher SSI incidence compared to patients with a colostomy (55 vs. 15%, P<0.001). Blood transfusion after surgery carried a higher risk of developing SSI (P=0.001). Postoperative complications such as anastomotic leakage were also significantly associated with a higher incidence rate of SSI with P values of 0.01 and 0.008, respectively. No significant correlation was found between tumor stages and SSI incidence (P>0.05). Among the patients who developed SSI, 62% were hospitalized in the ICU for less than two days and 38% for more than two days, and there was no difference in SSI rates as the P value was >0.05. The mean operation time was 200.8±34.1 minutes (60-570 minutes); compared to the non-SSI group, patients with surgeries lasting more than 200 minutes showed a higher rate of SSI development (P=0.01). Patients who had higher admission to surgery time and surgery to discharge time (6 days and 7 days, respectively) carried a higher risk of developing SSI (P=0.04 and <0.001, respectively). The median time of SSI occurrence was 5.5 (3.0-12 days) after surgery. The risk factors significantly associated with SSI development were diabetes mellitus, rectum surgery, emergency surgery, history of neoadjuvant chemotherapy, laparoscopy and then laparotomy approach, colostomy /ileostomy, blood transfusion

Table 2: Multivariate analysis of variables that were statistically significant in univariate analysis

Variables	Odds Ratio (95% Confidence Interval)	P value
Preoperative WBC	0.53 (0.13-2.19)	0.38
Diabetes mellitus	0.63 (0.28-1.41)	0.26
Neoadjuant chemoradiotherapy	0.31 (0.11-0.85)	0.02
Operation type (elective vs. emergent)	0.16 (0.42-0.6)	0.001
Operation approach Laparotomy Laparoscopy Laparoscopy converted to laparotomy Other	0.71 (0.26-1.93)	0.51
Operation site Colon Rectum Both	5.92 (1.44-24.29)	0.014
Surgery consistent ostomy creation or closure None Ileostomy Colostomy	0.34 (0.75-1.53)	0.16
Blood transfusion	0.32 (0.13-0.8)	0.016
Post-operation anastomosis leakage	0.8 (0.18-3.58)	0.77
Post-operation fever	0.6 (0.18-1.95)	0.4
Admission to operation period	0.53 (0.28-1.02)	0.06
Operation duration	0.76 (0.4-1.48)	0.43
Operation to discharge period	0.15 (0.08-0.3)	<0.001

after surgery, anastomotic leakage, and surgery lasting more than 200 minutes. After multivariant analysis, neoadjuvant chemoradiotherapy, operation type (emergency), operation site (rectum), postoperative blood transfusion, and operation to discharge days are associated with a remarkably higher SSI risk (Table 2).

Discussion

A surgical site infection (SSI) is the second most common nosocomial infection following surgery, especially colorectal surgery, with up to a 30% incidence rate. American College of Surgeons National Surgical Quality Improvement Program reported that SSI incidence in 2015 following colorectal surgery was 5.11% (9). Moreover, Japan's nosocomial infection surveillance system national database from 2008 through 2010 reported 17.8% and 15% for the cumulative SSI incidence rate after colon and rectal surgery, respectively (10). Because SSI is related to a high mortality rate and a considerable burden on the healthcare system, many studies and clinical interventions have investigated the causes, risk factors, and effective ways to reduce SSI rates following colorectal surgery (11-13). This observational study investigated the incidence rate of SSI and related risk factors of colorectal surgery among 473 patients, of which SSI occurred in 103 patients, and the incidence rate of SSI was estimated at 21.7% following colorectal surgery. The incidence rate of SSI after colorectal surgery has varied from 3–35% in various studies. Anthony et al. (8), in a randomized clinical trial, reported a 35% incidence rate of SSI following colorectal surgery. In another study, Hedrik et al. reported that nearly 26% of patients developed SSI following elective colorectal surgery (14).

Despite the few studies that reported male gender as a risk factor for developing SSI (15), in this study, no significant difference was found between gender groups. Univariate analysis identified that patients with DM were more prone to developing SSI after surgery. In a study by Martin et al. (16), pre-existing diabetes and perioperative hyperglycemia were associated with poor surgical outcomes and higher SSI occurrence. In our study, no significant relationship was found between BMI and SSI occurrence, but in other series (17), BMI>30 was reported to be strongly associated with SSI after colorectal surgery, and BMI≥25 was reported as a predictor of SSI occurrence (18). Among perioperative laboratory values, only a high level of WBC (more than 11,000 /µl) was strongly associated with a higher rate of SSI, and unlike other studies, no association was found between hypoalbuminemia and SSI occurrence (7, 19).

In this study, the positive history of neoadjuvant chemoradiotherapy was strongly associated with developing SSI. Moreover, in some studies, neoadjuvant chemotherapy was shown to double the rate of SSI incidence (20-22). Therefore, further studies are needed to investigate the correlation of SSI incidence with different time intervals between neoadjuvant chemotherapy and surgery. Consistent with the literature, our study showed that patients undergoing emergent surgery, prolonged duration of operation (>200 minutes), and converting laparoscopy to a laparotomy approach carried a higher risk of SSI (7, 22-25). Blood transfusion was associated with a higher rate of SSI. This might be due to immunosuppression induced by allogeneic blood transfusion (26). Hence, improving surgical techniques to reduce blood loss during surgery and thereby minimizing the need for blood product transfusion can be an effective way to reduce SSI occurrence (27).

Few articles have been published regarding the relationship between ileostomy/colostomy and developing SSI. However, ostomy-related procedures, whether ostomy closure or implantation, are associated with a high risk of SSI because an ostomy has an inherent contamination risk (20, 28). Previous studies have linked leakage from anastomosis with a higher risk of SSI, and our results confirmed this finding (29).

The follow-up was carried out via a telephone interview or review of readmission records if patients were discharged less than 30 days following the surgery. The multivariate analysis revealed that the preoperative WBC level, neoadjuvant chemotherapy, operation site (colon, rectum), blood transfusion, and days of operation to discharge were independent risk factors for SSI. In our study, lower SSI incidence was reported in patients with mechanical bowel preparation compared with other groups. World Health Organization (WHO) suggests a combination of preoperative mechanical and oral antibiotics for bowel preparation in order to reduce SSI in elective surgery (30).

Our study has a few limitations. This was a single-center study, so it did not reflect differences between other populations or institutions, and it only evaluated patients who underwent colorectal surgery. Studies with a greater sample size are warranted to collect and analyze the different risk factors of developing SSI. Also, although diabetes mellitus was identified as a significant risk factor, our study did not record some details, including the variation of blood glucose levels during the postoperative period.

Conclusion

The incidence rate of SSI after colorectal surgery was 21.7%. Several factors such as a history of neoadjuvant chemotherapy, emergency surgery, site of operation (rectum), surgical approach, blood transfusion, WBC level, and history of DM were associated with SSI occurrence after colorectal surgery. Considering the importance of SSI,

more studies, such as randomized clinical trials, interventional approaches, etc., must be conducted to shed further light on the risk factors associated with SSI development.

Conflicts of interest: None declared.

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