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Original Article

Prevalence of Bacterial surgical site infection in traumatic patients undergoing orthopedic surgeries: a cross-sectional study

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Abstract: Background and objective: Infection at the surgical site is one of the most common postoperative complications. Due to the high prevalence of orthopedic surgery site infection, epidemiologic studies that evaluate the frequency distribution of bacterial infection and related risk factors seem crucial. In the present study, we aimed to investigate and evaluate the prevalence of bacterial infections in traumatic operated patients. Methods: This is a cross-sectional study that was performed in 2011-2020 on all trauma cases with closed fractures re-admitted to the traumatic referral hospital due to surgical site infection after orthopedic surgeries. Data regarding surgical site culture and antibiogram and the most effective antibiotics were also collected from medical documents of patients. Results: During this study, 5950 people underwent traumatic closed fracture surgeries, of which 238 (4%) were readmitted due to infection. Data of 157 patients were analyzed and showed that the most common site of infection was knee in 46 patients (29.3%). Data also showed that gram-positive bacteria were detected in 55 patients (56.7%) while gram-negative micro-organisms were found in 42 patients (43.3%). Based on the statistical analysis, vancomycin was the most effective antibiotic in staphylococcus infections. There was also a significantly higher risks of bacterial surgical site infection for tibial injury (OR = 1.18, P < 0.001), knee injury (OR = 1.50, P < 0.001), presence of Staphylococcus (OR = 1.50, P < 0.001) and also Enterobacter (OR = 1.50, P < 0.001) both in the crude and adjusted models. Conclusion: The prevalence rate of infection was 4% and the most common bacteria was Staphylococcus aureus. Vancomycin was also the most effective antibiotic in patients. We suggest that more studies should be conducted on the use of prophylactic antibiotics.

Keywords: Trauma, orthopedic, bacterial infection, antibiotic

Introduction

Infection at the surgical site is one of the most common postoperative complications, with a prevalence of about 5% [1]. This complication can occur both early and late. In early cases, it can occur up to 30 days after surgery [2] and in late cases, it can sometimes show up 1 to 2 years after surgery and prosthesis placement [3]. Late-onset surgical site infection is more common in orthopedic surgeries and in traumatic patients than in other disciplines as it is estimated that up to 20% of all surgical site infections can occur in orthopedic patients [4, 5].

Factors influencing infection include old age, diabetes, smoking, obesity, previous surgical infection, nutrition, non-observance of sterility and congestion in the operating room and duration of surgery [6].

According to most studies, staphylococcus is the most common organism that causes surgical infection in orthopedic patients. Other organisms that are regularly isolated from surgical site infections include gram-negative bacilli, coagulase-negative staphylococci, Enterococcus species, and Escherichia coli [7]. Methicillin-resistant S. aureus (MRSA) is an important pathogen that causes more than

50% of Staphylococcal infections acquired in the United States and Europe and poses challenges for treatment due to its resistance to multiple antibiotics [6].

Evaluations of 16 studies have shown that treatment costs increase by 115% compared to a person without the complication with surgical site infection, and in orthopedic patients with surgical infections can extend the length of hospital stay from 12 to more than 20 days [8]. However, it is estimated that about 40 to 60% of surgical infections are preventable [9].

Due to the high prevalence of orthopedic surgery site infection, differences in pathogens causing infection, differences in bacterial resistance to antibiotics and consequently the need to start different antibiotics, epidemiologic studies that evaluate the frequency distribution of bacterial infection and related risk factors seem crucial. Previous studies have claimed that the rate of bacterial surgical site infection in traumatic patients are dependent on various factors and vary from 2-9%. The specific organisms responsible for infections should also be determined in specific populations [8, 9]. So far, very few studies have been conducted on this issue in our region. Therefore, here in the present study, we aimed to investigate and evaluate the bacterial infections and their risk factors in traumatic patients operated in our referral trauma center in Isfahan, Iran.

Methods and materials

Study deign

This is a cross-sectional study was performed in 2011-2020 in Kashani hospital that is a trauma referral center affiliated to Isfahan University of Medical Science. The current study was conducted on all trauma cases with bone fractures re-admitted to this hospital due to surgical site infection after orthopedic surgeries. The study protocol was approved by the Research and Ethics Committees of Isfahan University of Medical Sciences (ethics code: IR.MUI.MED.REC.1398.578).

Inclusion and exclusion criteria

The inclusion criteria were patient's age between 18-75 years, traumatic bone fractures undergoing orthopedic surgeries, re-admission due to surgical site infection, diagnosis of infection using cultures, complete documents of surgical site culture and antibiogram and signing the written informed consent to participate in this study. The exclusion criteria were open fractures, new trauma to the operated site, history of immunosuppression, incomplete data in medical documents and patient's will to exit the study.

Data collection

Demographic data of patients including age, gender, site of fracture and surgeries and their risk factors were collected. The risk factors included obesity, diabetes mellitus, anemia, immunodeficiency and smoking. Data regarding surgical site culture, bacterial strain, the consumed antibiotics, and the most common effective antibiotics were collected from medical documents of patients.

Data analysis

The obtained data were entered into the Statistical Package for Social Sciences (SPSS) version 18. We used Independent t-test and repeated measure tests and also logistic regression for risk analysis. *P*-value < 0.05 was considered as the significance threshold.

Results

Study population

During this study, 5950 people underwent elective orthopedic surgery due to traumatic closed fractures, of which 238 (4%) were readmitted due to infection. Eighty-one people were excluded from the study due to incomplete files and lack of access to information and data of 157 infected patients were analyzed.

Demographic data

The mean age of the patients was 43.22 ± 5.81 years, and 62.4% of the patients were male. The most common tissue involvement was bone tissue (84.7%). The most common comorbidity was diabetes mellitus (32.5%) and the most common site of infection was the knee (29.3%). We showed that 84.7% of patients required repeated surgeries (**Table 1**).

Bacterial strains

Analysis of bacterial strain responsible for surgical site infection showed that gram-positive

Table 1. Basic demographic and clinical characteristics of study participants

Variable		Number	Percent
Gender	Male	98	62.4%
	Female	59	37.6%
Damaged tissue	Bone	133	84.7%
	Bone/soft tissue	5	3.2%
	Soft tissue	19	12.1%
Comorbidity	HIV	2	1.3%
	Addiction	13	8.3%
	Diabetes	51	32.5%
	Smoking	8	5.1%
	Hypertension	10	6.4%
	Hepatitis B	3	1.9%
	Anemia	28	17.8%
	Obesity	35	22.3%
	No	7	4.5%
Surgical site	Tibia	44	28.0%
	Forearm	5	3.2%
	knee	46	29.3%
	Femur	26	16.6%
	Humerus	1	0.6%
	Pelvis	35	22.3%
Repeated surgery	No	24	15.3%
	Yes	133	84.7%

Table 2. Frequency of Bacterial strains in infected patients

Variable		Number	Percent
Bacterial strain	Gram positive	55	56.7%
	Gram negative	42	43.3%
Bacterial type	Staphylococcus	53	33.7%
	Enterobacter	18	11.4%
	Klebsiella	11	7%
	Acinetobacter	2	1.2%
	Pseudomonas	3	1.9%
	E-coli	7	4.4%
	Non-hemolytic streptococcus	3	1.9%
	Negative	60	38.2%

bacteria were detected in 56.7% of patients while gram-negative micro-organisms were found in 43.3% of patients (**Table 2**). Antibiogram reports showed that the most common bacteria were Staphylococcus (33.57%). Staphylococcus bacteria were classified into coagulase-negative or positive. We showed that coagulase-negative staphylococcus was responsible for 77.36% of infections (unspecified strain 76%, epidermidis 21.5% and saprophyticus 2.5%) and coagulase-positive staphylococcus (Staphylococcus aureus) were responsible for 22.64% of infections.

Evaluation of risk factors for variables in the present study was also performed. Based on our data, there was a significantly higher risks of bacterial surgical site infection for tibial injury (OR = 1.18, P < 0.001), knee injury (OR = 1.50, P < 0.001), presence of Staphylococcus (OR = 1.50, P < 0.001) and also Enterobacter (OR = 1.50, P < 0.001) both in the crude and adjusted models. These data are provided in **Table 3**.

Antibiotics

Our study results showed that the most commonly consumed antibiotics were vancomycin (30.57%), (**Table 4**). Calculation of the most effective antibiotic to which any bacterium has responded are indicated in **Table 5**. Based on these data, vancomycin was most effective in staphylococcus infections and for patients with no bacterial growth on culture, clindamycin was mostly prescribed.

Discussion

Surgical site Infections are a common side effect in orthopedic patients, and despite aseptic precautions during surgery, there is still the possibility of this complication. In our study, the infection rate at the orthopedic surgery site was 4%, which is in the range estimated in other studies. Of course, it should be noted that the incidence of infection at the surgical site, due to differences in the number of the study population, time and place of study, type of hospital, surgical team, type of surgery and several other factors can vary.

We also showed that there was a higher risk of bacterial surgical site infection for tibial injury, knee injury, presence of Staphylococcus and also Enterobacter.

Table 3. Considering the risk factors for bacterial surgical site infection

Variable	Crude model			Adjusted model*		
	OR	95% CI	P	OR	95% CI	P
Comorbidity	1.94	(0.85-4.41)	0.12	0.53	(0.17-1.60)	0.26
Tibial injury	1.28	(1.19-1.37)	< 0.001	1.18	(1.08-1.29)	< 0.001
Knee injury	1.66	(1.44-1.91)	< 0.001	1.50	(1.26-1.78)	< 0.001
upper extremity injury	1.10	(0.94-1.29)	0.23	1.09	(0.88-1.34)	0.44
pelvic injuy	1.006	(1-1.01)	0.08	1.003	(0.99-1.01)	0.47
Gram positive	1	(0.59-1.70)	1	0.83	(0.41-1.67)	0.60
Gram negative	1.05	(1-1.10)	0.06	1.06	(0.98-1.14)	0.13
Staphylococcus	1.66	(1.44-1.91)	< 0.001	1.50	(1.26-1.78)	< 0.001
Enterobacter	1.69	(1.45-1.97)	< 0.001	1.50	(1.24-1.81)	< 0.001

*Adjusted by age and gender.

Table 4. The frequency of prescribed antibiotics in infected patients

Antibiotic	Number	Percent
Vancomycin	48	30.5%
Linezolid	18	11.4%
Rifampin	25	15.9%
Clindamycin	33	21.0%
Ciprofloxacin	36	22.9%
Amikacin	20	12.7%
Cefepime	19	12.1%
Targocid	5	3.1%
Ceftazidime	8	5.0%
Gentamycin	7	4.4%
Co-trimoxazole	4	2.5%
Meropenem	12	7.6%
Polymyxin b	8	5.0%
Tazocin	3	1.9%
Oxacillin	1	0.6%
Imipenem	24	15.2%
Cefixime	1	0.6%
Tobramycin	1	0.6%
Cefotaxime	5	3.1%
Levofloxacin	1	0.6%
Cefotaxime	2	1.2%
Cefazolin	7	4.4%
Cefalotin	4	2.5%
Ceftizoxime	4	2.5%
Ceftriaxone	2	1.2%
Tetracycline	1	0.6%

A study conducted in Saudi Arabia on 3096 orthopedic patients showed that the prevalence of infection was 2.5% [10]. Another study in Nigeria on orthopedic patients showed that the incidence of surgical infection in these patients was about 9.9% [11]. These data indicate significant differences between infection rates in various populations.

In our study, the most common offense is the staph family and the most common type involved is coagulase-negative staph. These results are in line with studies conducted by Li and others and Phillips and colleagues. These studies reported coagulase-negative staphylococci as the most common infectious microorganisms [12, 13]. Other studies of orthopedic patients in 2012 found that the most common cause of surgical site infection was the Staphylococcus aureus [14, 15]. Another study of 200 patients with spinal surgery identified the most common pathogen as Staphylococcus aureus [16].

In our study, 38.2% of the submitted samples were negative. This number can vary depending on the method of sample preparation, the correct method of maintaining the culture medium, the type of microbe and the method of sample analysis. In a 2014 study of 159 patients (45.9%) of patients with positive clinical signs of infection had a negative culture result. From the positive culture results, the most common isolates were Staphylococcus aureus (28.9%), Pseudomonas aeruginosa (9.4%), Klebsiella pneumoniae (7.5%), Mycobacteria (3.8%), Staphylococcus coagulase-negative (1.3%), MRSA (1.3%) and others (4.3%) [6]. Although in most studies, the most common strain is from the Staff family, in general, due to differences in resistant strains in each geographical area, there is a difference in the results of these studies.

Table 5. The most common prescribed antibiotic

Bacteria	Antibiotic	Number	Percent
Staphylococcus	Vancomycin	24	42.2%
	Linezolid	11	20.7%
Enterobacter	Imipenem	6	33.3%
	Amikacin	4	22.2%
	Ciprofloxacin	4	22.2%
Klebsiella	Rifampin	3	25.0%
Acinetobacter	Amikacin	1	50.0%
Pseudomonas	Amikacin	3	100%
	Imipenem	2	66.6%
E-coli	Imipenem	5	71.4%
	Amikacin	4	57.1%
Negative	Clindamycin	23	38.3%
	Vancomycin	21	35.0%
	Ciprofloxacin	17	28.3%

These differences could be due to variations in study populations and also other clinical conditions. In our study, the most common antibiotic that patients responded positively to was vancomycin. Improper use of antibiotics in the community and hospital has caused high resistance of bacteria to penicillin, ampicillin, cloxacillin, cephalexin, etc. Many studies have suggested that the patient's life should not be endangered by the use of antibiotic-resistant antibiotics and that vancomycin should be used in the treatment of patients with acute infections [17, 18]. Other studies have suggested that cefazolin or nafcillin should be used for oxacillin-sensitive staphylococci and vancomycin for MRSA infections [19]. According to the study, the most common infection with Staphylococcus aureus and the most effective antibiotic was vancomycin, it is recommended that vancomycin be used prophylactically instead of cefazolin.

Other variables affecting surgical site infection that were examined in our study include underlying diseases, which in our study was the most common disease of diabetes, which many studies have stated as a risk factor for surgical site infection [20]. Another risk factor that was prevalent in our study was obesity, which other studies have addressed. For example, a 2006 meta-analysis showed that obesity could double the risk of infection in normal people [21]. Due to the impact of underlying diseases on infection at the site of orthopedic surgery, it is recommended that anemia must be corrected. Diabetes and hypertension must be controlled. It is also recommended that smoking and drug abuse should be stopped. Besides, in patients with underlying disease, the intervals of visits should be shortened so that they can be treated effectively in case of infections.

Due to the high number of negative cultures (38.2%) in conventional culture media despite positive clinical evidence, it is recommended to use a specific culture medium or anaerobic or PCR to accurately determine bacterial strains. Our study, like other studies, faced limitations, the most important of which is the loss of a number of our statistical population due to the retrospective design of the study and deficiencies in the file. It is recommended that new studies should be done prospectively.

Conclusion

By evaluating the frequency distribution of bacterial infection and related risk factors in traumatic patients undergoing orthopedic surgeries, we showed that the incidence rate of infection was 4% and the most common bacteria was Staphylococcus aureus. Vancomycin was also the most effective antibiotic in patients. This study highlights the importance of infections after surgeries and also showed that the incidence rate in Kashani hospital was similar to other hospitals in developed regions. We suggest that more studies on the use of prophylactic antibiotics should be performed.

Disclosure of conflict of interest

None.

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