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Incidence, Risk Factors and Etiology of Surgical Site Infections in a Tertiary Care Hospital

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ABSTRACT

Introduction: Surgical site infections (SSIs) have plagued surgeons since time immemorial. They are important causes of morbidity and mortality and also account for additional costs. The unrestrained and rapidly spreading resistance to the available array of antimicrobials further contribute to the existing problem.

Aim: The study was undertaken to estimate the incidence of SSI, identify the risk factors, study the pathogens and their antimicrobial susceptibility pattern.

Methodology: This prospective study was conducted for 2 years which included 500 surgical cases. Surgical wounds were graded and samples were collected from the depth of the wound and sent to the laboratory for culture and sensitivity. Identification and antimicrobial susceptibility testing of the isolates were performed by the Vitek-2 (BioMerieux) method. Also, methicillin-resistant *Staphylococcus aureus* (MRSA) and β-lactamase production were noted by the Vitek-2 method.

Results: The incidence of SSI was found to be 14% (70/500). The risk factors associated were increasing age, co-morbidities like diabetes, prolonged preoperative hospital stay, type of surgeries (emergency surgery) and a class of wound. The commonest organism isolated was *S. aureus* (31.6%), followed by *K. pneumonia* (26.6%). Twenty-eight (28%) of *S. aureus* isolates were MRSA and 64.7% of Gram-negative isolates were β-lactamase producers.

Conclusion: The incidence of SSI is higher in developing nations. Although SSI cannot be eliminated the reduction of the rate of infection to minimal can have significant benefits by reducing the wastage of healthcare resources, patient morbidity and mortality.

Keywords: β-lactamase, Emergency surgeries, MRSA, SSI, *S. aureus*

INTRODUCTION

Wound infection has always been the most dreaded complication of surgery and trauma. Surgical site infection (SSI) is defined as an infection occurring within 30 days after a surgical operation (or within 1 year if an implant is left in place after the procedure) and affecting either incision or deep tissues at the operation site. The Centre For Disease Control and Prevention (CDC) has proposed specific criteria for diagnosis of SSI which splits SSIs into 3 groups- Superficial incisional, Deep incisional and Organ space infections depending on the site and the extent of infection.[1] It is estimated that SSI develops in at least 5% of hospitalized patients undergoing operative procedures.[2] They are associated with increased morbidity, mortality, prolonged hospital stay and increased economic costs for patient care.[3] Local sepsis manifesting in the form of redness, pain, localized tenderness and swelling may also involve the discharge of serous, seropurulent, purulent, sanguinous and sanguinopurulent contents from the surface of the wound.[4] The US National Research Council group in 1964 devised four wound classes as following: clean, clean-contaminated, contaminated and dirty.[5]

The normal flora and organisms present in the hospital environment are responsible for SSI. *Staphylococcus aureus, Coagulase Negative Staphylococci, Enterococci, Proteus, Pseudomonas, Escherichia coli* and *klebsiella* species are the

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common organisms encountered in post-operative wound infections. In case of wound infections following appendectomy or other lower bowel surgery, indigenous flora of the lower gastrointestinal tract is involved like *Escherichia coli*.[6]

Patients during inpatient admission are at risk of acquiring infections from organisms endemic to that particular hospital environment. Microorganisms in such situations manifest unique patterns of antimicrobial activity. The logical approach of SSI control depends on the availability of epidemiological data that the surgeon needs to be aware of. Resistance to antimicrobials also has become a serious problem necessitating an in-depth study of SSI to prevent future complications in operated cases. So, the present study was undertaken to estimate the burden of SSI, identify its risk factors and also the pathogens causing it and study their antimicrobial susceptibility pattern in a tertiary care hospital in Eastern Odisha.

MATERIALS AND METHODS

This study was conducted prospectively in the Department of General Surgery and Department of Microbiology, for 2years extending from December 2017-November 2019. A total of 500 surgical cases (elective and emergency) were included in this study. Following surgery, surgical sites were examined on postoperative day 3 and every 3 days thereafter. Surgical wounds were categorized as per CDC criteria and were also graded on the following scale: grade 1= normal healing, grade 2= suture line erythema <1 cm, grade 3= suture line erythema >1 cm, grade 4= purulent discharge. Signs of inflammation like the local rise of temperature, oedema and fever were also noted. SSI was clinically diagnosed in wounds with grades 3 and 4 with any signs of inflammation. The detailed history of each case such as age, sex, co-morbid conditions, and pre-operative hospital stay was also noted. Samples were collected from the depth of the wound using sterile cotton swabs and sent to the microbiology department for culture and sensitivity.

Laboratory procedure: Samples were inoculated on Blood agar and MacConkey agar and incubated at 37°C. Culture plates were examined for the growth of bacterial colonies after 24-48 hours and Gram staining was done. Further identification and antibiogram of the isolates were obtained by Vitek-2 (BioMerieux) method using the identification card (ID) and antimicrobial susceptibility testing card (AST) as per Clinical Laboratory Standards Institute (CLSI) guidelines and manufacturer's instructions. MRSA and β-lactamase production were also noted in the Vitek-2 method. Statistical analysis was done by chi-square test using SPSS software and p valve <0.05 was considered as significant.

RESULTS

A total of 500 surgical cases were analyzed during the study period and SSI was found in 70 cases (14%).

Of these 70 cases, 54 were males and 16 were females with a male: female ratio of 3.4:1 but the difference in incidence was statistically insignificant. (Table 1)

The age of the study population ranged between 15-79 years. The majority of the cases belonged to the>45 years age group. This was found to be statistically significant as the frequency of SSI increased with age. (Table 1)

The co-morbidities association studied were diabetes and hypertension. Forty-seven (74.6%) patients of 63 diabetics and 15 (20.8%) patients of 72 hypertensives developed SSI. The association of diabetes as a comorbid condition was found to be statistically significant. (Table 1)

The majority (468) of the patients underwent operation within 48 hours of admission and 50 (10.7%) among developed SSI. Rest (32) waited for a week to undergo surgery and among them, 20 (62.5%) developed SSI. The difference in the duration of pre-operative hospital stay leading to SSI was found to be statistically significant. (Table 1)

Of 500 cases, 340 cases belonged to elective surgeries and 160 cases belonged to emergency surgeries. The incidence of SSI in elective surgeries was 6.47% (22/340) and emergency surgery was 30% (48/160) as shown in fig 1. This result was statistically significant with a p-value <0.05.

Out of 70 cultures proven SSIs, 61 samples yielded a single organism (monomicrobial) and 9 samples yielded 2 organisms (polymicrobial) on culture. So, out of 79 bacterial isolates altogether, 34 (43.1%) were Gram-negative bacteria (GNB), 29 were Gram-positive bacteria (GPC-36.7%) and 16 were non-fermenting Gram-negative bacteria (NF-GNB-20.2%). *Staphylococcus aureus* (31.6%) was the commonest organism isolated followed by *Klebsiella pneumoniae* (29.1%) and *Pseudomonas aeruginosa* (14%). (Table 2)

The commonest organism isolated was *S. aureus* in class I and II wounds and *K. pneumoniae* in class III and IV wounds. (Table 3)

Gram-positive organisms (N=29) showed maximum susceptibility towards linezolid (96.5%) followed by vancomycin (86.2%) and were least susceptible to erythromycin and tetracycline (17.2% each). (Figure 2)

From 25 *S. aureus* isolates, 7 (28%) were MRSA.

Gram-negative organisms belonging to the family Enterobacteriaceae (N=34) showed maximum susceptibility towards amikacin (82.4%) and meropenem (64.7%) and were least susceptible to ampicillin (5.9%) and cefuroxime (0%). (Figure 3).

Out of 34 GNB, 22 (64.7%) were found to be β-lactamase producers. 1 out of 2 (50%) *Citrobacter*, 16 out of 22 (72.2%) *Klebsiella* and 5 out of 9 (55.6%) *E. coli* were β-lactamase producers.

Non-fermenting Gram-negative bacteria (N=16) showed maximum susceptibility towards meropenem, doripenem and imipenem (75% each) and were least susceptible to ticarcillin-clavulanic acid (6.25%). (Figure 4)

DISCUSSION

SSIs are an important cause of morbidity and mortality following various surgeries and also account for additional costs. The management of post-operative wound infection is a complex and important aspect of wound care. Despite the modern surgical and sterilization techniques and the use of prophylactic antimicrobials, SSIs continue to pose an important clinical challenge. The unrestrained and rapidly spreading resistance to the available array of antimicrobials further contribute to the existing problem.

The present study included 500 surgically treated cases and the incidence of SSI was found to be 14% which is well within the range reported by other studies.[7,8] While many Indian studies have consistently reported high incidence rates ranging from 21-38%,[9,10] the global estimate varies from 2-10%.[11,12] The rate of SSI varies greatly among hospitals and also from developing to developed nations because of the difference in standards of health care.

Though the major proportion of SSI was found in male (77.1%) patients as compared to female (22.9%) patients in the present study, the difference was statistically insignificant. According to Berard F et al., sex is not a risk factor for wound infection.[13]

The present study has highlighted some risk factors associated with SSI, such as age, comorbidities associated with diabetes, duration of pre-operative hospital stay, type of surgery associated with emergency surgeries. These findings are comparable with other researcher's works.[7,14] The rate of SSI increases with age which may be due to poor immune response and associated comorbidities. Prolonged preoperative hospitalization provides the opportunity for bacterial colonization, thereby directly affecting the patient's susceptibility to infection by lowering host resistance. Emergency surgeries lack adequate preoperative preparation and lack of control of other medical conditions (like diabetes) which may lead to an increase the rate of wound infection.

In concordance with other studies,[15,16] *S. aureus* was the predominant cause of SSI in the present study, followed by *K. pneumoniae* and *P. aeruginosa*. This may be because *S. aureus* is present in the skin as normal flora and thus can invade deeper during surgery. Though S. aureus was the commonest cause of SSI, Gram-Negative bacteria belonging to the family Enterobacteriaceae caused the major number of post-operative wound infections. This can be attributed to being acquired from the patient's normal endogenous flora.

Gram-positive isolates were mostly susceptible to linezolid and vancomycin and Gram-negative and non-fermenting isolates towards amikacin and meropenem. This finding is comparable to a study by Jain S et al.[16]

In the present study, 28% of S. aureus were MRSA and 64.7% of GNB isolates were β-lactamase producers, a finding which is supported by Boubaker I et al. and Kumar MS et al. respectively.[17,18]

CONCLUSION

SSIs are a menacing problem for healthcare providers. The incidence of SSI is high in developing countries as compared to developed nations. Risk factors associated with the development of wound infection are extremes of age, comorbid conditions like diabetes, length of preoperative hospital stay, duration of surgical procedure, type of surgery and class of wound, etc. *S. aureus, K. pneumoniae and P. aeruginosa* are the 3 commonest isolated pathogens causing SSI. Amikacin, meropenem, linezolid and vancomycin are potent antibiotics that can be used to treat wound infections. Although SSI cannot be eliminated the reduction of the rate of infection to minimal can have significant benefits by reducing the wastage of healthcare resources, patient morbidity and mortality. This can be achieved by optimal preoperative, intra-operative and post-operative patient care. Also, there is good evidence that attention to patient-related and procedure-related risk factors can decrease the risk of SSIs significantly.

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Conflicts of Interest - None

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Table 1: Risk factors associated with SSI:

Factors		SSI (%)	No SSI (%)	TOTAL	P value
Gender					
Male		54 (15.4%)	296 (84.6%)	350	0.15965 Not significant at p<.05
Female		16 (10.7%)	134 (89.3%)	150	
Age group					
15-45 years		28 (10.4%)	240 (89.6%)	268	0.1388 Significant at p<.05
>45 years		42 (18.1%)	190 (81.9%)	232	
Co-morbidities					
Diabetes	Yes	47 (74.6%)	16 (25.4%)	63	<.00001 Significant at p<.05
	No	23 (5.3%)	414 (94.7%)	437	
Hypertension	Yes	15 (20.8%)	57 (79.2%)	72	0.07080 Not significant at p<.05
	No	55 (12.8%)	373 (87.2%)	428	
Pre-operative hospital stay					
<2 days	50 (10.7%)		418 (89.3%)	468	<.00001 Significant at p<.05
2-7 days	20 (62.5%)		12 (37.5%)	32	

Table 2: Spectrum of bacterial isolates: (N=79)

ORGANISM	NO. OF ISOLATES	PERCENTAGE
Gram-positive isolates (n=29)		
Staphylococcus aureus	25	31.6%
Coagulase negative staphylococcus	2	2.5%
Enterococcus faecalis	2	2.5%
Gram-negative isolates (n=34)		
Klebsiella pneumoniae	21	26.6%
Escherichia coli	9	11.4%
Citrobacter freundii	2	2.5%
Proteus mirabilis	2	2.5%
Non-fermenting Gram negative isolates (n=16)		
Pseudomonas aeruginosa	11	14%
Acinetobacter species	5	6.4%

Table 3: Spectrum of bacterial isolates according to the class of wound

ORGANISM	CLASS I WOUNDS	CLASS II WOUNDS	CLASS III WOUNDS	CLASS IV WOUNDS
S. aureus	7	3	4	11
K. pneumoniae	-	2	5	14
P. aeruginosa	2	2	2	5
E. coli	-	1	1	7
Acinetobacter spp.	-	1	2	2
C. freundii	-	-	1	1
E. faecalis	-	-	1	1
CoNS	2	-	-	-
P. mirabilis	-	-	1	1

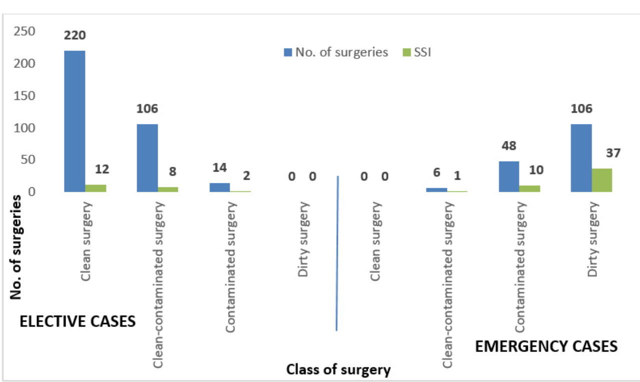

Figure 1: Comparison of SSI rate according to the class of surgery in elective and emergency cases.

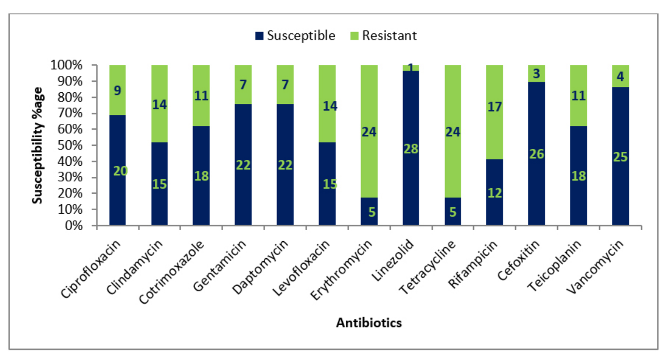

Figure 2: Antibiogram pattern of Gram-positive isolates.

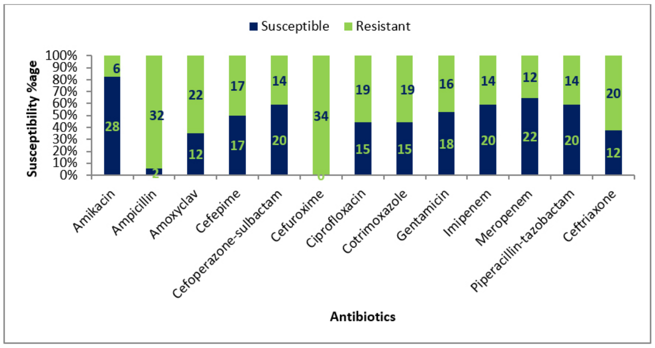

Figure 3: Antibiogram pattern of Gram-negative isolates.

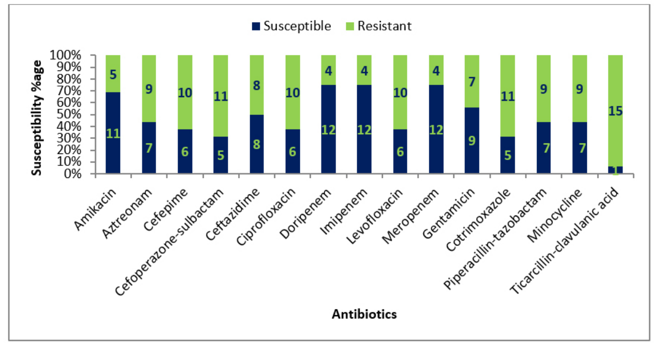

Figure 4: Antibiogram pattern of Non-fermenting Gram-negative isolates.