

Evaluating Risk Factors of Surgical Site Infection After Surgery in Orthopedic Patients of Dr. Shariati Hospital, During 2006 - 2012

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Background: Surgical site infection (SSI) is defined as an infection that occurs at or near a surgical incision, within 30 days of the procedure, or within one year, if an implant is left in place. They are the leading cause of nosocomial infections after surgery, accounting for nearly 40% of nosocomial infections in surgical patients. Identifying the risk factors that increase the probability of SSI can help us take preventive measures and design control strategies, leading to a decrease in the rate of infection.

Objectives: We aimed to assess the effects of probable SSI risk factors, making it possible to control these variables and to avoid complications of SSI, thereby decreasing its direct and indirect costs.

Patients and Methods: In this nested case-control retrospective study, 208 patients, who underwent orthopedic surgery in Dr. Shariati Hospital, Tehran, Iran, during 2006 - 2012, were included, as the study population. Data were gathered from the patients' records and were analyzed by SPSS v.20 software via independent samples t test, chi-square test and binary logistic regression analysis.

Results: The mean age of the study population was 40.88 years, with a 2-year-old, as the youngest subject, and an 85-year-old, as the oldest. Statistical significance was achieved at a $P < 0.05$ and the differences observed between the two groups of SSI+ and SSI- were found to be statistically significant regarding opium addiction ($P = 0.035$), smoking ($P = 0.009$), blood transfusion ($P < 0.001$), duration of surgery ($P = 0.003$), duration of hospitalization ($P = 0.013$). According to multivariate logistic regression analysis, independent risk factors of SSI included smoking ($P = 0.002$, OR = 0.35) and blood transfusion ($P = 0.001$, OR = 0.24).

Conclusions: We found smoking and blood transfusion to be independent risk factors for SSI, whereas, regarding the disagreements between the results of various studies, further investigations are required to identify absolute independent risk factors of SSI.

Keywords: Surgical Wound Infection; Risk Factors; Orthopedics; Smoking; Blood Transfusion

1. Background

Surgical site infection (SSI) is defined as an infection that occurs at or near a surgical incision within 30 days of the procedure, or within one year, if an implant is left in place (1, 2). The centers for disease control and prevention reported an annual incidence of 500000 new patients with SSI in the USA (3). They are the leading cause of nosocomial infections after surgery, accounting for nearly 40% of nosocomial infections, in surgical patients (2). Cost of care for the first 8 weeks after the surgery, in patients with SSI, is nearly three times the cost for patients without this problem (3). These infections decrease the quality of life in the patients (4) and, each year, increase days of hospitalization by approximately 3.7 million days and they account for an annual extra health care cost of 1.6 billion dollars (5). Furthermore, the risk of readmission, in patients with SSI, is five times the patients without this condition, and they have 60% more chance of requiring an intensive care unit admission, while the mortality rate among them is twice the patients without SSI (6).

During recent decades, multiple risk factors have been

suggested for SSI in the retrospective case control and quasi-experimental studies. Of these variables, the ones that have been shown to be independent risk factors for SSI, in multiple regression analyses, include diabetes, age (7), obesity (8), and not using antibiotics or improper use of these drugs (9). Identifying the risk factors that increase the probability of SSI can help us take preventive measures and design control strategies, leading to a decrease in rate of infection.

2. Objectives

We aimed to assess the effects of probable SSI risk factors, to better control these variables in so that complications of SSI could be avoided and to decrease its direct and indirect costs.

3. Patients and Methods

This nested case-control retrospective study was conducted on patients who underwent orthopedic surgery in

Dr. Shariati Hospital, Tehran, Iran, during 2006 - 2012. The study population included all the patients with SSI, as the case group, and a matched control group. Regarding the main objective of this survey and evaluation of nine possible risk factors, 208 patients were included. The inclusion criteria were the following: orthopedic patients with or without SSI, according to its definition (an infection that occurs at or near a surgical incision within 30 days of the procedure or within one year if an implant is left in place), complete and thorough medical records, no prior surgeries at the site of infection or other types of infections.

Medical records of the patients, who underwent orthopedic surgeries during this period, were reviewed and all subjects who met the criteria for SSI were selected, as the case group, including 107 patients. For the control group, 101 patients without SSI were chosen.

Data gathered from the patients' records comprised of two sets of information, demographic characteristics and medical history of the patients and information regarding their surgery. The first set of data included age, smoking, opium addiction, past medical history of diabetes, rheumatoid arthritis and chronic kidney disease. Surgical information included site of surgery, type of surgery, duration of surgery, duration of hospitalization, the settings of the surgery (i.e. emergent or not), blood transfusion before, during, or after surgery, the time passed from the surgery until the patient presented with SSI and wound depth.

Data were entered into SPSS v.20 software (SPSS Inc., Chicago, IL, USA) and were analyzed via independent samples t-test, chi-square test and binary logistic regression analysis.

A $P < 0.05$ was considered to be statistically significant.

4. Results

As mentioned, 107 patients with SSI and 101 subjects without SSI were included. The mean age of all the subjects was 40.88 years, with the minimum and maximum of 2 and 85 years, respectively. The mean age in SSI+ group was 43.46 years and in the SSI- group was 38.15 years, although the differences were not found to be statistically significant. There was also no statistical difference between both groups concerning gender and type of surgeries (elective, urgent or emergent) ($P > 0.05$).

The differences between these two groups, regarding qualitative and quantitative variables, are presented in Tables 1 and 2. Prevalence of smoking in patients with SSI was 38.3% (41 subjects) and 21.8% (22 subjects) in patients without SSI and the differences were significant, with a $P = 0.009$. In other words, according to the computed odds ratio, it can be concluded that smoking cessation decreases the risk of SSI by half (OR, 0.44; 95% CI: 0.2 - 0.8). Nineteen subjects (17.8%) from the SSI+ group were opium addicts. This figure was significantly lower in SSI- group, with only eight subjects (7.9%) ($P = 0.035$). Regarding the odds ratio of 0.4 computed, opium withdrawal decreases the risk of SSI to one third (OR, 0.4; 95% CI, 0.1 - 0.9). Thirty nine patients (73.6%), of the 53 subjects who underwent blood transfusion, developed SSI, while this figure was 43.9% (68 subjects), in the patients without blood transfusion. The differences were found to be statistically significant with a $P < 0.001$ (OR, 0.3; 95% CI, 0.1 - 0.6).

Table 1. Differences Between the Two Groups of Surgical Site Infection Positive and Surgical Site Infection Negative Regarding Qualitative Variables

Variables	Surgical Site Infection Positive	Surgical Site Infection Negative	P Value
Emergent surgery			0.108
No	101 (94.4)	89 (88.1)	
Yes	6 (5.6)	12 (11.9)	
Smoking			0.009
No	66 (61.7)	79 (78.2)	
Yes	41 (38.3)	22 (21.8)	
Opium addiction			0.035
No	88 (82.2)	93 (92.1)	
Yes	19 (17.8)	8 (7.9)	
Diabetes			0.093
No	98 (91.6)	98 (97.0)	
Yes	9 (8.4)	3 (3.0)	
Chronic renal failure			0.341
No	104 (97.2)	100 (99.0)	
Yes	3 (2.8)	1 (1.0)	
Blood transfusion			< 0.001
No	68 (63.6)	87 (86.1)	
Yes	39 (36.4)	14 (13.9)	

^a Values are presented as No. (%).

Table 2. Differences Between the Two Groups of Surgical Site Infection Positive and Surgical Site Infection Negative Regarding Quantitative Variables

Variables	Surgical Site Infection		Total	P Value
	Positive	Negative		
Age, y	43.46 ± 18.30	38.15 ± 22.07	40.88 ± 20.344	0.06
Duration of surgery, h	2.52 ± 0.954	2.11 ± 0.977	2.32 ± 0.984	0.003
Duration of hospitalization, d	7.04 ± 3.675	5.70 ± 3.931	6.39 ± 3.851	0.013

The mean duration of surgery was significantly higher in SSI+ patients, with 2.52 hours in SSI+ group and 2.11 hours in SSI- group ($P = 0.003$). The mean duration of hospitalization was also significantly higher in SSI+ patients, with 7.04 days in SSI+ group and 5.7 days in SSI- group ($P = 0.013$). None of the subjects had rheumatoid arthritis and this variable was removed. No significant difference was found between the two SSI+ and SSI- groups, regarding a history of chronic renal failure and diabetes, setting of the surgery and site of fracture (Table 1).

Backward stepwise multiple logistic regression analysis was performed, based on likelihood ratio to evaluate independent risk factors of SSI. Only smoking and blood transfusion were found to be independent risk factors of SSI, with $P = 0.002$ and < 0.001 and odd ratios of 0.35 and 0.24, respectively. In other words, risk of developing SSI in smokers is three times the risk in non-smokers and patients who underwent blood transfusion were four times more at risk of developing SSI.

5. Discussion

The SSIs pose a great socioeconomic and medical burden on the patients, hospitals and insurance companies. Direct costs include the increase in duration of hospitalization, the need for a second surgery, costs of extra laboratory tests and radiologic evaluations, while the indirect costs include impairment of the patients' function and their families (10). Estimated costs for SSIs vary according to the site of infection, type of surgery and the depth of the infection. For example, the cost is estimated to be less than 400 dollars for each patient with superficial infection, while this figure, for complicated infections, such as prosthesis infections or sternal infections in need of heart surgeries, may reach tens of thousands of dollars per patient (11). The SSI is accompanied by an increase in morbidity and mortality and waste of resources (12). Various measures have shown to be effective on decreasing the incidence and morbidities of SSI, including prophylactic antibiotics and enhancement of sterilization techniques (12). The most common organism responsible for SSI, in high risk orthopedic patients, is *Staphylococcus aureus* (*S. aureus*) (12). It is reported that 48% of these infections have been associated with this organism, of which 68% were methicillin-resistant *S. aureus* (MRSA) (13).

In this study, we evaluated the risk factors of SSI in pa-

tients who underwent orthopedic surgeries. No significant relation was found between age and risk of SSI ($P = 0.06$). Controversial results have been yielded from other studies, regarding the relation between age of the patients and risk of SSI. For example, in the surveys conducted by Watanabe et al. (14) and Eseonu et al. (15), results were compatible with our study, whereas, on the other hand, de Boer et al. (16), Ridgeway et al. (17), Cheadle (18) and Schimmel et al. (10) reported a significant increase in the risk of SSI, with increasing age. Kaye et al. (19) reported an increase in the risk of SSI, with increasing age, in patients of 17 - 65 years old and a decrease in the risk of SSI, with increasing age, in patients older than 65 years.

We found that smoking cessation decreases the risk of SSI by half. Cheadle (18) and Schimmel et al. (10) also found a significant relation between smoking and increases in the risk of SSI, while Malone et al. (20) and Watanabe et al. (14) did not find any significant relation. We also found opium addiction to be related to an increase in risk of SSI, while no other studies had evaluated the effects of this variable.

No significant relation was found between diabetes and risk of SSI, although only Minnema et al. (21) and Eseonu et al. (15) yielded the same results as ours. On the contrary, most studies reported a significant increase in the risk of SSI in patients with diabetes, including surveys conducted by Malone et al. (20), Olsen et al. (22), Cheadle (18), Pull ter Gunne and Cohen (23), Schimmel et al. (10) and Watanabe et al. (14). None of the patients included in our study had rheumatoid arthritis, therefore this variable was ignored, although Schimmel et al. (10) evaluated the relation between this variable and the risk of SSI and found it to be insignificant. Our results, regarding the relation between chronic renal failure and risk of SSI, were compatible with the results of Minnema et al. (21), reporting the relation to be insignificant.

While we found no significant relation between the settings of surgery (elective, urgent or emergent) and risk of SSI, Blam et al. (24) reported a significant increase in the risk of SSI, among the patients who underwent emergent surgeries.

In our survey, patients in whom blood was transfused had a risk of SSI three times greater than the patients without blood transfusion. Cheadle (18) confirmed our results, while Minnema et al. (21) yielded opposite results. The mean duration of surgery was significantly higher in patients who developed SSI. Ridgeway et al.

(17), van Kasteren et al. (25), Urquhart et al. (26), Cheadle (18), Pull ter Gunne and Cohen (23) and Watanabe et al. (14) reported the same relation, although Minnema et al. (21) results were in contrast with the others, finding no significant relation between duration of surgery and risk of SSI. The mean duration of hospitalization was also significantly higher in the SSI group, which was compatible with the results of other surveys including de Boer et al. (16), Blam et al. (24), Olsen et al. (22), Lee et al. (27) and Eeonu et al. (15). Opposite results were found in the study of Watanabe et al. (14). As mentioned, multiple regression analysis found smoking and blood transfusion to be independent risk factors for SSI.

As can be seen, for each variable, various results have been reported and no consensus has been reached, regarding most probable risk factors of SSI. Therefore, further investigations are required to yield definite results concerning this matter.

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