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ORIGINAL ARTICLE

Risk factors, bacteriological profile and outcome of surgical site infections following orthopaedic surgery

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ABSTRACT

Background and Objectives: Surgical site infection (SSI) is a challenge for the surgeon. Incidence of SSI reported in literature varies from 0.5% to 15%. Severity of SSI ranges from superficial skin infection to life-threatening condition like septicaemia. It is responsible for increased morbidity, mortality, and economic burden to the hospital in general, and the patient in particular. The aim of this study was to assess the risk factors, bacteriological profile, length of hospitalization, and cost due to orthopaedic SSI in patients admitted to a tertiary care hospital.
Materials and Methods: This was a prospective case control study. Cases were diagnosed based on CDC definition of nosocomial SSI. All cases were assessed preoperatively, intraoperatively and postoperatively, according to type of surgery, wound class, duration of operation, antimicrobial prophylaxis, use of drain, preoperative hospital stay, causative micro organism, total hospital stay, re-admission rates and cost incurred. Age, sex and surgical procedure matched controls without SSI, were also assessed. Chi- square test and Fisher's exact test were used for analysis. P= <0.05 was considered significant.
Results: Out of 1023 patients, 47 cases had SSI, with a rate of 4.6%. Cigarette smoking was a risk factor for SSI (P = 0.0035). The most common etiologic agents were *Acinetobacter baumannii* and *Staphylococcus aureus*. Incidence of re- admission among SSI cases was more compared to controls (P= 0.0001). Costs attributable to SSI (Indian Rupees) was Rs 32,542 (17,054 to 87,514) which was significantly more than those without SSI (P= <0.001).
Conclusion: Despite latest surgical amenities, meticulous sterilization protocols and pre-operative antibiotic prophylaxis, SSI continues to be present in healthcare settings. The increase in duration of hospital stay due to SSI adds to additional burden to an already resource-constrained healthcare system.

Keywords: Surgical site infection; Orthopaedic procedure; Risk factors; *Acinetobacter baumannii*; *Staphylococcus aureus*; Financial burden

INTRODUCTION

Healthcare-associated infections (HAIs) are acquired by patients when receiving care, in both primary and secondary environments. These are the most common adverse events affecting patient safety worldwide. Recent data by the World Health

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Organization's (WHO) 'Clean Care is Safer Care program' shows that surgical site infection (SSI) is the most reported and frequent type of HAI in low- and middle-income countries (LMICs). It affects up to one-third of the patients who have undergone a surgical procedure (1). In LMICs, the overall incidence of SSI is 11.8/100 surgical procedures (range 1.2—23.6). While the global estimates of SSI have varied from 0.5% to 15%, studies in India have consistently shown higher rates ranging from 23% to 38% (2). The rate of SSI among clean surgeries is 4.04-30% and clean contaminated surgeries is 10.06-45%. SSI continues to be a major problem even in hospitals with most modern facilities following standard protocols of pre-operative preparation and antibiotic prophylaxis (1-4).

By definition, a condition can be labelled as a SSI only if infection occurs within 30 days of surgery or 90 days if implants are present and involves the site of incision. There are many risk factors associated with increase in the rate of SSIs, like increased duration of pre-operative stay, increased duration of surgeries, diabetes and hypertension (5).

Microbial contamination of the surgical site is an essential precursor of SSI. These infections are caused by exogenous (from the environment of the operating theatre or the surgical ward) and endogenous microorganisms, patient's skin, mucous membrane or hollow viscera. When mucous membrane or skin is incised, the exposed tissues are at risk for contamination with endogenous flora (6). *Staphylococcus aureus*, coagulase negative *Staphylococcus*, *Enterococcus* species, *Escherichia coli* remain the most frequently involved pathogens (7, 8). Outbreaks of SSI have also been caused by unusual pathogens such as *Rhizopus oryzea*, *Clostridium perfringens*, and *Rhodococcus* (9, 10).

In recent years there is a substantial increase in the multi-drug resistant organisms in hospitals and in the community which has led to the need to evaluate SSI and their antibiotic susceptibility pattern. The incidence of SSI may be predisposed by factors such as pre-operative care, the theatre environment, post-operative care and the type of surgery (11). Many other factors influence surgical wound healing and determine the potential for infection (9-11).

Patients who develop an SSI are likely to have an extended hospital stay with additional economic costs, mainly attributable to the extended length of stay (12). Indirect costs, such as loss of productivity by the patient and an increased burden on their care givers, further add to the cost of SSI to healthcare systems (13).

The present study was designed to determine the rate, risk factors, microbial etiology and antibiotic susceptibility profile of SSI in orthopaedic surgeries. The study also aimed to measure the outcome of orthopaedic SSI based on duration of hospital stay, frequency of re-admission and costs attributable to SSI.

MATERIALS AND METHODS

This was a prospective case control study conducted in the Department of Microbiology and Orthopaedics from January 2015 to December 2015 in Pondicherry Institute of Medical Sciences, Pondicherry. The study was reviewed and approved by the institute research and ethics committee (IEC: RC/14/115). Written informed consent was obtained from the patient/legal guardian and confidentiality was maintained. All the patients who underwent any surgery in Department of Orthopaedics and developed SSI (Clinical or bacteriologically proven) were included in the study as cases. Single team of surgeons operated all the cases. Age, sex, surgical procedure and surgeon matched controls (n=47) were selected by simple random sampling. Cases of stitch abscess were excluded from this study.

A predesigned proforma was used to collect the relevant clinical data from all the patients who underwent surgery. The surgical wound was inspected for any signs of infection at the time of dressings. The SSI was diagnosed based on the CDC definition of nosocomial surgical site infection (14).

We classified the surgical wounds based on CDC classification, which is world-wide accepted nomenclature for classification of SSI. All closed fractures were classified as clean wounds. Open fractures were classified as clean-contaminated, contaminated or dirty based on the pre-operative and intra-operative findings. If the wound edges were healthy with minimal soft-tissue contamination which could be irrigated and cleaned macroscopically to the satisfaction of the surgeon, the fracture was classified as clean-contaminated. When an open fracture needed additional soft-tissue coverage in the form of a flap/ skin grafting, with minimal contamination, it was labelled as contaminated wound. If the open fracture was macroscopically grossly contaminated with mud, gravel or grease particles it was categorized as dirty wound (14).

The patients were assessed preoperatively, intraoperatively and postoperatively. Details included were; type of surgery, wound class, type and duration of operation, antimicrobial prophylaxis, use of drain, preoperative hospital stay and total duration of hospital stay. The patient details were collected from the time of admission until discharge from the hospital and also subsequently when they came to OPD for post operative follow up.

If SSI was suspected, discharge from the wound was collected with sterile swabs or aspirates/pus was collected in sterile containers. The specimens were transported to the microbiology laboratory immediately and processed as per standard protocol. Antibiotic susceptibility testing was done and results interpreted as per CLSI guidelines 2015.

The outcome of SSI was assessed by duration of hospital stay, incidence of readmissions and cost attributable to SSI.

Statistical analysis. Chi- square test was used to determine the significant associations between the risk factors and outcome and odds ratios were calculated using Fisher's exact test to test for the strength of association between risk factors. *P*= <0.05 was considered statistically significant.

RESULTS

Patient factors associated with surgical site infection (SSI). A total number of 1023 patients underwent major surgery, of which 47 cases had surgical site infection, rate 4.6% (Fig. 1). Most cases with SSI were in the age group of 21 to 40 years. SSI was more among men compared to women. Comorbidities like

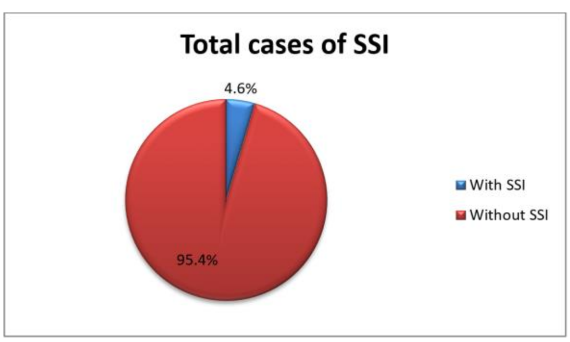

Fig. 1. Rate of surgical site infection (SSI)

diabetes, hypertension and hypothyoidism did not differ significantly between cases and controls. There was history of cigarette smoking in 17 patients with SSI which was a significant finding (*P*= 0.0035) (Table 1).

Pre operative factors associated with SSI. Out of the 47 cases of SSI, 14 cases were hospitalized for > 3days prior to surgery (*P*= 0.0208). All 47 cases of SSI had received antimicrobial prophylaxis prior to surgery. Hair removal prior to surgery was done in 44 cases (*P*= 0.1809). Skin preparation done with iodine alone was done in 42 cases of SSI (*P*= 0.0005). The SSI rates for American Society of Anesthesiologists (ASA) classification; I, II and III were 70.2, 25.5% and 4.25% respectively (*P*= 0.628) (Table 2).

Intra operative factors associated with SSI. Details of Intra operative factors associated with SSI like nature of operation, type of anaesthesia, surgeon, use of drain, wound classification (Clean, Clean contaminated, Contaminated, Dirty), suture material used (Nylon, Ethilon, Staples, Vicryl), duration of operation, number of people in theatre are mentioned in Table 3.

Frequency of various pathogens causing surgical site infection. Out of the 1023 surgeries included in the study, 4.6% (n = 47) developed SSI. A single etiologic agent was identified in 30 cases, 2 in 10 cases, 3 in 4 cases and no growth in 3 cases (Table 4). The commonest etiologic agents were *A. baumannii* and *S. aureus* other etiologic agents are mentioned in Table 5. Out of the 11 *A. baumannii* isolated 10 were multidrug resistant (MDR). Five out of 11 *S. aureus* were MRSA.

Outcome of SSI. The mean duration of hospital stay among cases was 12.54 and controls was 10.52 (*P*= 0.715). Incidence of re-admission among cases was more compared to controls (*P*= 0.0001). Costs attributable to SSI (Indian Rupees) was Rs 32,542 (17,054 to 87,514) (*P*= <0.001) (Table 6).

DISCUSSION

The overall SSI rate in the present study was 4.6% and comparable with other reported rates ranging from 2.5 to 41.9% (3, 5, 7, 10, 11). In this study, most of the patients were in the age group 21-40 and

Table 1. Patient factors associated with surgical site infection (SSI)

Variable	Cases (n)	Controls (n)	p value	Odds ratio	95% confidence interval
Age groups (years)					
<21	4	4			
21-40	27	25	0.913	0.926	0.209 to 4.103
41-60	12	16	0.719	1.333	0.276 to 6.442
>61	4	2	0.533	0.5	0.056 to 4.474
Sex					
Female	6	4			
Male	41	43	0.503	1.573	0.4136 to 5.983
Co morbidities					
None	41	37			
Diabetes mellitus	3	7	0.179	2.585	0.622 to 10.736
Hypertension	3	2	0.747	0.738	0.117 to 4.67
Hypothyroidism	0	1	0.442	3.32	0.131 to 84.011
Smoking					
No	30	42			
Yes	17	5	0.0035	0.2101	0.0698 to 0.6322

Chi-square test was used to compare the cases and controls. P<0.05 considered as significant.

Table 2. Pre operative factors associated with SSI

Variable	Cases	Controls	p value	Odds ratio	95% confidence interval
1) Pre op duration of hospitalization					
≤ 3 days	33	42			
> 3 days	14	5	0.0208	0.2806	0.0917 to 0.8586
2) Antimicrobial prophylaxis					
Yes	47	47			
No	-	-			
3) Hair removal					
Yes	44	40			
No	3	7	0.1809	2.567	0.6210 to 10.604
4) Skin preparation					
Iodine	42	27			
Iodine with isopropyl alcohol	5	20	0.0005	6.222	2.086 to 18.563
5) ASA					
I	33	30			
II	12	16	0.4016	1.4667	0.598 to 3.597
III	2	1	0.628	0.55	0.047 to 6.379

Chi-square test was used to compare the cases and controls. P<0.05 considered as significant.

showed a male preponderance. Similar demographic observation was reported by another study (15). Co morbidities like diabetes, hypertension and hypothyoidism were not a risk factor for SSI. There was a statistically significant association between cigarette smoking and SSI in this study. Cigarette smoking was significantly found to be associated with SSI in a previous multivariate analysis (16). Cigarette smoking has been reported to have an impact on wound healing through impairment of tissue oxygenation and local hypoxia via vasoconstriction (17-19).

Prolonged pre-operative duration of hospitalization

Table 3. Intra operative factors associated with SSI

Variable	Cases	Controls	p value	Odds ratio	95% confidence interval
Nature of operation					
Elective	33	30			
Emergency	14	17	0.5104	1.336	0.5634 to 3.167
Type of anaesthesia					
General anaesthesia	17	20			
Spinal anaesthesia	30	27	0.5265	0.765	0.334 to 1.7539
Surgeon					
Assistant Professor	36	28			
Associate Professor	11	19	0.0767	2.221	0.9101 to 5.419
Use of drain					
Yes	21	15			
No	26	32	0.203	1.723	0.7432 to 3.995
Wound classification					
Clean	18	21			
Clean contaminated	18	15	0.478	0.714	0.282 to 1.811
Contaminated	7	8	0.973	0.979	0.297 to 3.232
Dirty	4	3	0.592	0.643	1.267 to 3.261
Suture					
Nylon	2	2			
Ethilon	20	10	0.5123	0.5	0.0611 to 4.0907
Staples	10	25	0.379	2.5	0.3084 to 20.267
Vicryl	15	10	0.7061	0.667	0.0803 to 5.537
Duration of operation					
<3 hrs	33	39			
≥3 hrs	14	8	0.1438	0.4835	0.1806 to 1.294
Number of people in theatre					
≤6	40	44			
≥7	7	3	0.1809	0.3896	0.0943 to 1.6098

Chi-square test was used to compare the cases and controls. P<0.05 considered as significant.

Table 4. Microbial growth

Growth	Number
No growth	3
3 organisms	4
2 organisms	10
1 organism	30

with exposure to hospital environment has been reported to increase the rate of SSI (20). The prolonged preoperative stay favors the colonization with bacteria and increases the risk of infection (20, 21). In this study hospitalization of more than 3 days prior to surgery increased the risk of SSI. Hair removal prior to surgery was not associated with increased rate of SSI. A cochrane review found insufficient evidence for an effect of preoperative hair removal on rates of

Table 5. Frequency of various pathogens causing surgical site infection

Organism	Number	MDR
Acinetobacter baumannii	11	10
Enterococcus faecalis	9	2
Enterococcus faecium	3	3
Pseudomonas aeruginosa	8	1
Staphylococcus aureus	6	
MRSA	5	
Streptococcus pyogenes	2	
Proteus mirabilis	2	
Escherichia coli	5	3
Klebsiella pneumoniae	4	2
Entertobacter species	4	2
Citobacter diversus	2	
Candida albicans	1	

Table 6. Outcome of SSI among cases and controls

Parameter	Cases	Controls	p value
Mean duration of hospital stay (days)	12.54 (4-35 days)	10.52 (3-23 days)	0.715
Incidence of re- admission (n)	Once-20	Once- 1	0.0001
	2 times- 7	2 times- 0	0.0001
	3 times -3	3 times- 0	0.3555
	4 times- 2	4 times- 0	0.2555
Costs attributable to SSI (Indian Rupees)	Rs 32,542(17,054 to 87,514)	Nil	<0.001

Chi-square test was used to compare the cases and controls. P<0.05 considered as significant.

SSIs (22). Skin preparation done alone with iodine had more SSI compared to iodine and isopropyl alcohol. Another cochrane review reported pre-operative skin preparation with 0.5% chlorhexidine solution with methylated spirit was more effective in preventing SSI than alcohol based povidine iodine paint (23). In this study it was observed that, the rate of SSI was not significantly associated with ASA classification; unlike observations made by other studies (10, 24).

Intra-operative factors like nature of operation, type of anaesthesia, surgeon, use of drain, wound classification, suture material used, duration of operation, number of people in theatre were not associated with SSI in this study. The number of people in theatre during operation has been considered as an independent predictor of SSI (25). Studies have shown that length of operation of more than 3 hours leads to 4 times higher risk for SSI (26, 27). Increasing the length of procedure increases the susceptibility of the wound, by increasing bacterial exposure and the extent of tissue trauma (more extensive surgical procedure) and decreasing the tissue level of the prophylactic antibiotic. Surgical wound classification has long been established as an important predictor of the postoperative surgical site infections (28).

A. baumannii and *Staphylococcus aureus* were the commonest isolates in this study similar to other studies where *S. aureus* was the commonest (4, 6-9). *A. baumannii* exhibited 100% resistance to cefotaxime, ciprofloxacin, piperacillin-tazobactam and imipenem. Number of studies in the literature indicate emergence of antibiotic resistant microorganisms in surgical patients (29, 30).

In the present study, mean postoperative stay in patients who developed infection was 12.54 as compared to patients who did not develop surgical site infection where the mean postoperative stay was 10.52 days which was not significant. Incidence of re-admission among cases was more compared to controls and was statistically significant. Our study supports the findings of other published reports that patients who have SSI following orthopedic procedures incur excess costs (19-21).

CONCLUSION

Despite latest surgical amenities, meticulous sterilization protocols and pre-operative antibiotic prophylaxis, SSI continues to be present the a healthcare setting. SSI persists to be a major encumber to the patient both physically and financially. The SSI rate can be reduced by appropriate preoperative, intraoperative and postoperative patient care; proper infection control measures and a sound antibiotic policy.

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