Original Research Article

BACTERIAL CHARACTERISTICS AND ANTIBIOTIC SUSCEPTIBILITY PATTERNS OF SURGICAL SITE INFECTIONS

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Abstract

Background: Surgical site infections (SSIs) pose a significant public health challenge globally, ranking as the second most commonly reported nosocomial infections. They contribute to escalated treatment expenses, prolonged hospitalization, and considerable morbidity and mortality. The present study aimed to analyze the bacteriological profile and antibiogram of surgical site infections/post-operative wound infections and identify effective drugs for empirical treatment.
Methods: A retrospective study was conducted over one year at the Department of Microbiology of Prathima Institute of Medical Sciences, Nagunur, Karimnagar. Samples were collected using sterile cotton swabs from 1687 patients clinically diagnosed with SSIs and processed according to established microbiological techniques. Antimicrobial susceptibility testing was performed using the modified Kirby-Bauer disc diffusion method.
Results: out of a total 844 samples studied 481(57.70%) were found to be positive. Among the positive culture, 270 (56.13%) were males and 211(43.87%) were females. *Staphylococcus aureus* is the most common cause of surgical site infections, with a frequency of 123 cases, representing approximately 25.57% of all infections. *Escherichia coli: E. coli* is the second most frequently identified organism, responsible for 113 cases (23.49%). *Citrobacter spp.*: *Citrobacter species* account for 84 cases, comprising around 17.46% of the infections. *Pseudomonas aeruginosa*: This bacterium is identified in 49 cases, making up about 10.18% of the infections. *Klebsiella spp. Klebsiella species* are responsible for 40 cases, representing approximately 8.31% of the infections. In *staphylococcus aureus* isolates, 62.6% showed sensitivity to Azithromycin, while 62.07% of CONS isolates were sensitive to this antibiotic. Vancomycin: This antibiotic demonstrated high sensitivity rates across both *Staphylococcus aureus* (94.3%) and CONS (96.55%) isolates
Conclusion: *Staphylococcus aureus* emerged as the most commonly isolated pathogen, followed by E. coli (25.57%). Imipenem, Piperacillin/Tazobactum, Gentamicin, and Amikacin are recommended for empirical treatment of gram-negative bacilli, while Vancomycin and Linezolid are suitable choices for empirical treatment in patients with surgical site infections.
Keywords: Postoperative wound infection, surgical site infection, Antibiotic susceptibility testing (AST)

Introduction

Infections occurring in the wound resulting from an invasive surgical procedure are commonly known as surgical site infections (SSIs). Distinguishing an SSI necessitates clinical evidence of infection symptoms rather than solely relying on microbiological evidence [1]. Typically, most SSIs manifest within 30 days post-operation, with a peak occurrence between the 5th and 10th days. However, SSIs affecting deeper tissues, particularly in cases involving prosthetic implants, may arise within a year following surgery. The CDC's definition describes three SSI categories [2]. Superficial incision infection involves the skin and subcutaneous tissue, typically marked by localized signs like redness, pain, heat, swelling, or pus drainage. Deep incisional infections affect the fascial and muscle layers and may exhibit signs such as pus presence, fever with wound tenderness, or incision edge separation exposing deeper tissues [3]. Organ or space infections involve any anatomy beyond the incision's reach, like joints or peritoneum, often indicated by pus drainage, or abscess formation evident in histopathological or radiological examinations, or during re-operation. Microbiological evidence of wound infection from cultures is possible, but positive cultures without clinical signs seldom indicate SSI due to normal skin colonization [4]. Research led by the World Health Organization highlights significantly higher infection rates in developing nations compared to developed countries, attributing this discrepancy to greater hospital infection burdens in poorer nations [5, 6]. Wound infections stem from microbial proliferation at the surgical site due to inadequate preoperative preparation, wound contamination, inappropriate antibiotic selection, or compromised immune response in immunocompromised patients. All incisions have some degree of contamination, exacerbated by setbacks in recoveries like malnutrition, cardiac failure, or reduced tissue oxygenation, which facilitate infection development [5, 6]. Skin and soft tissue infections (SSTIs) or surgical site infections, known colloquially as "The Silent Killer: Nosocomial Infections" [7], represent a spectrum from minor, self-resolving surface infections to severe ailments necessitating extensive medical intervention. They stand as the second most common nosocomial infection type [8, 9], posing a persistent threat to patients despite the availability of modern antibiotics. While appropriately administered antibiotics can mitigate postoperative SSIs, indiscriminate prophylactic antibiotic use may foster multi-drug-resistant bacteria. Elevated rates of SSIs correlate with increased morbidity, mortality, and healthcare expenses [8, 9]. This study aims to discern the bacterial etiology of SSIs and their susceptibility to antibiotics, facilitating the identification of drugs suitable for empirical treatment.

Material and Methods

This retrospective study was conducted by the Department of Microbiology Prathima Institute of Medical Sciences, Naganoor, Karimnagar. Institutional Ethical approval was obtained for the study. The retrospective data was analyzed. A total of 844 samples of surgical site infections (SSIs) were collected, without restriction to age or gender. Patients of both sexes exhibiting discharge from surgical wounds, whether serious or seropurulent, along with concurrent signs of sepsis (including warmth, erythema, induration, tenderness, pain, and elevated local temperature) were included [1]. *Sample Collection*: Pus and serous fluid samples from the wounds were obtained using two sterile moist swab sticks under strict aseptic conditions.

Transportation and Storage: The swab sticks were transported in 2ml normal saline and Brain Heart Infusion (BHI) broth to the laboratory at the earliest. In case of any delay, samples were refrigerated. Sample Processing: Two pus swabs were aseptically collected from each patient suspected of having an SSI. One swab stick was immersed in normal saline for gram staining and incubated for 24 hours at 37°C. The other swab stick, dipped in BHI, was inoculated on Blood Agar and MacConkey Agar and incubated for 24-48 hours at 37°C. Subsequently, isolates were identified based on their cultural characteristics, morphology, and biochemical reactions. Antimicrobial Susceptibility Testing: All isolates underwent antimicrobial susceptibility testing using the Kirby Bauer disk diffusion technique on Muller Hinton Agar. Results were interpreted according to the guidelines set by the Clinical Laboratory Standards Institute [10]. The antibiotics used for susceptibility testing included: Amikacin, Ampicillin/Sulbactam, Ceftriaxone, Ciprofloxacin, Gentamicin, Piperacillin-Tazobactam, Imipenem, Azithromycin, Vancomycin, Linezolid, Ofloxacin, and Cefoxitin.

Statistical analysis: All the available data was uploaded to an MS Excel spreadsheet and analyzed by SPSS version 15 in Windows format. The continuous variables were expressed as Mean ± SD and percentage, and the chi-square test and unpaired Student's t-test were employed for data comparison when applicable. The values of p (<0.05) were considered as significant.

Results

Out of 844 samples included in the study, 481(57.70%) were found to be positive. Among the positive culture, 270 (56.13%) were males and 211(43.87%) were females. Table 1 categorizes patients into different age groups, ranging from 0 to 80 years and above. For each age group, the table provides the frequency of patients and the corresponding percentage. Age Groups: The age groups are defined in ranges, such as 0-10, 11-20, 21-30, and so on, up to 71-80 years. Frequency: This column indicates the number of patients within each age group who tested positive for culture. Percentage: The percentage column shows the proportion of patients in each age group relative to the total number of culture-positive patients.

Table 1: Age-wise Distribution of Culture Positive Patients.

Age in year	*Frequency*	*Percentage*
0-10	23	4.78
11-20	62	12.88
21-30	161	33.47
31-40	80	16.63
41-50	60	12.47
51-60	48	9.98
61-70	33	6.86
71-80	14	2.91
Total	481	100.0

The age group with the highest frequency of culture-positive patients is 21-30 years, accounting for 161 patients, which represents approximately 33.47% of the total. Patients aged 31-40 and 11-20 years also have notable frequencies, with 80 and 62 patients, respectively. The distribution of culture-positive patients gradually decreases as age increases beyond 30 years, with fewer patients in each successive age group. The age groups 0-10 and 71-80 years have the lowest frequencies, with 23 and 14 patients, respectively. Overall, the table indicates that the majority of culture-positive patients fall within the younger age groups, particularly between 21 and 40 years old, while the number of cases decreases in older age groups.

Table 2: Distribution of Organisms Causing Surgical Site Infection.

Organism	*Frequency*	*Percentage*
Staphylococcus aureus	123	25.57
Escherichia coli	113	23.49
Citrobacter spp.	84	17.46
Pseudomonas aeruginosa	49	10.18
Klebsiella spp.	40	8.31
CONS	29	6.03
Enterobacter spp.	27	5.61
Acinetobacter spp.	11	2.28
Proteus spp.	5	1.04
Total	481	100.0

Table 2 provides the distribution of organisms responsible for causing surgical site infections (SSI). *Staphylococcus aureus*: This bacterium is the most common cause of surgical site infections, with a frequency of 123 cases, representing approximately 25.57% of all infections. *Escherichia coli: E. coli* is the second most frequently identified organism, responsible for 113 cases (23.49%). *Citrobacter spp.* : *Citrobacter species* account for 84 cases, comprising around 17.46% of the infections. *Pseudomonas aeruginosa*: This bacterium is identified in 49 cases, making up about 10.18% of the infections. *Klebsiella species* were responsible for 40 cases, representing approximately 8.31% of the infections. CONS (*Coagulase-Negative Staphylococci*): CONS are found in 29 cases, contributing to 6.03% of the infections. *Enterobacter spp.* : *Enterobacter species* are identified in 27 cases, comprising approximately 5.61% of the infections. *Acinetobacter spp. : Acinetobacter species* are less common, with 11 cases, accounting for 2.28% of the infections. *Proteus spp*: Proteus species are least frequently identified, with only 5 cases, making up approximately 1.04% of the infections.

Table 3: Antibiotic Sensitivity in Isolated Gram-Negative Bacteria from SSI

Drugs	*Escherichia coli n=113 (%)*	*Citrobacter spp. n=84 (%)*	*Klebsiella spp. n=40 (%)*	*Pseudomonas aeruginosa n=49 (%)*	*Enterobacter spp. n=27 (%)*
Gentamicin	76 (67.6%)	37 (44.04%)	15(37.5%)	28 (57.14%)	11 (4.074%)
Ciprofloxacin	30 (26.6%)	35 (41.66%)	13(32.5%)	26 (53.06%)	13 (48.15%)
Piperacillin/ Tazobactam	84 (74.6%)	27 (32.14%)	12(30.0%)	30 (61.22%)	14 (51.85%)
Amikacin	85 (75.1%)	35 (41.67%)	17(42.5%)	26 (53.06%)	16 (59.26%)
Ampicillin/ Sulbactam	34 (30.1%)	18 (21.23%)	11(27.5%)	14 (28.57%)	6 (22.22%)
Impinem	99 (88.2%)	63 (75%)	31(77.5%)	34 (69.38%)	21 (77.78%)
Ceftriaxone	26 (23.1%)	20 (23.81%)	9(22.5%)	21 (42.85%)	11 (40.74%)

Table 4 presents the antibiotic sensitivity patterns of isolated Gram-negative bacteria obtained from surgical site infections (SSI). Gentamicin: Among *Escherichia coli* isolates, 67.6% showed sensitivity to Gentamicin, while lower sensitivity rates were observed for other bacteria such as *Citrobacter spp.* (44.04%), *Klebsiella spp.* (37.5%), *Pseudomonas aeruginosa (57.14%)*, and *Enterobacter spp.* (4.074%). Ciprofloxacin: Escherichia coli exhibited sensitivity in 26.6% of cases, whereas *Citrobacter spp., Klebsiella spp., Pseudomonas aeruginosa,* and *Enterobacter spp*. showed varying degrees of sensitivity ranging from 32.5% to 53.06%. Piperacillin/Tazobactam: This antibiotic demonstrated relatively high sensitivity rates across all bacterial species, with *Escherichia coli* showing 74.6% sensitivity, followed by varying sensitivities in other species. Amikacin: High sensitivity rates were observed for Amikacin, with *Escherichia coli* showing 75.1% sensitivity, followed by varying sensitivity rates in other species. Ampicillin/Sulbactam: Lower sensitivity rates were observed for Ampicillin/Sulbactam across all bacterial species, with *Escherichia coli* showing 30.1% sensitivity, followed by varying sensitivities in other species. Imipenem: This antibiotic exhibited high sensitivity rates across all bacterial species, with *Escherichia coli* showing 88.2% sensitivity, followed by varying sensitivity rates in other species. Ceftriaxone: Relatively lower sensitivity rates were observed for Ceftriaxone across all bacterial species, with *Escherichia coli* showing 23.1% sensitivity, followed by varying sensitivities in other species.

Table 4: Antibiotic Sensitivity in Isolated Gram-Positive Bacteria.

Drugs	*Staphylococcus aureus (%) (n=123)*	*CONS (%) (n=29)*
Azithromycin	77 (62.6%)	18 (62.07%)
Vancomycin	116 (94.3%)	28 (96.55%)
Linezolid	118 (95.93%)	28 (96.55%)
Gentamicin	95 (77.2%)	25 (86.20%)
Ofloxacin	100 (81.3%)	20 (68.96%)
Cefoxitin	84 (68.29%)	17 (58.62%)
Amikacin	101 (82.11%)	20 (68.96%)

Table 4 provides information on the antibiotic sensitivity of isolated Gram-positive bacteria, Azithromycin: Among *Staphylococcus aureus* isolates, 62.6% showed sensitivity to Azithromycin, while 62.07% of CONS isolates were sensitive to this antibiotic. Vancomycin: This antibiotic demonstrated high sensitivity rates across both Staphylococcus aureus (94.3%) and CONS (96.55%) isolates. Linezolid: Similarly, Linezolid showed high sensitivity rates in both *Staphylococcus aureus* (95.93%) and CONS (96.55%) isolates. Gentamicin: *Staphylococcus aureus* isolates exhibited a sensitivity rate of 77.2% to Gentamicin, while CONS isolates showed slightly higher sensitivity at 86.20%. Ofloxacin: *Staphylococcus aureus* isolates exhibited a sensitivity rate of 81.3% to Ofloxacin, whereas CONS isolates showed a slightly lower sensitivity rate of 68.96%. Cefoxitin: Among *Staphylococcus aureus* isolates, 68.29% demonstrated sensitivity to Cefoxitin, while 58.62% of CONS isolates were sensitive to this antibiotic. Amikacin: Both *Staphylococcus aureus* (82.11%) and CONS (68.96%) isolates showed relatively high sensitivity rates to Amikacin.

Discussion

Despite advancements in surgical techniques and a better understanding of wound infection pathogenesis, the management of surgical site infections (SSIs) remains a significant concern for healthcare professionals. Patients with SSIs are particularly vulnerable to microbial populations present in hospital environments, which are often rich with pathogens. In our study, the rate of culture-positive SSIs was found to be 57.7%, which is consistent with rates reported in various other studies conducted in India, ranging from 6.1% to 38.7% [11-14]. This variability may be attributed to factors such as inadequate attention to infection control measures, improper hand hygiene practices, and overcrowding in hospital settings. Our findings also indicated a higher incidence of infections among male patients (56.13%) compared to females. This observation aligns with the results reported by V Negi et al. [15] where 74.6% of affected individuals were male, contrasting with 25.5% being female [15]. Conversely, PS Gangania et al. [16] found a more balanced distribution, with 20% of females and 19% of males affected. Regarding age distribution, our study revealed that the highest culture positivity was observed in the age group of 21-30 years (33.47%), followed by 31-40 years (16.63%). Similar findings were reported by PS Gangania et al. [16] who noted the highest incidence of SSIs among patients aged 16-45 years (24%). This trend may be attributed to the heavy workload and stress commonly experienced in this age group, coupled with the relatively smaller sample size in older age groups. *Staphylococcus aureus* (25.5%) emerged as the most frequently isolated pathogen, followed by *Escherichia coli* (23.49%). The findings of our study are in line with those reported by SP Lilani et al. [14] and Mulu W et al. [17] indicating a high prevalence of *Staphylococcus aureus* infection. The propensity of *S. aureus* to cause infection is likely associated with endogenous sources, given its presence in skin and nasal flora, as well as potential contamination from the environment, surgical instruments, or healthcare workers' hands [15]. Among gram-negative organisms, *Escherichia coli* demonstrated sensitivity to Imipenem (88.2%), followed by Amikacin (75.1%) and Piperacillin/Tazobactam (74.6%) (Table 3). These findings are consistent with a previous study by M. Saleem et al. [18] which also highlighted *E. coli's* high sensitivity to Imipenem.

Similarly, *Citrobacter spp*. exhibited high sensitivity to Imipenem (75%), with Gentamicin (44.04%) being the next effective option. For *Klebsiella spp*., Imipenem (77.5%) followed by Gentamicin (37.5%) were the preferred antibiotics (Table 3). These results align with a study by J Sonawane et al. [19] which also indicated high sensitivity of *Citrobacter* and *Klebsiella* to Imipenem. *Pseudomonas aeruginosa* displayed maximum sensitivity to Imipenem (69.38%), followed by Piperacillin/Tazobactam (61.22%). Similar findings were reported by J Sonawane et al. [19]. Imipenem, Piperacillin/Tazobactam, Gentamicin, and Amikacin emerged as the most effective antibiotics against gram-negative bacilli (Table 3). These results are consistent with those of M. Saleem et al, [18] who also found these antibiotics to be highly efficient against gram-negative bacilli. In gram-positive cocci, *Staphylococcus aureus* exhibited sensitivity primarily to Linezolid (96.6%), followed by Vancomycin (95.93%) (Table 4). This corresponds with the findings of PP Singh et al. who concluded that *S. aureus* was sensitive to Vancomycin (100%) and Linezolid (100%) [20]. Both Linezolid and Vancomycin were effective antibiotics against gram-positive cocci (Table 4), consistent with the study conducted by Vikrant Negi et al. [15] which also identified these antibiotics as highly efficient against gram-positive cocci.

Conclusion

In conclusion, *Staphylococcus aureus* was the most commonly isolated pathogen, followed by E. coli. Imipenem, Amikacin, and Piperacillin/Tazobactam were effective against gram-negative bacilli, while Linezolid and Vancomycin were suitable for treating gram-positive cocci. Empirical treatment with these antibiotics may help manage surgical site infections effectively. Despite modern aseptic practices, SSIs remain a significant challenge. Hospitals serve as reservoirs for SSIs due to their harboring of various pathogenic microbes, including multidrug-resistant strains. Understanding the bacteriological profile and antibiotic susceptibility of SSIs is crucial for selecting appropriate empirical antibiotic therapy, ultimately reducing morbidity, mortality, and the SSI rate.

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