Original Articles

Study of Factors for Incisional Surgical Site Infection after Elective Surgery of the Lower Digestive Tract

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Objective: Obesity is a general risk factor for surgical site infection (SSI). In this study, we investigated the relationship between incisional SSI, which comprises two-thirds of the number of SSI cases, and measurements of subcutaneous fat thickness (SCF) instead of body mass index (BMI) as obesity index.

Materials and Methods: The subjects were 102 patients who underwent elective surgery of the lower digestive tract in our hospital from February 2004 to June 2005. The relationship between incisional SSI and the following parameters was investigated: sex, age, obesity (SCF), BMI anemia, nutritional condition, respiratory function (preoperative PaO₂), preoperative systemic condition, incidence/absence of diabetes, operation time, bleeding volume and procedure type.

Results: The odds-ratio and p-values were 5.873 and 0.011 in the high-SCF group and 4.997 and 0.019 in the low-preoperative PaO₂ group, respectively.

Conclusions: It was suggested that the high-SCF and low-preoperative PaO₂ groups were high-risk groups for incisional SSI.

Key Words: surgical site infection, incisional surgical site infection, surgery of the lower digestive tract

Introduction

Postoperative surgical site infection (SSI) is the most common postoperative complication after surgery of the digestive tract. In particular, following surgery of the lower digestive tract, the incidence of complications is very high¹⁾ and SSI risk factors and measures are important issues for surgeons for the lower digestive tract.

Obesity is one of the risk factors for SSI²⁾ and subcutaneous fat at the actual infected site is also an important factor. In this study, we investigated the relationship between incisional SSI which is one of the classification of SSI³⁾

(Fig. 1) and multiple factors including measurements of subcutaneous fat thickness (SCF) in patients who underwent elective surgery of the lower digestive tract.

Materials and Methods

The subjects were 102 patients who underwent elective surgery of the lower digestive tract in our hospital from February 2004 to June 2005. In this study, steroid-treated and hemodialyzed patients were excluded. The subjects consisted of 63 male and 39 female patients of 39-86 years old (mean age: 65.5 ± 10.8 years old).

Based on the diagnostic criteria of the Cen-

Fig. 1 Classification of SSI³⁾Table 1 SSI risk index of NNIS⁷⁾

• Surgical Wound Classification	: I or II → 0, III or IV → 1
• Preoperative Systemic Condition	: ASA, PS I or 2 → 0, PS 3 or 4 → 1
• Operation Time	: < 75% Percentile → 0 ≥ 75% Percentile → 1
Total Points (0 ~ 3) → Risk Index of Patient	

* American Society of Anesthesiologist ** Physical Status

ters for Disease Control and Prevention in the United State (CDC)³⁾, the presence/absence of incisional SSI was evaluated and 22 patients were diagnosed with SSI (SSI (+) group) and 80 patients without SSI (SSI (-) group).

Evaluation items

I. Patient factors

1. Sex

2. Age

The patients were classified into low and high-age groups with a cut-off of 66 years old.

3. Obesity

a) SCF

Subcutaneous fat thickness (mm) at the mid-line point just above the umbilicus was measured in abdominal CT scan before surgery. The patients were classified into low and high-SCF groups with a cut-off value of 18 mm.

b) Body Mass Index (BMI)

The patients were classified into high and low-BMI groups above and below 25 based on the diagnostic criteria of the Japan Society for the Study of Obesity⁴⁾.

4. Anemia

Anemia was diagnosed with preoperative hemoglobin based on the diagnostic criteria of

Table 2 Surgical wound classification⁸⁾⁹⁾

<u>Class I : Clean</u>
An uninfected operative wound in which no inflammation is encountered and the respiratory, Alimentary, genital or uninfected urinary tract is not entered. In addition, clean wounds are Primarily closed and, if necessary, drainage with closed drainage. Operative incisional wounds that follow nonpenetrating(blunt) trauma should be included in this category if they meet the criteria.
<u>Class II : Clean-contaminated</u>
An operative wound in which the respiratory, alimentary, genital, or urinary tract are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.
<u>Class III : Contaminated</u>
Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (e.g.,open cardiac message) or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered are included in this category.
<u>Class IV : Dirty-infected</u>
Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative Infection were present in the operative field before the operation.

our hospital (male : 13.4 g/dl ; female : 11.1 g/dl).

5. Nutritional condition

Nutritional condition was determined with preoperative albumin based on the diagnostic criteria of our hospital and patients were classified into two groups (above or below 4.0 g/dL).

6. Respiratory function

Respiratory function was diagnosed with preoperative PaO₂ and the patients were classified into two groups with a cut-off value of 86 mmHg.

7. Preoperative systemic condition

Preoperative systemic condition was diagnosed in accordance with the criteria for physical status of the American Society of Anesthesiologists (ASA)⁶⁾ and the patients were classified into two groups (No-risk group : 2 and less, Risk group : 3 and more) based on the Risk Index for SSI National Nosocomial Infections Surveillance (NNIS) of the CDC⁶⁾ (Table 1).

8. Diabetes

Patients who were being treated for diabetes

and patients whose fasting blood glucose level was 110 mg/dl and higher on admission were considered diabetic patients.

II. Surgical factors

1. Operation time

The patients were classified into two groups with a limit of 180 minutes, which was defined as “risky” on colon surgery by the NNIS.

2. Bleeding volume

The patients were classified into two groups according to whether or not they lost a volume of 200 ml of blood intraoperatively.

3. Procedure type

Procedure types were classified based on the Japanese Classification of Colorectal Carcinoma (6th edition)⁷⁾. The breakdown of procedure types was as follows : 44 cases of anterior resection ; 8 cases of abdominoperineal resection ; 14 cases of sigmoidectomy ; 3 cases of left hemicolectomy ; 22 cases of right hemicolectomy ; 3 cases of ileocecal resection ; 7 cases of subtotal colectomy and 1 case of total colectomy. All cases underwent open laparotomy.

Table 3 Patient characteristics

Characteristics	SSI (+) (n=22)	SSI (-) (n=80)	p value
Sex			
male	54.5% (12)	63.8% (51)	0.431
female	45.5% (10)	36.2% (29)	
Age (years old)			
66 >	45.5% (10)	50.0% (40)	0.760
66 ≤	54.5% (12)	50.0% (40)	
SCF*			
18mm >	27.3% (6)	58.8% (47)	0.009
18mm ≤	72.7% (16)	41.2% (33)	
BMI**			
25 >	59.1% (13)	78.8% (63)	0.061
25 ≤	40.9% (9)	21.2% (17)	
Anemia			
(-)	36.4% (8)	51.3% (41)	0.216
(+)	63.6% (14)	48.7% (39)	
Alb			
4.0 g/dl >	72.7% (16)	57.5% (46)	0.195
4.0 g/dl ≤	27.3% (6)	42.5% (34)	
PaO ₂			
86mmHg >	72.7% (16)	42.5% (34)	0.012
86mmHg ≤	27.3% (6)	57.5% (46)	
ASA***			
2 ≥	95.5% (21)	92.5% (74)	0.627
3 ≤	4.5% (1)	7.5% (6)	
Diabetes			
(-)	81.8% (18)	87.5% (70)	0.493
(+)	18.2% (4)	12.5% (10)	

* Subcutaneous fat ** Body Mass Index *** American Society of Anesthesiologist

As for the patient factors of age, SCF and PaO₂ and surgical factor of bleeding volume, the patients were classified into two groups to show the minimum differences in the number of patients between the groups.

Surgical wounds of all patients were classified into Class II (clean-contaminated) based on the classification for surgical wounds in SSI Surveillance by the CDC⁽⁸⁾⁽⁹⁾ (Table 2).

Statistical analyses were conducted using SPSS II for Windows Version 11.0J (SPSS Inc.). χ^2 test was used for univariate analysis (significance test between 2 groups) and logistic regression analysis was used for multivariate analysis (significance test for multigroup com-

parison). The significance level was considered to be 0.05.

Results

1. Univariate analysis

I. Patient factors (Table 3)

1) Sex

The SSI (+) group comprised 12 males (54.5%) and 10 females (45.5%) and the SSI (-) group consisted of 51 males (63.8%) and 29 females (36.2%), suggesting no significant differences between the groups.

2) Age

In the group aged less than 66 years, there were 10 patients (45.5%) in the SSI (+) group

and 40 patients (50.0%) in the SSI (–) group. In the group aged 66 years and more, there were 12 patients (54.5%) in the SSI (+) group and 40 patients (50.0%) in the SSI (–) group. No significant differences in SSI were found between the groups by age.

3) Obesity

a) SCF

In the group with SCF less than 18 mm, there were 6 patients (27.3%) in the SSI (+) group and 47 patients (58.8%) in the SSI (–) group. In the group with SCF of 18 mm or more, there were 16 patients (72.7%) in the SSI (+) group and 33 patients (41.2%) in the SSI (–) group. The incidence of SSI was significantly higher in the group with SCF of 18 mm or more ($p=0.009$).

b) BMI

In the group with a BMI of less than 25, there were 13 patients (59.1%) in the SSI (+) group and 63 patients (78.8%) in the SSI (–) group. In the group with a BMI of 25 or more, there were 9 patients (40.9%) in the SSI (+) group and 17 patients (21.2%) in SSI (–) group. The incidence of SSI was higher in the group with a BMI of 25 or more without any significant difference ($p=0.061$).

4) Anemia

In the group with anemia (male : 13.4 g/dl and lower ; female : 11.1 g/dl and lower), there were 14 patients (63.6%) in the SSI (+) group and 39 patients (48.7%) in the SSI (–) group. In the group without anemia, there were 8 patients (36.4%) in the SSI (+) group and 41 patients (51.3%) in the SSI (–) group. No significant differences in the incidence of SSI were between the groups by anemia.

5) Nutritional condition

In the group with albumin levels of less than 4.0 g/dl, there were 16 patients (72.7%) in the SSI (+) group and 46 patients (57.5%) in the SSI (–) group. In the group with albumin of 4.0 g/

dl and higher, there were 6 patients (27.3%) in the SSI (+) group and 34 patients (42.5%) in the SSI (–) group. No significant differences in the incidence of SSI were found between the groups by nutritional condition.

6) Respiratory function.

In the group with preoperative PaO_2 of less than 86 mmHg, there were 16 patients (72.7%) in the SSI (+) group and 34 patients (42.5%) in the SSI (–) group. In the group with preoperative PaO_2 of 86 mmHg and higher, there were 6 patients (27.3%) in the SSI (+) group and 46 patients (57.5%) in the SSI (–) group. The incidence of SSI was significantly higher in the group with preoperative PaO_2 of less than 86 mmHg ($p=0.012$).

7) ASA physical status

In the group with ASA physical status of less than 2, there were 21 patients (95.5%) in the SSI (+) group and 74 patients (92.5%) in the SSI (–) group. In the group with ASA physical status of 3 and higher, there was 1 patient (4.5%) in the SSI (+) group and 6 patients (7.5%) in the SSI (–) group. No significant differences in the incidence of SSI were found between the groups by ASA physical status.

8) Diabetes

In the non-diabetic group, there were 18 patients (81.8%) in the SSI (+) and 70 patients (87.5%) in the SSI (–) group. In the diabetic group, there were 4 patients (18.2%) in the SSI (+) group and 10 patients (12.5%) in the SSI (–) group. No significant differences in the incidence of SSI were found between the groups according to diabetes.

II. Surgical factors (Table 4)

1) Operation time

In the group with an operation time of less than 180 minutes, there were 7 patients (31.8%) in the SSI (+) group and 34 patients (42.5%) in the SSI (–) group. In the group with an operation time of 180 minutes and longer, there were

Table 4 Operative characteristics

Characteristics	SSI (+) (n=22)	SSI (-) (n=80)	p value
Operation time			
180 min >	31.8% (7)	42.5% (34)	0.365
180 min ≤	68.2% (15)	57.5% (46)	
Bleeding volume			
200ml >	45.5% (10)	55.0% (44)	0.427
200ml ≤	55.5% (12)	45.0% (36)	
Procedure type			
Anterior resection	27.3% (6)	47.5% (38)	0.192
Abdominoperineal resection	18.2% (4)	5.0% (4)	
Sigmoidectomy	13.6% (3)	13.7% (11)	
Left hemicolectomy	9.1% (2)	1.3% (1)	
Right hemicolectomy	18.2% (4)	22.5% (18)	
Ileocecal resection	4.5% (1)	2.5% (2)	
Partial colectomy	9.1% (2)	6.2% (5)	
Total colectomy	0.0% (0)	1.3% (1)	

15 patients (68.2%) in the SSI (+) group and 46 patients (57.5%) in the SSI (-) group. No significant differences in the incidence of SSI were found between the groups by operation time.

2) Bleeding volume

In the group with a bleeding volume less than 200 ml, there were 10 patients (45.5%) in the SSI (+) group and 44 patients (55.0%) in the SSI (-) group. In the group with a bleeding volume of 200 ml and more, there were 12 patients (55.5%) in the SSI (+) group and 36 patients (45.0%) in the SSI (-) group. No significant differences in the incidence of SSI were found between the groups by bleeding volume.

3) Procedure type

In the anterior resection group, 6 (27.3%) of 44 patients were in the SSI (+) group, and in the abdominoperineal resection group, 4 (18.2%) of 8 patients were in the SSI (+) group. In the sigmoidectomy group, 3 (13.6%) of 14 patients were in the SSI (+) group. In the left hemicolectomy group, 2 (9.1%) of 3 patients were in the SSI (+) group, and in the right hemicolectomy group, 4 (18.2%) of 22 patients were SSI (+). In the ileocecal resection, 1 (4.5%) of 3 patients was in the SSI (+) group, and in the subtotal colectomy group 2 (9.1%) of 7 patients were in the SSI (+) group. None of the

Table 5 Multivariable analysis

	OR	CI (95%)	p value
Sex	0.933	0.244—3.567	0.933
Age	1.141	0.322—4.040	0.838
SCF*	5.873	1.498—23.030	0.011
BMI**	1.659	0.425—6.477	0.466
Anemia	0.574	0.168—1.964	0.376
Alb	0.491	0.127—1.898	0.302
PaO ₂	4.997	1.301—19.197	0.019
ASA***	0.336	0.014—8.224	0.504
Diabetes	1.251	0.259—6.075	0.779
Operation time	1.790	0.431—7.438	0.423
Bleeding volume	1.492	0.382—5.818	0.565
Procedure type	1.247	0.976—1.593	0.078

* Subcutaneous fat ** Body Mass Index *** American Society of Anesthesiologist

patients (0%) who underwent total colectomy were in the SSI (+) group. No significant differences in the incidence of SSI were found between the groups by procedure type.

2. Multivariate analysis (Table 5)

All items that underwent univariate analysis were also evaluated with the multivariate analysis.

Of patient factors, the odds-ratio, 95% confidence interval and p-values were 5.873, 1.498—23.030 and 0.011 in the high-SCF group and 4.997 1.301—19.197 and 0.019 in the low-preoperative PaO₂ group, respectively. Therefore, high-SCF and low-preoperative PaO₂ were selected as risk factors increasing the incidence of incisional SSI.

Discussion

SSI comprises the third highest (14% to 16%) hospital infectious disease¹⁰⁾ and 38% of hospital infectious diseases in patients who underwent surgery¹¹⁾. In particular, incisional SSI comprises two-thirds of total SSI¹¹⁾ and its development increases medical expenses¹²⁾ and prolongs hospitalization periods¹³⁾, which causes physical and mental strain on patients. Therefore, if the factors that contribute to the

onset of incisional SSI and clarified, reduction of the incidence of SSI and medical expenses could be helpful for patients.

The NNIS system indicated SSI risk factors, i. e., (1) duration of surgery more than the limited hours (180 minutes in colon surgery); (2) 3 and higher ASA physical status score, and (3) Class 3 or 4 (contaminated or infected) operation. In this study, no significant differences in the incidence of SSI were found between the groups according to operation time and ASA physical status. Nishioka et al.¹⁴⁾ reported no significant differences in the incidence of SSI between the groups according to operation time and ASA physical status, and the validity of the NNIS SSI risk factors has not been confirmed in Japan. In this study, no significant differences in the incidence of SSI were shown between the groups by sex, age, anemia, nutritional condition and diabetes (patient factors) and bleeding volume and procedure type (surgical factors). The CDC Guideline (1999)¹⁵⁾ indicated that age, nutritional condition, diabetes and operation time were risk factors for SSI. Some studies reported that significant differences in the incidence of SSI were found between the groups based upon anemia, procedure type and bleeding volume^{16)~18)}. In this study, the incidence of SSI was high in the high-BMI group, however, no significant differences were found. In studies in Europe and the United States¹²⁾¹⁹⁾, the incidence of SSI was significantly high in the high-BMI group. This discrepancy was related to the difference in obesity rate, i. e., in Europe and the United States, 30% of people had a BMI 30 or more but this proportion only comprised approximately 3% of the Japanese subjects²⁰⁾. As for SCF which was an index for obesity used in this study in addition to BMI, surgeons know empirically that incisional SSI develops frequently in patients with high SCF. However, few studies

have confirmed the relationship between SCF and the incidence of incisional SSI. The results of this study showed significant difference between SCF and the incidence of incisional SSI. BMI has been adopted as an index for obesity in most countries. However, in East Asia including Japan and Southeast Asia²¹⁾ where there are few obese people with a BMI of 30 or more, SCF has been considered more useful as a risk factor for the incidence of incisional SSI compared with BMI.

Inadequate oxygenation of the hypodermal tissue²²⁾ was one of the reasons for the high incidence of incisional SSI in the high-SCF group. Barbara et al.²³⁾ reported that wounds and tissues of obese patients were hypoxic and that insufficient oxygenation in the hypodermal tissue increased portoperative infection in obese patients.

The results of our study also demonstrated a significantly high incidence of incisional SSI in the low preoperative PaO₂ group, which suggested that respiratory dysfunction inhibited oxygenation in tissues during and after surgery, leading to infection.

The incidence of incisional SSI in the United States ranged from 3% to 30% (mean: approximately 10%)¹²⁾. However, the incidence in this study was 21.6%, slightly higher. One possible reason is that the admission period in the United States is shorter than that in Japan and surveillance after discharge were not conducted for a sufficiently long duration²⁴⁾.

SSI has an adverse effect on patients and is an important problem for surgeons. Therefore, in accordance with the NNIS, the Japanese Society of Environmental Infections devised the nosocomial infection surveillance system in Japan in 1998 and has been conducting surveillance of SSI²⁵⁾. It was reported that introduction of this system reduced the incidence of SSI²⁶⁾.

Various devices and procedures have been developed to reduce the incidence of incisional SSI as follows: use of protection for wounds and its surrounding including a wound protector²⁷⁾ and bandage protector²⁸⁾, lavage of the hypodermal tissue immediately before closure of the skin using warm saline and sterilized sponge¹⁾, insertion of a Penrose drain and an aspiration drain into the hypodermal tissue²⁹⁾.

Considering our results, the high-SCF and low-preoperative PaO₂ patients were considered a high-risk group for incisional SSI, and the above preventive procedures would be effective for reduction of the incidence of incisional SSI.

Conclusion

It was suggested that the incidence of incisional SSI was higher in patients with thick subcutaneous fat.

It was suggested that the incidence of incisional SSI was higher in patients with low-preoperative PaO₂.

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