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A retrospective analysis of factors affecting surgical site infection in orthopaedic patients

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Abstract

Objective: To investigate the factors affecting surgical site infections (SSI) in patients undergoing orthopaedic surgery.

Methods: The electronic medical records of patients undergoing orthopaedic surgery between September 2010 and July 2018 were retrospectively retrieved and reviewed. Logistic regression analyses were used to analyse the correlation between surgery-related variables and SSI. The odds ratio (OR) and 95% confidence interval (CI) were estimated for the risk factors.

Results: Clinical data from 25 954 patients were reviewed and 804 (3.1%) were found to have become infected at the surgical site. Older age (≥60 years) was a risk factor (OR 2.218) and younger age (<18 years) was a protective factor (OR 0.258). Diabetes mellitus (OR 6.560) and hypertension (OR 3.991) were independent risk factors. Compared with type II incisions, type I incisions had a lower risk for SSI (OR 0.031), while type III incisions had a greater risk of SSI (OR 2.599). Compared with upper limbs and hands, the feet had a lower risk of infection, while surgery performed at the spine and joints did not increase the risk as compared with foot surgery.

Conclusion: Older age, hypertension, diabetes mellitus and type III incisions were risk factors for SSI following orthopaedic surgery.

Keywords

Orthopaedics, surgical site infection, risk factor, hypertension, diabetes mellitus

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Introduction

Surgical site infection (SSI) is one of the most common complications after orthopaedic and other surgeries.[1–4] In recent years, with the improvement of orthopaedic surgical techniques, the treatment of bone injury has evolved significantly and surgical treatments have been increasingly adapted to treat many bone diseases that were previously treated conservatively. Increased orthopaedic indications, complexity of orthopaedic surgery and use of implants in orthopaedic surgery all contribute to the risk of SSI.[5,6] Once infected, patients can experience increased hospital stay, additional pain and medical care burden, as well as a variety of adverse consequences.[7,8] Although extensive studies have been done regarding the factors affecting SSI in orthopaedic patients,[9–12] the conclusions remain inconsistent. Whether age, hypertension and other comorbid conditions are related to SSI have not been fully determined. For example, a previous study found that the age of the patient was not related to the SSI rate,[13] while other research found that old age was a risk factor for SSI.[14] In addition, the SSI rate was demonstrated to be similar between hypertensive and normotensive patients,[15,16] while other studies showed that diabetes mellitus and incision length were related to SSI after posterior lumbar surgery and spine operations.[7,16]

Surgical site infections are preventable complications that can lead to a significant burden on patients in terms of morbidity, mortality and cost of treatment. For example, research has shown that patients that develop SSIs are up to 60% more likely to stay in the intensive care unit, five-times more likely to be readmitted to hospital, and twice as likely to die compared with patients without SSIs.[17,18]

Therefore, further investigation, particularly in a large population, is necessary to better understand the factors that affect SSI. Additional information on the risk factors for SSI would support better clinical planning and prevent SSI with the appropriate use of preventive and treatment strategies. The aim of this present study was to investigate the factors affecting SSI in orthopaedic patients.

Patients and methods

Study population

This retrospective study extracted demographic, clinical and perioperative data from the electronic database of Yuxi Municipal Hospital of Traditional Chinese Medicine, Yuxi, Yunnan Province, China for patients that underwent orthopaedic surgery and were discharged between September 2010 and July 2018. Patients were included if they were diagnosed and recorded as infected according to the Diagnosis of Nosocomial Infection and Standards for Hospital Infections promulgated by the Ministry of Health in 2009.[19] Patients were excluded if they received simple manual reduction, radiofrequency ablation, biopsy, bone traction and other noninvasive or simple operations. Patients were also excluded if they had malignant bone tumours, chronic osteomyelitis, infections in sites other than the surgical site or infections that existed before the surgery.

This study was approved by the Research Ethics Committee of Yuxi Municipal Hospital of Traditional Chinese Medicine (no. YUMH-SY211). As it was a retrospective study, consent was waived from patients.

Study methods

Clinical data that were extracted from the electronic database included general information such as identification number, name, sex, age, date of admission, date of

discharge; and surgical information such as surgical name, surgical site, surgical type, incision type, anaesthesia method and wound healing. Expenses regarding the therapy were extracted, including total cost, patient-paid cost and cost for antibiotic treatment. The classification of diseases was recorded based on International Classification of Diseases (ICD-9). SSI was diagnosed based on American College of Surgeons and Surgical Infection Society: Surgical Site Infection Guidelines.[20] A type I incision was defined as a clean and uninfected operative wound, a type II incision was made in respiratory, alimentary, genital or uninfected urinary tracts without obvious contamination, while a type III incision was fresh and open surgery.

Statistical analyses

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA). Categorical data are presented as *n* of patients (%) and were compared using Pearson's χ^2-test. Continuous variables are presented as mean ± SD and were compared using independent sample *t*-test or analysis of variance. Continuous data that were not normally distributed are presented as median (interquartile range) and were compared using the non-parametric test. Multivariate logistic regression was used to analyse the factors affecting the SSI rate and a likelihood ratio test was used to verify the correlations between variables and SSI rate. In the logistic regression analyses, the variables included age, the comorbidities hypertension and diabetes mellitus, incision type, incision site, anaesthesia method and payment method. Odds ratio (OR) and 95% confidence interval (CI) were estimated. Juveniles were excluded when hypertension and diabetes mellitus were analysed since they may have different risk factors for SSI from adults. All the tests were two tailed and a P-value < 0.05 was considered statistically significant.

Results

A total of 25 954 patients that underwent orthopaedic surgery between September 2010 and July 2018 were reviewed and included in the study. Among the patients, 13 852 (53.4%) were male and their age ranged from 1 to 89 years old. Of the 17 474 adult patients, 1730 (9.9%) had diabetes mellitus and 4980 (28.5%) had hypertension. Their medical expenses were covered by Urban Worker Medical Insurance (5269 of 25 954 patients; 20.3%), Urban Resident Medical Insurance (8695 of 25 954 patients; 33.5%) and New Cooperative Medical Insurance (10 511 of 25 954 patients; 40.5%). The 51–55-year age group accounted for 11.8% (3071 of 25 954) of the included patients. For patients below 51 years of age, there were more male than female patients (9291 versus 5288). In contrast, for patients over 55 years of age, there were more females than males (5203 versus 3101). The mean ± SD operative times for surgery at the foot, upper limb, hand, lower limb, spine and joint were 1.88 ± 1.12, 1.28 ± 6.18, 2.18 ± 0.67, 1.18 ± 1.11, 2.88 ± 1.12 and 2.48 ± 0.87 h, respectively.

Of the included 25 954 patients, SSI occurred in 804 patients giving an SSI rate of 3.1% (804 of 25 954). The percentage of type I, II and III incisions were 62.18% (16 138 of 25 954), 28.49% (7394 of 25 954) and 9.33% (2422 of 25 954), respectively; and the infection rates in these types of incisions were 0.34% (55 of 16 138), 7.14% (528 of 7394) and 12.18% (295 of 2422), respectively (Table 1). Logistic regression analysis showed that age, comorbid diseases (hypertension and diabetes mellitus), incision type and surgical site were significant risk factors for SSI. Relative to the adult group (≥18 and <60 years old), the juvenile group had a

Table 1. Logistic regression analysis of factors affecting the rate of surgical site infection in orthopaedic patients ($n = 25\,954$) that were treated at one institution.

Variables	Subgroup	*n*	Infection *n* (%)	Regression coefficient	Wald value	OR (95% CI)	Statistical analysis
Age	Adult	17 474	543 (3.11)	0.678	3.912	1.00	$P < 0.001$
	Juvenile (<18 years)	2616	27 (1.03)			0.258 (0.144, 0.451)	$P < 0.001$
	Elderly (≥60 years)	5864	234 (3.99)			2.218 (1.792, 2.860)	$P < 0.001$
Comorbid conditions	Diabetes mellitus	1730	188 (10.87)	0.876	12.213	6.560 (4.258, 8.382)	$P < 0.001$
	Hypertension	4980	252 (5.06)			3.991 (2.520, 4.928)	$P < 0.001$
Incision	Type II	7394	5.28 (7.14)	0.872	9.123	1.00	$P < 0.001$
	Type I	16 138	55 (0.34)			0.031 (0.018, 0.053)	$P < 0.001$
	Type III	2422	295 (12.18)			2.599 (2.035, 3.470)	$P < 0.001$
Surgical site	Foot	3532	102 (2.89)	0.162	1.2	1.00	$P = 0.046$
	Upper limb	8480	392 (4.62)			1.771 (1.470, 2.486)	$P = 0.005$
	Hand	2056	100 (4.86)			1.929 (1.204, 2.907)	$P = 0.019$
	Lower limb	6224	252 (4.05)			1.352 (0.936, 1.953)	NS
	Spine	3730	57 (1.53)			0.877 (0.400, 1.924)	NS
	Joint	1932	24 (1.24)			0.652 (0.122, 3.479)	NS

OR, odds ratio; CI, confidence interval; NS, no statistical association ($P \geq 0.05$).

lower risk of SSI (OR 0.258; 95% CI 0.144, 0.451; $P < 0.001$). In contrast, the SSI risk in the elderly group (≥60 years old) was the highest (OR 2.218; 95% CI 1.792, 2.860; $P < 0.001$), so age ≥60 years was a risk factor. Diabetes mellitus and hypertension were independent risk factors for SSI; patients with diabetes mellitus (OR 6.560; 95% CI 4.258, 8.382; $P < 0.001$) and hypertension (OR 3.991; 95% CI 2.520, 4.928; $P < 0.001$) had a significantly higher risk for SSI as compared with patients without these comorbidities. The incision type was closely related to SSI risk. As expected, type I, which is sterile, had a lower risk of SSI than types II and III; and type III had the highest SSI risk. The SSI rates were not significantly different between upper and lower limbs, hands and feet (Table 1). However, joint and spine surgery had lower SSI rates than surgery on the limbs, hands and feet. Further regression analyses showed that sex, anaesthesia method, admission type, payment method and post-operative transfer were not significantly associated with SSI (Table 2).

Discussion

In this current study, the overall SSI rate in over 25 000 patients undergoing orthopaedic surgery was 3.1%, which was similar to previously reported rates,[16,21] although slightly higher than that reported for spinal surgeries;[7] but much lower than rates reported in other developing countries (e.g. India 20.09%;[22] Egypt 22.6%[23]). The lower SSI rate in present study compared with other developing countries might be due to the use of modern instruments, operating rooms and adequately trained healthcare professionals.

There was no statistically significant correlation between sex and the SSI rate in this current study, which was in agreement with a previous study.[24] Among patients aged

Table 2. Logistic regression analysis of factors not affecting the rate of surgical site infection in orthopaedic patients ($n = 25\,954$) that were treated at one institution.

Variables	Subgroup	Odds ratio
Sex	Male	1.382
	Female	
Anaesthesia type	General anaesthesia	0.087
	Local anaesthesia	
Admission	Walk-in	5.613
	Emergency	0.959
	Transfer	3.319
Cost payment	Urban worker medical insurance	4.576
	Urban resident medical insurance	0.534
	New cooperative medical insurance	2.616
	Own expense	1.857
	Other	0.708
Postoperative transfer		0.003

There were no statistical associations ($P \geq 0.05$).

51 and younger, there were more male patients than female patients, while among patients aged over 55 years, there were more women than men. This may be attributed to the occurrence of osteoporosis due to reduced oestrogen levels in women after menopause, leading to them becoming more prone to bone fractures. In addition, the mean life expectancy of females is greater than that of males.[25]

Currently, whether the age of patients is related to orthopaedic SSI remains disputed. The current data indicate that younger age (<18 years) was a protective factor (OR 0.258) for SSI, while older age (≥60 years) was a risk factor (OR 2.218), as compared with the adult middle-aged people (≥18 and <60 years). These findings were similar to those of previous reports as discussed in a review.[26] As age increases the immune response decreases and the occurrence of chronic disease increases, which synergistically result in an increased susceptibility to SSIs.[27]

Since diabetes mellitus is becoming increasingly prevalent,[28] the appropriate management of patients with diabetes mellitus has become increasingly important for the prevention of hospital-acquired infections. In this current study, patients with diabetes mellitus were six-times more likely to have an SSI than patients without diabetes mellitus (OR 6.560). In a meta-analysis, diabetes mellitus was as a risk factor for SSI,[29] although the overall effect size for the association between diabetes mellitus and SSI was lower than that observed in the current study (OR 1.53). For patients with cardiac surgery, the OR was 2.03 compared with surgeries of other types.[29] Diabetes mellitus is likely to contribute to SSI through hyperglycaemia at the time of surgery,[30,31] although this association has not been consistently found.[32,33] Meanwhile, once infected, the infection in patients with diabetes mellitus is more difficult to control than other patients and often leads to a poor prognosis.[34]

This current study also found that hypertension was an independent risk factor for SSI (OR 3.991). Hypertension is common and its prevalence is rising in China as well as in other countries.[35,36] In an earlier study, hypertension was not found to be associated with increased SSI after posterior lumbar surgery[16] or only weakly associated with SSI in spinal surgery,[37] suggesting that the effect of hypertension on SSI may vary depending on the surgical site.

As expected, the SSI rate increased with the incision type from type I to type III in the current study and this was consistent with a previous study.[38] Type I incisions are clean with an uninfected operative wound, type II incisions are without obvious contamination, while type III incisions are fresh and open surgery with a greater chance of microbial contaminations.

Therefore, type III incisions are more likely become infected.

Previous research has demonstrated that SSI rates were significantly higher in incisions in the lumbar, hip and lower extremities than in the limbs, shoulder and neck.[39] However, this current study showed that after removing other confounding factors, the risk of infection was lower in the feet than in the upper limb (OR 1.771) and hands (OR 1.929). This might have been due to better immobilization of patients before and after foot surgery, which might help prevent bacterial infections.

This current analysis demonstrated that the type of admission and orthopaedic SSI were not correlated. The payment method was also not a risk factor for the SSI, suggesting that patients' financial burden was not the cause of infection. In contrast, the occurrence of SSI was the cause of the patients' financial burden. Patients that experience SSI usually require prolonged hospitalization, reoperation, readmission and have increased mortality rates.[4]

Postoperative transfer was not an independent risk for SSI in the current study. Multi-specialty cooperation and cross-specialty diagnosis and treatment should be encouraged and strengthened for better treatment. Early interventional rehabilitation therapy is also encouraged to ensure the effectiveness of surgery, facilitate the functional recovery of the patients and improve their prognosis.

The duration of the operation and the complexity of the surgery are likely to be important factors affecting the risk of SSI. In the current study, the duration of the surgical operations varied greatly among the surgeons even for similar surgeries and the times were not fully recorded in the medical record database, which made it difficult to be analyse this factor in the regression models. With regard the role played by the surgical complexity, a previous study reported on the usefulness of the classification of surgical complexity for cataract surgery using a surgical complexity classification index.[40] However, because the surgeries undertaken in this current study involved many different procedures and skeletal sites, their complexity was not classified based on clinical and surgical records, so could not be used for the regression analyses.

This current study had several limitations. First, the data were extracted from the medical records database of a single regional hospital and variables related to healthcare professionals, antibiotic use, antiseptics used for patient preparation, methods used for equipment sterilization and type of anaesthesia used were not included. Secondly, no survey such as a questionnaire-based investigation was carried out for follow-up. Thirdly, the impact of the duration of surgery and smoking were not analysed in the study due to a lack of data. These factors have been demonstrated previously to be risk factors for SSI.[13,41,42] Finally, patients were not classified as deep/superficial/organ space since these classifications were not commonly used in the study setting.

In conclusion, this current study provides information on incidence rate and predictors of SSI in patients undergoing orthopaedic surgery. This information might be useful in the development of measures to prevent and manage SSI.

Authors' contributions

JY and XZ designed the study. JY, XZ and WL collected the data. XZ and WL performed the statistical analyses. JY and XZ drafted the manuscript. All authors read and approved the final manuscript.

Declaration of conflicting interest

The authors declare that there are no conflicts of interest.

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