A prospective study on bacteriological profile and antibiogram of postoperative wound infections in a tertiary care hospital in Western Rajasthan

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Abstract

Background: Surgical site infections (SSI) are one of the most common hospital-acquired infections worldwide. SSI are known to increase morbidity, mortality, length of stay in hospital as well as the cost of treatment to the patients. The incidence varies from 1% to 20% among developed countries to as high as 40% in developing world. Aims: To find the incidence and risk factors, bacteriological profile, and antibiogram for SSI in General Surgery department of a tertiary care hospital in Western Rajasthan. Methods: Culture and sensitivity of wounds of all the clinically suspected cases of SSI were taken. Bacterial identification and antimicrobial susceptibility were performed according to standard CLSI guidelines. Statistical analysis was done using Microsoft Excel, SPSS 13 software. Results: Among total 609 patients, 102 were clinically suspected SSI and 88 were culture positive. Incidence of SSI was 14.45%. The most common organism was Staphylococcus aureus followed by Klebsiella pneumoniae. Most of the Gram-positive isolates were resistant to penicillin and cephalosporin antibiotics and were moderately susceptible to fluoroquinolones and aminoglycosides. Gram-negative isolates were resistant to beta-lactam and beta-lactam/beta-lactamase inhibitor combination also but were susceptible to fluoroquinolones, aminoglycosides, and carbapenems. Conclusion: High incidence rate of SSI in our setup emphasizes the need of quality surgical care which takes into consideration all the three important factors, i.e. host, environmental, and microorganism characteristics before doing any surgery. Increasing resistance to commonly used antibiotics warrants the judicious use of antibiotics and establishment of antibiotic policy in the hospital.

Keywords: Antimicrobial resistance, infection control, surgical site infections

Introduction

Infection is encountered by all the surgeons, as surgeries invariably impair the first line of host defenses between environmental microbes and the host’s internal milieu resulting in postoperative wound infection known as surgical site infections (SSI).¹² SSI are associated with increased morbidity, mortality, prolonged hospital stays, and increased economic costs for patient care.¹³ Centre for Disease Control guidelines define SSI as infection occurring within 30 days or in some specific surgeries 90 days after a surgical operation. The incidence of SSI in developing countries has been reported to be around 2-40%. The aim of the present study is to find incidence and risk factors for SSI in the General Surgery department of our hospital and to know bacteriological profile and antibiogram of organisms causing SSIs.

Material and Methods

Study unit

All patients who underwent elective surgery in General Surgery department of institute and who developed sign and symptoms of wound infection after surgery were included in the study.

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Surgical sites were considered to be infected according to the set of clinical criteria mentioned by CDC.\(^3\) Wounds were classified as clean, clean contaminated, contaminated, and dirty using wound contamination class system, proposed by U.S. National Research Council (1964).\(^{19}\)

**Study setting**

This descriptive cross-sectional study was carried out in Mahatma Gandhi hospital, a government tertiary care hospital associated with Dr. S.N. Medical College, Jodhpur. The study was done between April 2014 to August 2014. Elective surgery patients with sign and symptoms of wound infection post-surgery and who gave informed consent were included in the study and wounds from burn patients were excluded in the study.

**Sample size**

The sample size for this study was calculated using the following formula:

\[
N = \frac{Z^2 P (1-P)}{E^2}
\]

Z is the standard deviation corresponding to two specified confidence interval and is 1.96 (at confidence interval 95%).

P is the proportion of SSI in a study conducted in tertiary care hospital in India which was approximately 15% (14).

E = Margin of error in the present study which we have set to 20%.

The minimum sample size \(N\) is 92; therefore, 102 participants were recruited into the study. Every day new patients were enrolled until the desired sample size was attained.

**Methods**

A structured questionnaire was used to extract the information including demographic data like age and sex of patients, any comorbidities, e.g. anemia, smoking, and diabetes mellitus, length of preoperative hospital stay, and duration of operation. The wound was examined for the presence of any sign of infection on 3rd postoperative day and every 3 days thereafter. Wound samples were taken using sterile swabs under all aseptic precautions using Levine technique. Two swabs were obtained from surgical site without contaminating with skin commensals and transported to the laboratory immediately with minimum delay.

Gram-stained smear was prepared directly from a sample using the first swab. It was screened for the presence of pus cells, morphology, and arrangement of microorganisms. Culture was done from the 2nd swab. Colony morphology, Gram staining, and conventional standard biochemical tests were used for the final identification of bacterial species. Antibiogram was prepared by evaluating the antimicrobial susceptibility testing performed by Kirby–Bauer disc diffusion method according Clinical and Laboratory Standards Institute guidelines.

Statistical analysis was done using Microsoft Excel, SPSS 13 software.

**Results**

A total of 609 patients underwent surgeries in the Department of General Surgery during the study period. Among the 609 patients, 102 patients with clinically suspected postoperative wound infections were enrolled and samples from these patients were further processed. Out of these 102 samples, 88 were found to be culture-positive which yielded an incidence of 14.45% [Table 1].

The majority (87.25%) of the Gram-stained smears revealed the presence of pus cells. Among these, 89.9% had bacterial growth while 10.1% had no bacterial growth. Out of the 13 smears with no pus cell, eight (61.5%) showed bacterial growth suggesting that the absence of pus cell on Gram stain does not exclude the possible presence of bacteria. Eight (8.5%) smears with obvious bacterial cell morphology on Gram stain had no bacterial growth on culture suggesting the possibility of anaerobic infection [Table 2].

**Incidence of SSI with associated risk factors**

Among males, 32 (29%) developed infection and among females, 7 (10%) developed SSI. Although SSI was slightly higher in females, the difference was not statistically significant (\(P = 0.896\)). The SSI incidence varied from 23.75% to 10.07% among different age groups, with highest being in the age group of >60 years and the least in the age group of ≤20 years. The change in SSI incidence among different age groups was highly significant (\(P = 0.000\)).

SSI incidence increased in patients with longer preoperative hospital stay. SSI developed in 15 (7.25%) of 207 patients with the preoperative stay of <2 days, 44 (15.02%) of 293 patients with the preoperative stay of 2–5 days, and 29 (26.61%) out of 109 patients with the preoperative hospital stay of >5 days. The
change in SSI incidence in relation to preoperative hospital stay was highly significant ($P = 0.000$).

With respect to duration of operation, it was observed that SSI incidence was highest (55.56%) among 18 cases that took >120 min per operation to complete and lowest (9.12%) in 340 operations that took ≤60 min per case. Among 251 operations that were completed between 61 to 120 min each, 47 (18.73%) developed SSI. The rate of SSI increased with the prolongation of duration of operation. The difference was highly significant ($P = 0.000$).

Comorbidities like anemia, smoking, and diabetes effecting SSI were also included in the study. Among 71 anemic patients, 16 (22.53%) developed SSI, whereas in 538 patients without anemia, 72 (13.38%) developed SSI. The difference in SSI incidence in relation to hemoglobin level was statistically significant ($P = 0.039$). In 19 (24.05%) patients out of 79 diagnosed to have diabetes mellitus, 19 (24.05%) developed SSI, whereas in 530 patients with normal glucose profile, 69 (13.02%) developed SSI. The difference in the rate of infection between these two groups was very obvious. Moreover, the difference was statistically significant ($P = 0.009$). While studying the relationship between SSI incidence and smoking, it was observed that 28 patients (17.28%) developed SSI among 162 smoker patients, whereas 60 (13.42%) of the 447 nonsmoker patients developed SSI. SSI incidence was higher in smokers, but the difference in SSI rate among the two groups was statistically not significant ($P = 0.231$) [Table 3].

### Incidence of SSI with respect to wound class

With relation to different types of wounds, by the degree of contamination, it was observed that SSI developed in 22 (8.91%) of the total 247 clean cases. There were 220 clean contaminated cases, among them SSI occurred in 34 (15.45%), whereas SSI developed in 25 (19.84%) of 126 patients with contaminated wounds. SSI incidence was highest in patients with dirty wounds, where 07 (43.75%) among 16 developed SSI. Change in SSI incidence among different wound classes was highly significant ($P = 0.000$). It can be assumed that the infection rate increased with that of a degree of wound contamination [Table 4].

### Frequency of pathogenic bacterial isolates from postoperative wounds

*Staphylococcus aureus* was the most common organism isolated, accounting for 35.16% isolates (32 isolates) followed by *Klebsiella pneumoniae* which accounted for 23.08% isolates (21 isolates). *Pseudomonas aeruginosa* was the third most common organism isolated in 15 samples (16.48%). Other organisms isolated from postoperative wounds with their frequency of occurrence in

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**Table 3: Incidence of surgical site infections with respect to associated factors**

| Gender       | Surgeries performed | Surgical site infection cases | Incidence (%) | P     |
|--------------|--------------------|-----------------------------|---------------|-------|
| Male         | 467 (76.68%)       | 67                          | 14.35         | 0.896 |
| Female       | 142 (23.32%)       | 21                          | 14.79         |       |

| Age in years | Surgeries performed | Surgical site infection cases | Incidence (%) | P     |
|--------------|--------------------|-----------------------------|---------------|-------|
| <20          | 45                 | 06                          | 13.33         |       |
| 21-40        | 288                | 29                          | 10.07         | 0.000 |
| 41-60        | 196                | 34                          | 17.35         |       |
| > 60         | 80                 | 19                          | 23.75         |       |

| Preoperative hospitalization duration | Surgeries performed | Surgical site infection cases | Incidence (%) | P     |
|-------------------------------------|--------------------|-----------------------------|---------------|-------|
| < 2 Days                            | 207                | 15                          | 7.25          |       |
| 2-5 Days                            | 293                | 44                          | 15.02         | 0.000 |
| > 5 days                            | 109                | 29                          | 26.61         |       |

| Duration of Surgery                  | Surgeries performed | Surgical site infection cases | Incidence (%) | P     |
|-------------------------------------|--------------------|-----------------------------|---------------|-------|
| ≤ 60 min                            | 340                | 31                          | 9.12          |       |
| 61-120 min                          | 251                | 47                          | 18.73         | 0.000 |
| > 120 min                           | 18                 | 10                          | 55.56         |       |

| Comorbidities | Surgeries performed | Surgical site infection cases | Incidence (%) | P     |
|---------------|--------------------|-----------------------------|---------------|-------|
| Diabetes      |                    |                             |               |       |
| Present       | 79                 | 19                          | 24.05         | 0.009 |
| Absent        | 530                | 69                          | 13.02         |       |
| Anemia        |                    |                             |               |       |
| Present       | 71                 | 16                          | 22.53         | 0.039 |
| Absent        | 538                | 72                          | 13.38         |       |
| Smoking       |                    |                             |               |       |
| Present       | 162                | 28                          | 17.28         | 0.231 |
| Absent        | 447                | 60                          | 13.42         |       |

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decreasing percentage were *Escherichia coli* (12.09%), *Proteus mirabilis* (6.59%), *Coagulase-negative Staphylococcus* (5.49%), and *Enterococcus sp.* (1.10%) [Table 5].

**Distribution of each organism with respect to wound class**

Taking into consideration of individual organism, *Staphylococcus aureus* was the most common isolate in clean, clean contaminated, and dirty wounds with SSI, whereas *Klebsiella pneumoniae* was the most common isolate in contaminated wounds with SSI [Table 6].

**Antibiotic resistance pattern of Gram-positive bacterial isolates**

14 (43.75%) out of 32 *Staphylococcus aureus* (43.75%) were screened as MRSA. All the Gram-positive isolates were highly resistant to ampicillin (resistance varying from 88.9% to 100%), amoxycillin-clavulanic acid (resistance varying from 80% to 100%), and cotrimoxazole (resistance varying from 60% to 100%), while all were highly susceptible to vancomycin (100% susceptibility) and linezolid (susceptibility varying from 92.86% to 100%). *Methicillin-resistant Staphylococcus aureus* isolates were significantly resistant to piperacillin-tazobactam (71.43%) and clindamycin (85.71%) also. All the isolates were moderately susceptible to ciprofloxacin, doxycycline, and amikacin [Table 7].

**Antibiotic resistance pattern of Gram-negative bacterial isolates**

Antibiogram of Gram-negative isolates showed most organisms were resistant to amoxycillin-clavulanic acid and other antibiotics of penicillin and cephalosporin group. Moderate susceptibility was seen to ciprofloxacin, doxycycline, and amikacin. Susceptibility to imipenem was good. *Pseudomonas sp.* was having good susceptibility toward ceftazidime and amikacin [Table 8].

**Discussion**

Despite several advances made in asepsis, antimicrobial drugs, sterilization, and operative techniques, SSI continues to be a major problem in all surgical specialties in hospitals. These infections are responsible for the increasing cost, morbidity, and mortality related to surgical operations. For any given type of surgery, the development of a wound infection approximately doubles the cost of hospitalization.[8‑7] SSI not only increase the cost of hospitalization but also can lead to antimicrobial resistance development in patient, which can further spread to other individuals in community, thus can affect the primary care also. The present study is an attempt to know the incidence of SSI in our setup, the bacteriological profile of organisms responsible for SSI, and their antibiogram and correlation with associated risk factors.

The overall SSI incidence rate of 14.45% of the present study can be well correlated with the infection rates of 6.09% to 38.7% in various Indian studies conducted between 1999 and 2013.[16‑17] Reports from other developed countries showed a lower incidence of infection range between 2.8% and 19.4%.[18‑28] Other studies done previously in India showed SSI rate ranging up to 49.50%,[9] SSI incidence has been decreased in many of the recent Indian studies,[11,13,16] but still higher as compared to developed countries.

SSI rates assessed in a Canadian and Irish hospital over a prolonged period of 10–16 years showed a rate of only 4.7% and 4.5%, respectively,[18,24] which indicates that larger groups studied over a longer duration give a better assessment of SSI rates. A higher infection rate in developing countries emphasizes the need of better implementation of infection control practices along with a proper surveillance system for the use of antibiotics.

Taking the host factors into consideration, SSI incidence was maximum among patients of the age >60 years (23.75%), whereas the lowest infection rate was in the age group of 21–40 years (10.07%) in the study. Similar findings have been reported in other studies,[7,29,30] which signifies that with increasing age, the incidence of SSI increases because of impairing immunity. There was a marginal preponderance of females (14.79%) over males (14.35%) with SSI, which is not statistically significant. There are various studies supporting the fact that gender difference is not significant.[7,15,17,30,31]

There was a statistically significant difference in the rate of SSI with respect to wound class with an increase in the rate of SSIs from clean to dirty surgeries. Similar results were observed in other studies also.[16,19,32‑34] It shows that increasing degree of contamination in the wound increases the chances of infection in the wound. Another important factor is preoperative hospital stay duration. Higher preoperative stay duration is associated with high SSI rates. SSI rate was 7.25% in patients hospitalized.
for <2 days, 15.02% in patients hospitalized for 2 to 5 days, and 26.61% in patients hospitalized for >5 days [Table 3]. The rates of SSIs increased with the increasing duration of preoperative hospitalization in almost every documented study.[11,13,15,17,29,30,38] This can be attributed to increased chances of colonization of patients with nosocomial strains in the hospital.[13,34]

With respect to the duration of surgery and percentage of SSI, it was observed that the infection rate increases with increased duration of surgery. It was only 9.12% when the duration of surgery was less than one hour and raised to 18.73% when it was between one and two hours and was as high as 55.56% when it was more than two hours [Table 3]. The reason could be that prolonged exposure of wound to the environment leads to more chances of inoculation of microorganisms in environment. These findings were consistent with the observation in different studies conducted in Tehran,[13] Aurangabad,[11] Hyderabad,[13] Canada,[49] Mumbai,[57] Brazil,[13] and Thailand.[39]

Certain underlying comorbid conditions like anemia, diabetes, and smoking may alter or decrease the immune status, thus significantly increase the risk of SSI. They are also an important cause of increased preoperative stay of the patient which also increases the chances of postoperative wound infections.[49] SSI incidence among patients with diabetes mellitus was found to be 24.05% as compared to 13.02% in normoglycemic patients. A significant difference in SSI rates between two groups has also been shown in the previous studies.[17,18,30,41]

Among a total of 609 patients who underwent surgery during the study period, 102 patients were clinically suspected and 88 (86.27%) were found to be culture-positive and were considered the definite cases of SSI. Similarly, in a previous study, 676 patients clinically diagnosed on basis of signs and symptoms to have postoperative wound infection, yielded 614 (90.8%) culture-positive cases.[42] Gram-negative bacilli (60.23%) were more common than Gram-positive cocci (43.18%). Gram-negative organisms were reported to be the predominant cause of postoperative wound infections in other studies as well.[13,44] Although as a group, Gram-negative organisms were most frequently isolated, Staphylococcus aureus was the most common organism accounting for 35.16% of total isolates. Similar was the observation in studies done for bacteriological profiling of organisms causing SSI.[13,37,45,51] Conversely, in some studies members of Enterobacteriaceae family were identified as the most common organism.[11,13,34] Among the Gram-negative isolates, Klebsiella pneumoniae was the most common isolate similar to the results of a study conducted in Puducherry, India.[13]

In our setup, the incidence of Gram-positive organisms was greater in infected clean wounds (68.18%) while Gram-negative organisms dominated in rest three categories, i.e., infected clean contaminated wounds (64.71%), infected contaminated wounds (76%), and infected dirty wounds (71.43%). Highest percent of total Staphylococcus aureus isolates were found in infected clean wounds (37.50%), while highest percent of both Klebsiella pneumoniae and Pseudomonas sp. isolates were found in infected contaminated wounds (47.62% and 33.33%, respectively) [Table 6].

Out of a total 32 Staphylococcus aureus isolates, 14 (43.75%) were Methicillin-resistant Staphylococcus aureus (MRSA). Other studies have reported the incidence of MRSA ranging from 20% to 56.5%.[33,34] The antibiogram of Gram-positive isolates including Staphylococcus aureus showed maximum susceptibility to vancomycin (100%), linezolid (92.86% to 100%), and amikacin (78% to 100%), whereas they were highly resistant to ampicillin (88.90% to 100%) and amoxycillin-clavulanic acid (80% to 100%). Other studies also support rise in resistance against penicillins and cephalosporin.[13,11,34,49,51] The antibiogram of Gram-negative isolates showed resistance to amoxycillin-clavulanic acid and cephalosporins, moderate susceptibility to fluoroquinolones and aminoglycoside, and good susceptibility to carbapenem.

The rising resistance to penicillin and cephalosporin group of antibiotics could be due to the overuse of these drugs and the high prevalence of extended-spectrum beta-lactamases (ESBLs) producing organisms, which is an alarming situation. Other studies also support the gradual increase in the emergence of antibiotic-resistant microorganisms in post-surgical patients. To decrease the emergence of such multidrug-resistant organisms, all the three important factors must be taken into account: host factors, microbial factors, and environmental factors.

**Conclusion**

On the basis of the above findings in our study, the following recommendations can be made:

- To decrease the emergence of multidrug-resistant organisms, all the three important factors must be taken into account: host factors, microbial factors, and environmental factors.
- Duration of operation should be optimum and aseptic.

### Table 6: Distribution of each organism with respect to wound class

| Organism                | Total | Clean | Percentage | Clean contaminated | Contaminated | Dirty | Percentage |
|-------------------------|-------|-------|------------|--------------------|--------------|-------|------------|
| S. aureus               | 32    | 12    | 37.50      | 10                 | 06           | 04    | 12.50      |
| Klebsiella pneumoniae   | 24    | 08    | 14.29      | 06                 | 06           | 02    | 9.52       |
| P. aeruginosa           | 15    | 03    | 20.00      | 04                 | 05           | 03    | 20.00      |
| E. coli                 | 11    | 01    | 9.09       | 07                 | 03           | 00    | 00.00      |
| Proteus mirabilis       | 06    | 00    | 00.00      | 05                 | 01           | 00    | 00.00      |
| CONS                    | 05    | 02    | 40.00      | 02                 | 01           | 00    | 00.00      |
| Enterococcus sp.        | 01    | 01    | 100.00     | 00                 | 00           | 00    | 00.00      |
measures must be strictly followed to minimize the level of wound contamination and prevention of SSI
• Reducing the preoperative stay to minimum and proper care of the patients throughout the postoperative period are very vital to reduce the rate of SSI
• Ensuring fitness of patient before undertaking the procedure, especially in patients of extreme age groups
• Proper collection and transport of samples from the surgical site immediately on suspicion of infection, and perform routine culture along with antibiotic susceptibility testing (AST)
• Awaiting antibiotic sensitivity test results and following strict guidelines while prescribing antibiotics in patients of SSIs
• Review guidelines for surgical antimicrobial prophylaxis at respective hospitals. Appropriate antibiotic prophylaxis should be practiced to avoid the emergence of resistant strains
• Conduct large study enrolling patients from all possible surgical specialties to isolate large number of isolates including anaerobic bacteria, establish the magnitude of SSIs due to antimicrobial-resistant pathogens, and identify relevant gene responsible for antibiotics resistance
• Establish continuous surveillance and feedback of results to surgeons, which may influence the surgical techniques.

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Conflicts of interest
There are no conflicts of interest.

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