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Surgical Site Infection: Re-assessment of the Risk Factors

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Rezumat

Infecția de plagă chirurgicală: reevaluarea factorilor de risc

Introducere: Infecția plăgii chirurgicale (SSI) este o complicație bine-cunoscută în chirurgia generală. Deși rata globală a SSI-urilor este relativ joasă, acestea sunt cele mai frecvent întâlnite infecții nosocomiale. Infecțiile de plagă chirurgicală afectează evoluția pacientului și costurile de îngrijire medicală.
Metode: Au fost incluși în studiu pacienții care au suferit intervenții chirurgicale generale în perioada 2003-2009. Infecțiile de plagă chirurgicală au fost diagnosticate pe baza criteriilor National Nosocomial Infection Surveillance System (NNIS). Pacienții au fost repartizați în două grupuri: SSI (+) and SSI (-). Datele demografice, comorbiditățile, detaliile procedurale, precum și tipurile de infecție a plăgii chirurgicale și tratamentul aferent au fost evaluate. S-a efectuat o analiză multivariată pentru a determina factorii de risc independenți pentru dezvoltarea de SSI.
Rezultate: În total, 4690 de pacienți au fost incluși în studiu. Rata globală a SSI-urilor a fost de 4,09% (192/4690). Chirurgia colorectală a fost asociată cu cea mai înaltă rată a SSI-urilor (9.43%), urmată de tratamentul chirurgical al chistului pilonidal (8,79%), chirurgia tractului gastrointestinal superior (GI) (8,09%), chirurgia hepatobiliară (6,68%), tratamentul chirurgical al herniilor (0,78%) și al glandelor mamare și tiroidiene (0,3%). Tipul procedurii (cura chirurgicală a chistului pilonidal, chirurgia colorectală, hepatobiliară și a tractului gastrointestinal superior), spitalizarea preoperatorie prelungită, un scor ASA ridicat, chirurgia de urgență, gradul de contaminare al plăgii, experiența chirurgului, durata operatorie prelungită, prezența drenurilor chirurgicale și transfuziile intraoperatorii au fost identificate ca factori de risc independenți pentru dezvoltarea de infecțiiale plăgilor chirurgicale ($p < 0,05$).
Concluzii: Majoritatea factorilor de risc determinați au fost dependenți de chirurg și de procedura chirurgicală. O rată redusă a SSI-urilor și rezultate finale mai bune pot fi obținute prin controlul factorilor de risc modificabili.

Cuvinte cheie: infecția plăgii chirurgicale, factor de risc, chirurgie generală

Abstract

Background: Surgical site infection (SSI) is a well-known complication of general surgery. Although overall SSI rate is relatively low, it is the most common nosocomial infection. SSI adversely affects patient outcomes and healthcare costs.
Methods: Patients who underwent general surgical procedures between 2003 and 2009 were included in the study. SSI diagnosed based on the National Nosocomial Infection Surveillance System (NNIS) criteria. Patients were classified into two groups: SSI (+) and SSI (-). Patient demographics, co-morbidities, procedural details, and SSI type and treatment were evaluated. Multivariate analysis was performed to determine independent risk factors of SSI.
Results: In total, 4690 patients were included. Overall SSI rate was 4.09% (192/ 4690). Colorectal surgery was

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associated with the highest SSI rate (9.43%) followed by pilonidal sinus (8.79%), upper gastrointestinal (GI) (8.09%), hepatobiliary (6.68%), hernia (0.78%), and breast-thyroid (0.3%) surgery. Procedure type (pilonidal sinus, colorectal, hepatobiliary and upper GI surgery), prolonged preoperative hospital stay, higher ASA score, emergency surgery, dirty- infected wound class, experienced surgeon, prolonged operating time, presence of surgical drains, and intraoperative transfusion were determined as independent risk factors of SSI ($p < 0.05$).

Conclusion: Most of the determined risk factors were surgeon and procedure related. Reduced SSI rate and better outcomes can be achieved by controlling modifiable risk factors.

Key words: Surgical site infection, risk factor, general surgery

Introduction

Regulations of antisepsis were described by Joseph Lister in 1867; however, surgical site infection (SSI) is still a common problem in surgical patients despite of the developments in medicine (1). It is estimated that 5% of 30 million surgeries performed each year are complicated with SSI (2). Although overall SSI risk is low, SSI is the most common nosocomial infection with the percentage of 38% (3).

Centers for Disease Control and Prevention (CDC) defined SSI as infection related to an operation that occurs at the surgical incision within 30 days after surgery, or within 90 days if prosthetic material implanted (4). SSI is classified as either incisional (involvement of skin only, or subcutaneous tissues with skin), or organ-space (any part of the body other than incision site layers, that involved in the operation) according to the National Nosocomial Infection Surveillance System (NNIS) criteria (5). Of all SSI's, nearly two-thirds are incisional, and one-third are organ-space.

SSI is associated with increased morbidity and mortality, length of hospital stay, and healthcare costs (2, 6-8). Mortality rate is doubled, and readmissions are five times more frequent in patients who develop SSI (9). It is reported that 77% of deaths in patients with nosocomial SSI were related to the infection (5). In Turkey, SSI is related with approximately 600$ rise of hospital costs per patient (6).

Since it is the most common nosocomial infection and associated with worse outcomes, SSI and related risk factors are major topics of surgical research. In this study, we aimed to determine independent risk factors of SSI in a large cohort of general surgical procedures.

Material and Methods

Patients who underwent general surgical procedures in our department from June 2003 to June 2009 were included in the study. The diagnosis of SSI was established according to NNIS criteria. Incisional SSI's were classified into two groups: superficial (skin, and subcutaneous tissue involved) incisional SSI, and deep (muscle, and fascia layers involved) incisional SSI.

Surgical procedures were investigated in 6 groups: hernia, pilonidal sinus, breast- thyroid, upper gastrointestinal (GI), hepatobiliary, and colorectal. Patient demographics, co-morbidities, American Society of Anesthesiologists (ASA) class, weight loss, obesity, steroid use, preoperative length of hospital stay, antimicrobial prophylaxis (whether appropriate, or not), preoperative hair removal, wound classification (clean, clean-contaminated, contaminated, infected),preoperative hair removal, operative data (surgeon's experience, incision device, use of drain, use of prosthetic mesh, operating time, intraoperative blood transfusion) were documented. Type of SSI (superficial incisional, deep incisional, or organ/ space), time of diagnosis, treatment (antibiotics, open wound dressings, and drainage) type were also documented. Two groups were identified: SSI (+) group, and SSI (-) group.

In our institution, cephazolin is used for antimicrobial prophylaxis when necessary. Additional doses are administrated when the operating time is longer than 4 hours. Intravenous metronidazole is used during colorectal procedures in addition to cephazolin. Prophylactic antibiotic administration within 30 minutes before incision, or at the time of anesthesia induction was accepted appropriate. Weight loss was defined as more than 10% loss of body weight within 6 months before surgery. Preoperative hair removal, if necessary, is performed at the operating room (OR) with razor.All incisions were performed with scalpel or electro-cautery. Follow-up time for the diagnosis of SSI was 30 days after hospital discharge.

Categorical variables were reported as frequency (%) and quantitative variables were reported as mean± standard deviation except otherwise noted. The significance of differences between categorical variables was analyzed using the Fisher's Exact or Chi-square tests, and quantitative and ordinal variables by using the Wilcoxon rank sum test. A logistic regression analysis was performed in order to determine independent risk factors of SSI. A p value of <0.05 was considered statistically significant. Statistical analyses were performed with JMP (JMP version 10, SAS Institute, Cary, NC) statistical analysis software.

Results

In total, there were 4690 patients. Overall SSI rate was 4.09%. Demographics, characteristics, and co-morbidities of the patients are shown in *Table 1*.

Preoperative length of hospital stay varied 1 to 2 days in the majority (55.7%) of the patients. SSI rate was 13.1% in patients with 8 or more preoperative length of hospital stay, while it was 2% for the patients who underwent surgery at the day of admission. There was statistically significant difference between the groups according to the preoperative length of hospital stay ($p < 0.0001$).

Table 1. *Demographic data, and patient co-morbidities*

	SSI[a] (-) n (%)	SSI (+) n (%)	P value
Age			0.057
≤44	1098 (24.4)	32 (16.7)	
45-64	1559 (34.7)	70 (36.5)	
65-74	1128 (25.1)	30 (15.6)	
>75	713 (15.9)	60 (31.3)	
Gender			0.0003
Female	2186 (48.6)	68 (35.4)	
Male	2312 (51.4)	124 (64.6)	
Body Mass Index (kg/m^2)			0.82
< 30	4054 (90.1)	174 (35.4)	
≥ 30	443 (9.8)	18 (64.6)	
Procedure			<0.0001
Hernia	1400 (31.1)	11 (5.7)	
Hepatobiliary	1103 (24.5)	79 (41.1)	
Breast- thyroid	985 (21.9)	3 (1.6)	
Colorectal	586 (13)	61 (31.8)	
Upper GI[b]	341 (7.6)	30 (15.6)	
Pilonidal Sinus	83 (1.8)	8 (4.2)	
Admission type			<0.0001
Emergency	481 (10.7)	59 (30.7)	
Elective	4017 (89.3)	133 (69.3)	
ASA[c] score			<0.0001
I	2383 (53)	66 (34.4)	
II	895 (19.9)	51 (26.6)	
III	752 (16.7)	44 (22.9)	
IV	445 (9.9)	29 (15.1)	
V	23 (0.5)	2 (1)	
Steroid Use			0.58
Yes	150 (3.3)	5 (2.6)	
No	4348 (96.7)	187 (97.4)	
Current Smoker			0.49
Yes	1716 (38.2)	78 (40.6)	
No	2782 (61.8)	114 (59.4)	
Malignancy			<0.0001
Yes	910 (20.2)	75 (39.1)	
No	3588 (79.8)	117 (60.9)	
COPD[d]			0.1
Yes	250 (5.6)	16 (8.3)	
No	4248 (94.4)	176 (91.7)	
Diabetes Mellitus			0.003
Yes	326 (7.2)	25 (13)	
No	4172 (92.8)	167 (87)	

a - Surgical site infection, b - Gastrointestinal, c - American Society of Anesthesiologists, d - Chronic obstructive pulmonary disease

Preoperative hair removal was performed for only male patients. Hair removal was performed in 63.4% of males. SSI rate was 7.1%, for hair removal performed groupwhile it was 1.7% for no hair removal group ($p < 0.0001$).

While majority of the patients (74%) were administrated appropriate antimicrobial prophylaxis (AMP), it was inappropriate in only 5.2% of the patients. There were also patients (20.8%) who underwent clean procedures, and they were not administrated AMP. SSI rates were significantly different between three groups (appropriate AMP group: 5.2%, inappropriate AMP group: 3.3%, no AMP group: 0.5%, $p < 0.0001$).Wound classifications, and operative characteristics of the patients were shown in *Table 2*.

Table 2. *Wound classification, and operative details for the study cohort*

	SSI (-) n (%)	SSI (+) n (%)	P value
Wound Classification			<0.0001
Clean	1529 (34)	14 (7.3)	
Clean-contaminated	1154 (25.7)	73 (38)	
Contaminated	1455 (32.3)	72 (37.5)	
Dirty-infected	360 (8)	33 (17.2)	
Surgeon			<0.0001
Attending surgeon	2198 (48.9)	131 (68.2)	
Senior resident	1152 (25.6)	53 (27.6)	
Junior resident	1148 (25.5)	8 (4.2)	
Incision device			0.01
Scalpel	4069 (90.5)	163 (84.9)	
Electro-cautery	429 (9.5)	29 (15.1)	
Operating time			<0.0001
< 1 hour	726 (16.1)	12 (6.2)	
1- 2 hours	1748 (38.9)	70 (36.5)	
2- 4 hours	1893 (42.1)	81 (42.2)	
>4 hours	131 (2.9)	29 (15.1)	
Drain			<0.0001
Yes	1530 (34)	134 (69.8)	
No	2968 (66)	58 (30.2)	
Mesh			<0.0001
Yes	1479 (32.9)	17 (8.9)	
No	3019 (67.1)	175 (91.1)	
Intraoperative transfusion			<0.0001
Yes	340 (7.6)	38 (19.8)	
No	4158 (92.4)	154 (80.2)	

Procedure type (pilonidal sinus, colorectal, hepatobiliary, upper GI), preoperative length of hospital stay, ASA score ≥ III, emergency admission, infected wound class, attending surgeon, operating time more than 4 hours, use of drain, and intraoperative blood transfusion were determined as independent risk factors of SSI in the multivariate analysis (*Table 3*).

Superficial incisional was the most common SSI type (42.19%), followed by deep incisional SSI (40.1%), and organ-space (17.71%). Diagnosis time was between postoperative days 3 and 7 in the most of superficial incisional (76.54%) and deep incisional (79.22%) SSI's. However, 70.59% of organ-space SSI's were diagnosed after postoperative day 7. There was a significant difference between the groups according to the SSI diagnosis time ($p < 0.0001$).

Most of the patients with superficial incisional (75.31%) and deep incisional (79.22%) SSI's were diagnosed before hospital discharge. Besides, diagnosis was established after hospital discharge in 47.06% of the patients with organ-space SSI. The difference between the groups was significant ($p = 0.0132$).The most common microorganism isolated in the wound cultures was Escherichia Coli (22.8%) followed by Enterococcus spp. (19.1%), KlebsiellaPneumoniae (8.5%), Enterobacter spp. (7.7%), coagulase negative Staphylococci (7.3%), Pseudomonas Aeruginosa (7.2%), Staphilococcus Aureus (4.9%), Proteus Vulgaris (4.4%), Morganella Morganii (4.2%), Acinetobacter Baumanii (3.6%), Streptococcus spp. (3.5%), CitrobacterFreundii (2.6%), Candida spp. (2.3%),

Table 3. *Independent risk factors for surgical site infection*

	Odds Ratio	Lower 95%	Upper 95%	P value
Procedure type				
Breast- thyroid	Referent			
Pilonidal sinus	18.8	4.14	104.47	0.0001
Colorectal	8.19	2.3	39.18	0.0007
Hepatobiliary	7.34	2.14	34.32	0.001
Upper GI	6.55	1.82	31.46	0.0031
Preoperative length of hospital stay				
0 day	Referent			
1- 2 days	2.12	1.28	3.6	0.0029
3- 7 days	2.72	1.5	5.01	0.0009
8 days	2.76	1.46	5.28 0.0019	
ASA[a] score				
I-II	Referent			
III-V	2.58	1.79	3.7	<0.0001
Admission type				
Elective	Referent			
Emergency	2.41	1.57	3.67	<. 0001
Wound classification				
Clean	Referent			
Infected	3.16	1.47	7.19	0.003
Surgeon				
Attending surgeon	Referent			
Junior resident	0.17	0.07	0.38	<. 0001
Operating time				
1 hour	Referent			
>4 hours	3.48	1.54	8.21	0.0026
Drain				
No	Referent			
Yes	1.78	1.22	2.62	0.003
Intraoperative transfusion				
No	Referent			
Yes	2.45	1.52	3.9	0.0003

a - American Society of Anesthesiologists

Serratia Marescens (1.2%), Stenotrophomonas Maltophilia (0.7%).

Drainage was necessary in 14.58% of the patients, while 53.13% were treated with wound dressings and antibiotics, and 32.29% were treated with only wound dressings. Treatment duration for SSI was significantly longer in organ-space SSI, followed by deep and superficial incisional SSI (20.41±21.5 days, 12.76±8.08days, 12.44±10.6 days, respectively; p= 0.0025).

Discussions

SSI is the most common nosocomial infection among surgical patients, and it is associated with increased risk of morbidity and mortality. Additionally, health-care costs are adversely influenced by the worse outcomes related to SSI. There is a complex interaction of patient, procedure, and surgeon related risk factors in the SSI etiology. However, it is not always possible to eliminate all risk factors.We determined several risk factors in this study, and most of them were procedure and surgeon related.

ASA score is not only an index assessing the preoperative physical status of the patient, but also an important component of SSI risk prediction (10). There are several studies suggestinghigh ASA score as a predictor of SSI (11, 12). Analysis of our data did not show DM, COPD, and malignancy as independentrisk factors affecting SSI rate, however, ASA score ≥ III was associated with increased risk of SSI. In the present study, preoperative length of stay was determined as another risk factor. It was reported that SSI risk would increase 1.1 times for an extra 3 days of preoperative hospital stay (13). Colonization of pathogen microorganisms during the prolonged preoperative hospital stay may be responsible for the increased SSI risk.

Lower GI procedures were reported to be associated with a higher risk of SSI comparing to the upper GI procedures (14). GI tract has a bacterial flora, and GI procedures are classified as clean-contaminated wounds, or even contaminated in certain circumstances.On the other hand, breast, thyroid, and hernia surgeries are considered as clean wounds (1). Reported SSI rates were 2.58% for clean, 6.67% for clean-contaminated, 8.61% for contaminated, and 11.8% for infected wound classes (15). Increased procedure specific SSI risk in GI procedures may be reflecting the impact of surgical wound class.

It was an interesting finding that surgeon experience was determined as a risk factor in the current study. Attending surgeonsmore frequently participate in complicated procedures comparing to residents. Thus, the increased SSI rate is not associated with only the surgeon's training level and volume, but also the increased incidence of patient related risk factors in patients who are undergoing complicated procedures. We believe that, increased SSI riskfor experienced surgeons should beconsidered as a factor indicating the difficulty of procedure.

Emergency surgery, operating time longer than 4 hours, use of drains, and intraoperative blood transfusion were other surgery related risk factors of SSI. There are several previous studiesdetermined those variables as independent risk factors (16-19). Increased risk of SSI due to prolonged operating time may be associated with the complexity of the procedure. Use of implants, prosthetic materials, and drains may lead increased SSI risk through colonization of microorganisms.The immunosuppressive impact of intraoperative blood transfusion may give rise to the risk of SSI. However, all of those risk factors are modifiable, with exception of the emergency surgery. Perioperative control of those factors; attempts to reduce operating time, avoiding use of unnecessary drains, and determining the circumstances for necessary blood transfusion may provide potential improvements in outcomes.

Its retrospective nature is the main limitation of this study. As being a tertiary referral center, there may be a selection bias for the subjects.However, it is clinically valuable due to the large sample size.

Conclusions

SSI is a well-known complication of general surgery that is adverselyinfluencing outcomes of patients. Majority of the risk factors we have determined in this study were procedure

and surgeon related. Thus, improvement in the outcomes and reduced SSI rate can be achieved with the control of modifiablerisk factors.

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Conflicts of interest

The authors have nothing to disclose.

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