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Surgical site infections after orthopedic procedures in a tertiary hospital in Oman: Incidence, characteristics and risk factors

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ABSTRACT

Background/Objectives: Surgical site infection (SSI) is a devastating complication of any surgery with negative impact on health care system worldwide. SSIs after orthopedic procedures have a wide range of effect on mortality and morbidity involving loss of implants and extension to bone and joint. This study aimed to determine the incidence of SSIs after different orthopedic procedures and their risk factors. Determining the characteristics of these SSIs and the common pathogens responsible for them were also aimed.

Subjects/Methods: A cohort study in tertiary hospital was carried out with all patients who underwent laminectomy, open reduction & internal fixation (ORIF) of long bones and Joint replacement procedures during a 1 year period and followed up for 1 year. Demographic, clinical and laboratory data were collected using the hospital electronic system. Data was analyzed using binary logistic regression.

Results: Between January and December 2012, 906 patients who underwent 922 procedures were involved. SSIs occurred in 8.57% of these procedures. The majority of SSIs were superficial (90.24%) and happened in the first 30 days of the procedures (58.54%). SSIs were found significantly higher in joint replacement than other procedures (P value 0.03). There was no significant association between SSIs and patients' age and ASA score. *Pseudomonas aeruginosa, Enterobacteriaceae*, *Staphylococcus aureus* and *Acinetobacter* were the most common pathogens detected with 37.5% of them were Multi-Drug Resistant (MDR).

Conclusion: The incidence of SSI after orthopedic procedures is high which emphasizes the importance of continuous surveillance and implementation of infection control measures to contain the problem.

Introduction

Surgical site infection (SSI) is a major health threat worldwide. It threatens the lives of millions of patients each year and contributes to the spread of antibiotic resistance. 11.2% of patients who undergo surgery are infected in low- and middle-income countries. On the other hand, in the United States, they contribute to patients spending more than 400,000 extra days in hospital at a cost of an additional US$ 10 billion per year [1].

A prospective, observational cohort study included 10,475 patients from 58 countries in 2014 showed that the incidence of SSI increased from high (7.4%), to middle (14.4%), to low (20.0%) income countries [2].

SSI has a major impact on morbidity and mortality. Relative risk of death attributable to SSI has been calculated to reach 2.2% [3].

In orthopedic surgeries, SSI might lead to disastrous consequences as it may involve the joints and bones in addition to loss of implants. The incidence of SSI varied between studies according to the type of procedure, the health care settings and the presence or absence of implants. For example, Amaradeep et. Al. reported an incidence of 4.4% (4) while Thahir et. Al. reported an incidence of 10.4% after orthopedic procedures with implants [5].

The most common organisms responsible for SSI after orthopedic procedures included Staphylococcus species, involving Methicillin Resistant Staphylococcus aureus (MRSA), Acinetobacter species, Klebsiella and Pseudomonas [6][7][8][9].

Cost of hospitalization was significantly higher for patients with SSI than for patients without SSI ($p<0.001$) [10], with direct costs of treating SSI after total knee arthroplasty were US $2701.29 per patient [11].

There are no studies evaluating the incidence and risk factors of SSI in orthopedic patients in Oman. This study was conducted to find out the incidence of SSI among patients undergoing orthopedic procedures, determine the characteristics of this infection and evaluate risk factors of its occurrence.

Materials/Subjects and Methods

Definitions: According to NHSN/CDC [12] with few adaptations for the purpose of the study as below.

Study design

This is a retrospective cohort study carried out in a tertiary hospital in Muscat, the capital city of Oman. The hospital is the major trauma & orthopedic center providing service to all governorates in the country.

Population

All patients who underwent laminectomy, open reduction & internal fixation (ORIF) of long bone fractures and joint replacement (arthroplasty/hemiarthroplasty) procedures from January to December 2012 were involved in this study. Those who did not have adequate follow up period, i.e. less than 1 month were excluded except for four patients who developed SSIs during that short follow up period.

Data collection

Clinical data were collected retrospectively using the electronic hospital information system (Al-Shifa system). The collected data included patient's age, sex, American Society of Anesthesiologists (ASA) score, procedure done, type of fracture (open vs closed), type of joint replacement (primary vs revision), follow up duration, presence or absence of SSI, type of SSI (superficial vs deep) and timing of SSI (early, delayed or late). All hospital visits for up to 1 year after the procedures were reviewed and checked for the occurrence of SSIs.

In addition, laboratory information including the organisms isolated and their antibiotic susceptibility patterns were collected in case SSIs were present. Antibiotic susceptibility testing and interpretation were done according to Clinical and Laboratory Standards Institute (CLSI) methods and break-points [13].

The follow up period after the procedures were divided into 3 groups: 1-<6 months, 6-<12 months and >= 12 months. For the study purpose, the time when SSI occurred was divided into those occurred within the first 30 days of operation (early), 1-<6 months (delayed), 6-<12 months (late) and >=12 months after operation. The age groups were divided into those <15 years, 15-65 years and >65 years of age.

Data analysis
Binary logistic regression examining the relations of the occurrence of SSI and different variables was performed. Step wise regression analysis selected procedure type and follow-up duration for best model fit.

Ethical approval:
All data were anonymous and no indication of any of the patient details was included in this study. Hence, ethical approval in this study was not required.

Results

During the study period, 922 procedures were included, done on 906 patients. Among these patients, 1 patient underwent 3 procedures and 14 underwent 2 procedures requiring more than one incision during the same hospital admission. Among the 906 patients included in this study, majority 669 (73.84%) were 15-65 years of age and male to female ratio was 1.47: 1.

Demographic and clinical data of these patients are shown in table 1.

Demographic & clinical data	No. (%)
Total patients Age:	**906**
<15 yrs	36 (3.97%)
15-65 yrs	669 (73.84%)
>65 yrs	201 (22.19%)
Sex:	
Males	539 (59.49%)
Females	367 (40.51%)
ASA score:	
I	418 (46.14%)
II	354 (39.07%)
III	115 (12.69%)
IV	15 (1.66%)
V	1 (0.11%)
NA	3 (0.33%)

Table 1: shows the demographic and clinical data of patients included.

For the follow up period after the procedures, more than half of the patients, 482 (53.20%) had follow up period of >= 12 months while 237 (26.16%) patients were followed up for 1 to < 6 months and 183 (20.20%) patients were followed up for 6 to <12 months after the procedures. The remaining 4 patients (0.44%) were followed up for less than 30 days but developed SSI during that short follow up period and were included in this study.
ORIF accounted for more than half of the procedures, 541 (58.68%) while laminectomies were 99 (10.74%) and joint replacement procedures were 282 (30.59%). Among the ORIF procedures, 48 (8.87%) were done on open fractures while the majority, 491 (90.76%) were done on closed fractures with two patients had no details of the type of their fractures. In addition, 92.20% of the joint replacements were primary procedures and 7.80% were done as revision procedures.

Out of the 922 procedures involved in this study, 79 (8.57%) ended up having SSIs with 3 procedures of these had 2 episodes of SSI each, making the total number of SSI episodes among all procedures 82 episodes. Among these episodes, 55 (67.07%) were lab-proven and 27 (32.93%) were clinical diagnosis made by the orthopedic surgeons. Analysis of these 82 episodes showed that 74 (90.24%) were superficial while only 8 (9.76%) were deep. More than half (58.54%) of them were early complications occurred during the first 30 days after the procedure. Figure 1 shows the different timing of these episodes.

The incidence of SSIs among different age group was not statistically significant (P-value 0.703) with similar finding among different ASA score with P-value 0.104. (Table 2) The most affected procedure was joint replacement with incidence of 11.70% in comparison with 7.76% among ORIF procedures and 5.05% among laminectomies. This was found statistically significant (P-value 0.03). Among the ORIF procedures, incidence was significantly higher in those operated for open fractures than those operated for closed fractures (P value < .001). Furthermore, among the joint replacements the incidence after revision procedures was significantly higher than after primary procedures 9.23% (P value < .001). (table 2)

Procedure type (N=922)	**SSI Infection**	**P-Value**
Join replacement	35 (41.7 %)	
ORIF	44 (52.4 %)	0.0317
Spinal	5 (6.0 %)	
ASA.score (N=922)	**SSI Infection**	**P-Value**
1	30 (35.7 %)	
2	36 (42.9 %)	0.104
3	16 (19.0 %)	
4	4 (2.4 %)	
5	0 (0.0 %)	
Age category (N=922)	**SSI Infection**	**P-Value**
15-65	62 (73.8 %)	
<15	2 (2.4 %)	0.703
>65	20 (23.8 %)	
Type of wound (N=821)	**SSI Infection**	**P-Value**
closed	36 (45.6%)	
open	8 (10.1%)	< .001
primary	25 (31.6 %)	
revision	10 (12.7%)	< .001

Table 2: Association of SSIs with different variables: type of procedure, ASA score, age and type of ORIF/joint replacement procedures.

Table 3 shows that the occurrence of surgical site infection is 45 % less in ORIF compared to arthroplasties and 74% less in laminectomies compared to arthroplasties. Although these results are significant, the difference between the occurrence of SSI in the two procedures, ORIF and laminectomies, is not significant. We could not capture any effects of the duration of the follow up on the occurrence of SSI.

Table 3: Multivariable analysis[1] of the relationship between the occurrence of surgical siteinfections,type of surgery and duration of follow-up

Variables	OR (95% CI)	P-Value
ORIF[2]	0.55 (0.34-0.88)	0.01
Spinal[2]	0.36 (0.12-0.86)	0.04
Follow up after 6 months	0.82 (0.51-1.37)	0.44

[1]binary logistic regression with occurrence of SSI as dependent variable and type of surgery, follow up period as independent variables.
[2]compared to joint replacement.

There were 72 bacterial strains isolated in the lab-proven SSIs. The commonest were *Pseudomonas aeruginosa* accounted for 25% and *Enterobacteriaceae* accounted for 23.61%. These were followed by *Staphylococcus aureus* (19.44%) and *Acinetobacter* (16.67%). Other bacteria detected included *Staphylococcus epidermidis, Streptococci, Candida and Pseudomonas* species. Among these strains, 27 (37.5%) were Multi-Drug Resistant Organisms (MDROs). MDROs included MRSA, Extended Spectrum Beta-Lactamase (ESBL) producing *Enterobacteriaceae* and Multi-Drug Resistant Acinetobacter (resistant to at least one antibiotic in at least 3 groups of antibiotics) (figure 2). Furthermore, 23.81% of the infected ORIF procedures had one or more of MDROs detected while among infected joint replacements and infected laminectomies this was 27.27% and 80% respectively. Infection with multidrug resistant organisms was independent of variables such as age and ASA score.

Discussion

To our knowledge, this is the first study highlighting the significance of surgical site infection among orthopedic patients in Oman. However, several studies addressed the incidence and characteristics of SSI in post-orthopedic procedures worldwide.

According to PHE surveillance between 2012 and 2017, the incidence of SSI in hip & knee transplant was <1% with trend of decreasing incidence over years [14]. In US, the incidence was 3.2% after spinal surgery [15] that declined to 1.2% in more recent studies [16], 1.5% after hip arthroplasty, 1.1% after knee arthroplasty [16] and 4.1% after spinal surgery [17].

In comparison, apart from the study conducted in Belgrade [18] with incidence of 22.7%, incidence in developing countries ranged between 2.55% and 11.0% depending on the type of orthopedic surgery, emergency versus elective procedures and patient risk factors [5][7][8][9][19][20][21].

This study showed that the incidence in our setting (8.57%) is toward the higher end which indicates the need for prompt action to handle this issue. The striking result in this study is the high incidence of SSIs among arthroplasties (11.70%) giving the fact that most of these were elective procedures done on clean site. Studies that evaluated the incidence rate of SSI among arthroplasties reported rates between 1.1% and 2.4% after Primary elective TKR (22,23,24), between 1.3% and 2.2% after primary elective THR (24, 25) and 3.68% after revision THR (25) which were much lower than our finding.

This high incidence of SSI after joint replacements, although done under laminar flow, can be explained by the fact that this is a retrospective study with clinical details obtained from the electronic system with many of these SSI episodes were clinical diagnosis with no lab evidence of infection making the diagnosis to be subjective according to the examiner which might over-estimate the problem.

In fact, ongoing surveillance of SSIs in arthroplasties as well as other surgeries is mandatory to detect the trend of SSIs prospectively as well as implementing SSI bundle of care to prevent SSIs.

The higher proportion of male in comparison to female (ratio 1.47:1) in those operated can be explained by the fact that males being more involved in outside activities and field occupation putting them at higher risk of accidents with fractures and spinal injuries. This predominance of males in operated patients has been previously illustrated in other studies [6][7][21].

The same explanation can be applied to the finding that the highest proportion of operated patients were those with 15-65 years of age (73.84%). The fact that lead to the predominance of this age group among infected patients with SSI which has also been mentioned in previous studies [6].

Age was not found to represent an independent risk factor for SSI following orthopedic surgeries. However, the data from previous studies showed different findings. Mardanpour et. Al. and Koyagura et. Al. found that incidence of SSIs in orthopedic patients significantly increased with age, with those >50 years of age having the highest incidence [7][21]. Same finding reported by Brophy et. Al. 2019 with age >=70 years was found to be independent factor associated with SSIs [26].

On the other hand, studies by Maksimović et. Al. and Tahir et. Al. showed that age was not associated with increase in incidence of SSIs similar to our study [5][18]. Although not statistically significant, the incidence of SSI increased with increased ASA score. Similar to our finding, Maksimovic et. Al. and Tahir et. Al. reported SSIs significantly associated with ASA of >2 [5][18].

The majority of SSI episodes (89.03%) occurred in the first 6 months following the procedures with 58.54% in the first 30 days similar to what has been reported earlier [6][9]. The majority were superficial SSI as was reported in several studies [5][20].

The significantly higher incidence of SSI among ORIF procedures done on open fractures than on closed fractures is expected with open fractures are more likely to be contaminated with pathogens at time of presentation. This has been shown in several studies with some considering open fracture as a risk factor for developing SSI [27][28][29]. Furthermore, the significantly higher incidence of SSI among revision joint replacement can be explained by the fact that these revision procedures were done as an emergency procedure most of the time due to infection already present in the joint. This increase in incidence of SSIs after revision procedures in comparison with elective primary ones has already been determined earlier [25].

Common pathogens encountered in SSI after orthopedic surgeries in previous studies were *S.aureus*, *Acinetobacter*, *E.coli*, *Klebsiella* and *pseudomonas* in different order among others [6][7][8][20] which are similar to our findings.

Our finding that Staphylococcus aureus was not the first in the list as in many (but not all) studies might reflect the effectiveness of Mupirocin eradication protocol for patients colonized with MRSA. In addition, antibiotic prophylaxis might have prevented infection with Methicillin Sensitive Staphylococcus aureus (MSSA) or render culture to be negative affecting the real statistics of this organism. In addition, high rate of Gram negative organisms might have resulted from technical issues in taking biopsies, specimen transport and storage with probability of environmental contamination.

The high rate of MDROs among infected laminectomies (80%) might be due to the low number of these procedures in comparison with others. Thus, despite this high proportion, the number of laminectomies complicated by MDRO infection was only 4 procedures, much less than those among the other procedures.

The strengths of this study are the big sample size of 922 procedures included and that it has been conducted in the major orthopedic and trauma center receiving patients from all over the country making the data representative of the population.

Limitation of this study was that being a retrospective study; depending only on the records to decide the presence/absence of SSIs.

Conflict of interest

The authors declare no conflict of interest.

Conclusion

SSI is a major problem in orthopedic patients in our setting with incidence rate showing alarming figure. Implementing infection control measures in form of SSI bundle of care is mandatory as well as ongoing surveillance to quantify the problem continuously and put action on time accordingly. Further prospective studies are needed in the future to assess the effectiveness of these infection control measures.

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Figures

Figure 1: Distribution of SSI episodes according to the timing of occurrence after the procedures (n=82).

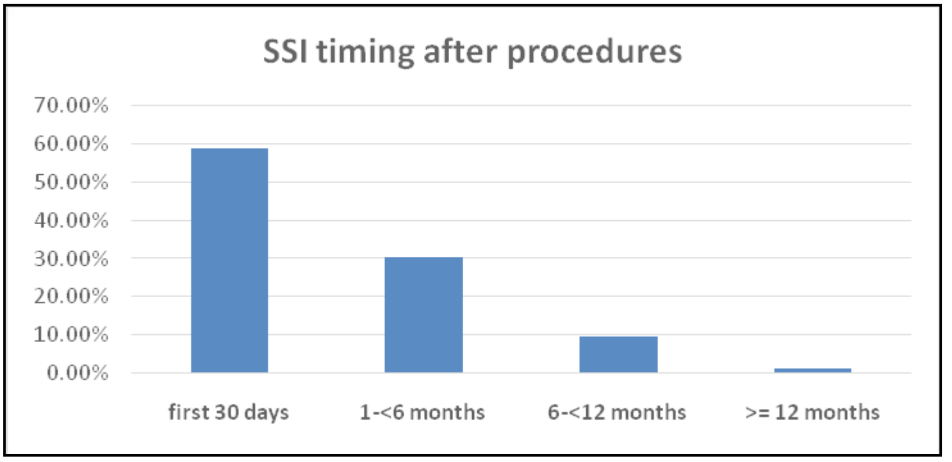

Figure 2: The common bacterial pathogens detected in lab-proven SSIs episodes. (n=72).