ORIGINAL ARTICLE

Surgical Site Infection: Bacteriological and Clinicopathological Profile and Antibiogram in a Tertiary Care Hospital

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ABSTRACT

Context: Surgical site infection (SSI) is one of the most common post-operative complications. It causes post-operative morbidity and mortality and prolonged hospital stay. Worldwide SSI rate varies from 2.5% to 41.9%. **Aims:** The present study aimed to determine the prevalence of SSI and to evaluate the bacteriological profile and antibiogram of surgical site pathogens along with determination of multidrug resistance (MDR) pattern among isolates. The study was also aimed to correlate the risk factors and ward with SSI. **Research Design**: This prospective study was conducted at the Department of Microbiology, SMSR, Sharda Hospital and University. **Methods and Materials**: It was a prospective study conducted for a period of 6 months. Patients who developed postoperative infections at the surgical sites within 30 days after surgery were included in the study. **Statistical Analysis Used**: The Chi-square test was used for assessing the relationship between the two proportions. $P < 0.05$ was considered as statistically significant. PASW Statistics for Windows, Version 18.0 (SPSS Inc., Chicago, USA) was used for analysis. The calculation of SSI Rate was carried out using following formula: $\text{SSI Rate} = \frac{\text{Total number of culture positive specimens}}{\text{Total number of surgries performed}} \times 100.$

The SSI rate was expressed in terms of percentage. **Results:** Out of 2128 surgeries, 140 patients developed clinically suspected SSIs. Among these 140 patients, 73 patients were confirmed as SSI, SSI rate being 3.43%. The most frequently isolated organism was *Staphylococcus aureus* followed by *Escherichia coli*. The higher incidence was associated with abdominal surgery. Vancomycin and teicoplanin were found to be most sensitive and Amoxicillin, Class I and II Cephalosporin and aminoglycosides were found to be most resistant. A high level of MDR was noted by *E. coli*, Klebsiella spp., Proteus spp., and *S. aureus*. Abdominal surgery, smoking, elderly adult, other medical problem or diseases, surgery that lasts >2 h, and over-weight are statistically significant ($P < 0.05$). In MDR, Gram-negative Bacilli cases significant statistical analysis were observed in general surgery, obstetrics and gynecology, and ICU ($P < 0.05$). In MDR, Gram-negative bacilli and Gram-positive cocci cases significant analysis were observed in orthopedics, obstetrics, and gynecology and ICU ($P < 0.05$). **Conclusion**: The rate of SSI is higher in developing countries. SSI surveillance should be performed regularly to identify the common pathogens and antibiotics should be used accordingly.

KEY WORDS: Antibiotic resistance, Methicillin resistant *Staphylococcus aureus*, Prevalence, Surgical site infection

Introduction

Skin is a natural barrier against infection, any surgery that causes a break in the skin can lead to a post-operative infection. Surgical site infection (SSI) is an important post-operative complication. SSI constitutes a major public health problem worldwide, it is the second most frequently reported nosocomial infection. It increases the length of hospital stay, treatment cost, and significant morbidity and mortality.[1]

The incidence of nosocomial infections is about 2–20% in developed nations.[2] The rate of SSI in India is 4.04–30%.[3] The most common cause of SSI

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is *Staphylococcus aureus*. It continues to be a major source of morbidity.

Infection is usually caused by exogenous and endogenous micro-organisms that enter the operative wound during the surgery. Recently Gram-negative organisms are also noted as cause of SSI.[1,2] The overuse of antibiotics has led to a major problem of resistant organisms.[1] Multidrug resistant (MDR) bacteria such as *Acinetobacter* spp. are emerging as pathogens of SSI. In developing countries like India the problem gets more complicated due to poor infection control, over-crowded hospitals, and inappropriate use of anti-microbials.[1]

Materials and Methods

It was a prospective study was conducted at the Department of Microbiology and Sharda Hospital for a period of 6 months (May 2019–October 2019). A total of 2128 surgeries were performed in this time period in which 140 pus samples were collected from the clinically suspected SSI patients through swab and transported immediately to the microbiology lad for processing.[4]

Processing

The pus specimen was subjected to gram stain and culture on 5% Sheep Blood Agar (SBA) and MacConkey (MAC) agar plates. he plates were incubated at 37°C for 48 h. The bacterial pathogen grown was identified by conventional bacteriological methods.

Identification of bacterial pathogen

Provisional diagnosis was made on the basis of colony morphology of the organisms on Blood Agar and MacConkey Agar subsequently. Gram staining and hanging drop were performed from the growth on agar plates. Confirmation was done by performing various recommended biochemical tests using conventional methods.[4]

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was performed for all organisms on Muller-Hinton agar. Lawn culture was done and antibiotics were placed according to Kirby Bauer disk-diffusion method. The plates were incubated at 37°C overnight. Zone size was measured for all antibiotics and sensitivity and resistance was noted.

Methicillin resistance in *Staphylococcus* spp. isolated was screened by disk-diffusion method using Cefoxitin (30 μg) disk on MHA.

Calculation

Formula:

$$\text{SSI Rate} = \frac{\text{Total number of culture positive specimens}}{\text{Total number of surgries performed}} \times 100$$

Results

Demographic details

A total of 2128 surgeries were performed out of which 140 patients, were suspected to be suffering from SSI. Out of these 140 clinically suspected cases of SSIs, bacterial pathogens were grown, cultured, and identified in 73 (52.2%) cases. The remaining 67 (47.8%) pus specimens were reported as sterile. Thus, the infection rate of SSI was calculated to be 3.43%.

Out of 73 culture positive specimens, 34 (46.6%) were males and 39 (53.4%) were females (Figure 1).

Infection rate was observed to be maximum from orthopedics (3.4%), followed by obstetrics and gynecology (3%) and general surgery (2.7%) (Table 1).

Bacteriological profile

Out of 73 pus specimens, 44 (60.3%) showed mono-microbial growth and 29 (39.7%) showed poly-microbial growth as depicted in Figure 2/Table 2. Total 105 microbial pathogens were isolated. Out of these, 43 (41%) were identified as Gram-positive Cocci, 60 (57.1%) as Gram-negative Bacilli, and 2 (1.9%) as *Candida* spp. (Figure 2).

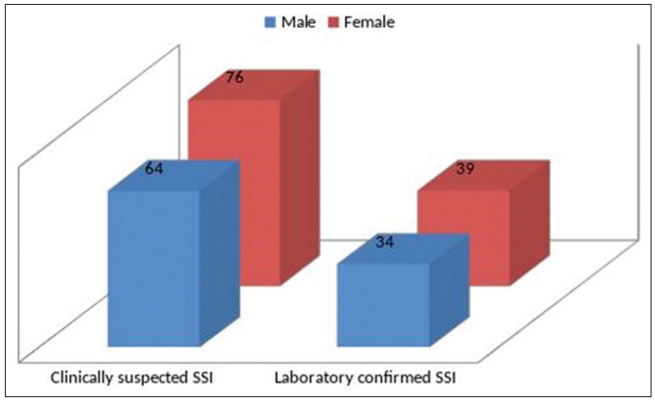

Figure 1: Distribution of gender in clinical SSIs and laboratory confirmed SSIs

Table 1: Ward wise distribution of clinically suspected SSIs

Wards	Number of surgeries performed	Clinically suspected SSIs *n*=140 (%)	Rate of infection (%)	Laboratory confirmed SSIs *n*=73 (%)	Rate of infection (%)
General surgery	917	45 (32.2)	4.9	25 (34.3)	2.7
Obstetrics and Gynecology*	547	39 (27.8)	7.1	16 (21.9)	3
Orthopedics*	664	36 (25.7)	5.4	23 (31.5)	3.4
ICU*	-	20 14.2)	-	9 (12.3)	-

*All the cases of SSIs from ICU were originally from the miscellaneous wards. Thus their infection rate was not calculated. *1 Candida spp. from Orthopedics and Obstetrics and Gynecology each

Table 2: Number and profile of bacterial isolates from surgical site infections

Organisms	Number of bacterial isolates (*n*=103) (%)
Staphylococcus aureus	25 (24.2)
Escherichia coli	21 (20.5)
Klebsiella spp.	17 (16.5)
CoNS	15 (14.6)
Proteus spp.	6 (5.8)
Acinetobacter spp.	6 (5.8)
Pseudomonas spp.	6 (5.8)
Citrobacter spp.	4 (3.8)
Enterococcus spp.	3 (3)

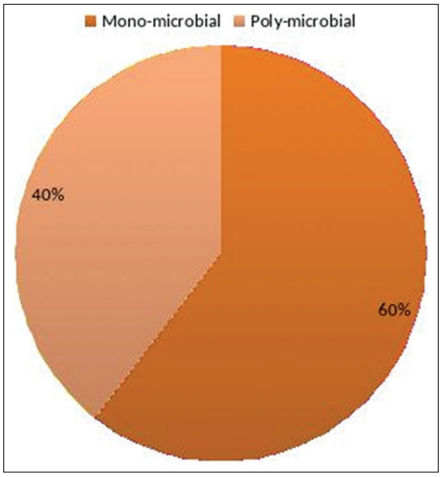

Figure 2: Distribution of SSIs cases in relation to mono-microbial and poly-microbial growth

A total number of 103 bacterial strains were isolated from 71 specimens, irrespective of mono-microbial, and poly-microbial growths (Table 2).

Antibiotic susceptibility pattern

Antibiotic susceptibility pattern showed that the most effective antibiotic for Gram-positive bacteria was Vancomycin and Teicoplanin and the least effective antibiotics for Gram-positive were Ampicillin and Penicillin (Table 3).

For *Escherichia coli*, *Klebsiella* spp., and Proteus spp., the most effective antibiotic was Chloramphenicol and Tobramycin. For *Citrobacter* spp., *Acinetobacter* spp. and *Pseudomonas* spp., Ciprofloxacin, Co-trimaxazole, and Tetracycline were found to be most effective (Table 4).

On observing the MDR pattern, it was found that 57 (80.3%) patients suffered from infections due to MDR bacteria. Of frequency their distribution was from general surgery (36.8%), orthopedics (33.3%), obstetrics and gynecology (19.4%), and ICU (10.5%).

A statistically significant analysis was observed between the MDR Gram-negative bacilli isolation rate and their wards of isolation, that is, general surgery, obstetrics and gynecology, and ICU ($P < 0.05$). Similarly, a statistically significant analysis was also observed between isolation rate of MDR Gram-negative bacilli and Gram-positive cocci and their wards of isolation, that is, orthopedics, obstetrics and gynecology, and ICU ($P < 0.05$) (Table 5).

Of the total number of Gram-positive Cocci isolates, 60% were MDR *S. aureus* and CoNS and 66.6% were MDR *Enterococcus* spp. (Table 6).

Risk factors

The risk factors looked for in the patients of SSIs were abdominal surgery, diabetes, smoking, elderly adult, other medical problems or diseases, surgery

Table 3: Antibiotic resistance pattern of Gram-positive bacteria

Antibiotic	*Staphylococcus aureus* n=25 (%)	CoNS n=15 (%)	*Enterococcus* spp. n=03 (%)
Ampicillin	13 (52)	10 (40)	2 (66.6)
Penicillin	12 (48)	9 (60)	2 (66.6)
Erythromycin	11 (44)	6 (24)	-
Cefoxitin	10 (40)	9 (60)	-
Ciprofloxacin	10 (40)	5 (20)	1 (33.3)
Clindamycin	8 (32)	4 (16)	-
Gentamicin	5 (20)	6 (24)	-
Linezolid	5 (20)	2 (8)	1 (33.3)
Levofloxacin	4 (16)	2 (8)	1 (33.3)
Vancomycin	0 (0)	0 (0)	0 (0)
Teicoplanin	0 (0)	0 (0)	0 (0)
High level gentamicin (for *Enterococcus* spp.)	-	-	0 (0)
High level streptomycin (for *Enterococcus* spp.)	-	-	0 (0)

*60% of *Staphylococcus aureus* strains were observed as MRSA

Table 4: Antibiotic resistance pattern of Gram-negative bacteria

Antibiotics	*Escherichia coli*	*Klebsiella*spp.	*Proteus*spp.	*Citro-bacter* spp.	*Acineto-bacter* spp.	*Pseudo-monas* spp.
	n=21 (%)	n=17 (%)	n=6 (%)	n=4 (%)	n=6 (%)	n=6 (%)
Ampicillin	18 (86)	13 (76)	4 (66)	3 (75)	-	-
Piperacillin	18 (86)	13 (76)	4 (66)	3 (75)	5 (83)	4 (66)
Ceftazidime	18 (86)	13 (76)	4 (66)	3 (75)	5 (83)	4 (66)
Ceftriaxone	18 (86)	13 (76)	4 (66)	3 (75)	5 (83)	-
Aztreonam	18(86)	13 (76)	4 (66)	3 (75)	-	4 (66)
Amoxyclav	14 (69)	9 (53)	3 (50)	2 (50)	-	-
Ampicillin - sulbactum	14 (69)	9 (53)	3 (50)	2 (50)	4 (66)	-
Piperacillin - tazobactum	14 (69)	9 (53)	3 (50)	2 (50)	2 (33)	2(33)
Cefepime	14 (69)	8 (47)	4 (66)	2 (50)	3 (50)	5 (83)
Co-trimaxozole	13 (65)	4 (23)	2 (33)	2 (50)	1 (16)	-
Tetracycline	11 (55)	4 (23)	2 (33)	2 (50)	1 (16)	-
Imipenem	10 (48)	6 (35)	3 (50)	2 (50)	4 (66)	2 (33)
Meropenem	10 (48)	6 (35)	3 (50)	2 (50)	4 (66)	2 (33)
Ciprofloxacin	8 (41)	6 (35)	2 (33)	1 (25)	1 (16)	2 (83)
Amikacin	7 (37)	4 (23)	3 (50)	1 (25)	5 (83)	3 (50)
Gentamicin	7 (37)	5 (32)	3 (50)	1 (25)	5 (83)	3 (50)
Tobramycin	7 (37)	4 (23)	3 (50)	1 (25)	5 (83)	3 (50)
Chloramphenicol	3 (16)	4 (23)	1 (16)	1 (25)	-	-

that last >2 h, over-weight, carcinoma, emergency surgery, and weak immunity (Table 7).

Out of 140 clinically suspected cases of SSI history of risk factors was obtained in 115 subjects only. In the laboratory confirmed cases of SSI history of risk factors could be obtained only in 56/73 patients.

Statistically clinically suspected cases of SSIs and laboratory confirmed cases of SSIs are comparable. Within laboratory confirmed cases of SSIs abdominal surgery, smoking, elderly adult, other medical problem or diseases, and surgery that lasts >2 h and over-weight are statistically significant ($P < 0.05$).

Discussion

The overall infection rate in current study was found to be 3.43%. In a study done by Karan *et al*.,[5] the infection rate reported was 5.5%, Kamath *et al*.[3] reported 4.3% infection rate and Kokate *et al*.[6] reported 2.69% SSI infection rate. In other studies, infection rate ranges from 4% to 33.4%.[6,7]

Of 140 clinically suspected cases of SSIs 52% were culture positive. Dhote *et al*.[8] observed growth in 92% cases, Kaur *et al*.[1] reported 60.5% culture positive cases, and Kokate *et al*.[6] reported 49.5% culture positive cases.

In our study, Gram-negative organisms (57.2%) were predominant, followed by Gram-positive organisms (40.9%) and Candida spp. (1.9%). A study done by Ramaiah *et al*.[9] showed 54.5% GNB, 44% GPC, and 1.5% Candida spp. Jain *et al*.[10] reported 67.14% Gram-positive organisms and 32.85% Gram-negative organism, Anand *et al*.[11] reported 89% Gram-negative organisms and 11% Gram-positive organisms.

Table 5: Correlation of resistance in MDR-GNB to various classes of antibiotics with wards

Resistance to classes of antibiotics	Number of MDR strains from wards				
	General Surgery *n*=24 (45.3%)	Orthopedics *n*=18 (34%)	Obstetrics and Gynecology *n*=8 (15%)	ICU *n*=3 (5.7%)	Total *n*=53 (100%)
3	5 (20.8)	4 (22.2)	-	-	9 (17)
5	2 (8.3)	2 (11.1)	1 (12.5)	-	5 (9.4)
7	5 (20.8)	3 (16.8)	2 (25)	1 (33.4)	11 (20.8)
8	1 (4.3)	2 (11.1)	1 (12.5)	-	4 (7.5)
9	6 (25)	5 (27.7)	4 (50)	-	15 (28.3)
10	5 (20.8)	2 (11.1)	-	2 (66.6)	9 (17)
Total (%)	24 (45.3)	18 (33.9)	8 (15.1)	3 (5.7)	-

Table 6: Correlation of wards and resistance to number of classes of antibiotics in MDR-GPC

Resistance to classes of antibiotics	No. of MDR strains from wards				
	General Surgery *n*=6 (23.1%)	Orthopedics *n*=7 (26.9%)	Obstetrics and Gynaecology *n*=7 (26.9%)	ICU *n*=6 (23.1%)	Total *n*=26 (100%)
5	4 (66.6)	6 (85.7)	3 (42.8)	4 (66.6)	17 (65.4)
6	2 (33.4)	1 (14.3)	4 (57.2)	2 (33.4)	9 (34.6)

Table 7: MDR from laboratory confirmed cases of SSI with wards

Wards *n*=71	GNB		GPC		Mixed of GNB and GPC		Total MDR *n*=57 (100%)
	Total	MDR	Total	MDR	Total	MDR	
General surgery (23)	10	8 (38)	8	6 (28.7)	7	7 (33.3)	21 (36.8)
Orthopedics (22)	5	5 (26.3)	5	4 (21)	12	10 (52.6)	19 (33.3)
Obstetrics and Gynaecology (15)	7	6 (54.5)	4	2 (18.2)	4	3 (27.3)	11 (19.4)
ICU (9)	1	1 (16.7)	2	2 (33.3)	6	3 (50)	6 (10.5)

In this study out of 73 samples, 60.3% showed mono-microbial growth and 39.7% showed poly-microbial growth. Shreeram *et al*.,[12] Negi *et al*.,[2] Mundhada *et al*.,[13] Benebdeslam *et al*.,[14] and Insan *et al*.[15] reported 80.4%, 94.7%, 50%, 76.8%, and 60% mono-microbial growth, respectively, in their studies.

The most commonly isolated pathogens in our study were *S. aureus* (24.2%), *E. coli* (20.5%), and *Klebsiella* spp. (16.5%), followed by CoNS (14.6%), Proteus spp., *Acinetobacter* spp., and *Pseudomonas* spp. (5.8% each, respectively), followed by *Citrobacter* spp. and *Enterococcus* spp. (3.8% and 3%, respectively). Dhote *et al*.,[8] Kokate *et al*.,[6] and Shreeram *et al*. 2016[12] reported *S. aureus* 13.7–32.2%, *E. coli* 10.2–32%, *Klebsiella* spp. 2.9–30%, *Pseudomonas* spp. 7.9–30.9%, CoNS 14.3%, Proteus spp. 1.7–3.6%, *Acinetobacter* spp. 5–8.6%, *Citrobacter* spp. 5.1–7.9%, and *Enterococcus* spp. 7.9%, respectively. Other studies also reported *S. aureus* and *E. coli* as most commonly found organisms.[3,5,13]

In our study, the maximum rate of infection was from orthopedics (3.4%), followed by obstetrics and gynecology (3%), and general surgery (2.7%). Nirupa *et al*.[16] reported maximum rate of infection in general surgery (10.34%), orthopedic surgery (6.12%), obstetrics and gynecology (1.79%), and cardiac surgery (1.07%).

The risk factors associated with laboratory confirmed cases of SSIs were abdominal surgery (30.3%), diabetes (25%), smoking (14.3%), elderly adult (5.5%), other medical problems and disease (10.4%), surgery that lasts >2 h (9%), and over-weight (5.5%). Syed *et al*.,[17] Zejnullahu *et al*.,[18] Shukla *et al*.,[19] and Bansal *et al*.[20] reported elderly adult, over-weight (1.5%), diabetes (66.6%), surgery >2 h, and smoking (16.66%) as risk factors.

AST was performed for all bacterial isolates. Gram-positive organisms were resistant to Ampicillin (52%), Penicillin (48%), Erythromycin (44%), Cefoxitin and Ciprofloxacin (40% each), Gentamicin and Linezolid (20% each, respectively), Clindamycin (32%), and levofloxacin (16%). Higher resistance pattern to Ampicillin (77.7%), Penicillin and Cefoxitin (88.8% each), Amoxyclav and Erythromycin (22.2% each), Levofloxacin, Clindamycin, and Gentamicin (33.3% each, respectively) was reported in the study done by Dr. Kamath *et al*.[3]

Gram-negative organisms in our study were found to be resistant to Ampicillin, Piperacillin, Ceftazidime, Ceftriaxone, and aztreonam (66–86%), similar resistance pattern (60%) was observed by Kamath *et al*.[3] Piperacillin – tazobactam (33–69%) and Cefepime (47–83%) were also resistant however, lower rate of resistance (20%) was seen in the study done by Kamath *et al*.[3] For imipenem and meropenem (33–66%), similar rate of resistance of 41.6% was observed by Kaur *et al*.[1] Resistance to Ciprofloxacin (16–83%), Amikacin, Gentamicin and Tobramycin (23–83% each), and Chloramphenicol (16–25%) was observed in our study, similar pattern of resistance (Gentamicin and Ciprofloxacin–85.72%, Amikacin – 64%) was observed in the study done by Kaur *et al*. (2017).[1]

In our study, out of 71 bacterial SSIs 57 (80.2%) were MDR; however, lower percentage (70%) of MDR samples was seen in a study by Adegoke *et al*.[21] About 40% of *S. aureus* organisms were found to be Methicillin resistant (MRSA) in this study. In a study done by Zahran *et al*.[22] they detected 88.3% MRSA.

Conclusion

SSI continues to be an important clinical challenge despite the modern surgical and sterilization techniques and the use of prophylactic antimicrobials. The study has determined MRSA as the commonest bacteria responsible for the post-operative wound infections. It is important to know the microbial epidemiology of institution so that most suitable empirical treatment for the patients can be provided. The prolong use of antibiotics should be avoided as this is leading to development of resistant micro-organisms which are more difficult to get rid of. The risk factors such as age, diabetes, and smoking require a closer observation.

There is a need for identical studies in health-care settings to identify locally prevalent factors to rectify them to decrease the morbidity and mortality associated with SSI.

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