Section: Microbiology

Original Research Article

ETIOLOGICAL AGENTS OF SURGICAL SITE INFECTIONS AND THEIR ANTIBIOTIC SUSCEPTIBILITY AT A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Surgical site infections (SSIs) are among the most common healthcare-associated infections and contribute significantly to postoperative morbidity, prolonged hospitalization, and increased healthcare costs. The emergence of antimicrobial resistance further complicates their management, particularly in developing countries.

Materials and Methods: This prospective study was conducted in the Department of Microbiology, Mahatma Gandhi Memorial Hospital, Warangal, over a period of 1 year and 8 months (January 2018 to September 2019). A total of 662 clinically suspected SSI cases were included. Pus samples were collected and subjected to aerobic culture. Bacterial isolates were identified using standard microbiological techniques, and antibiotic susceptibility testing was performed using the Kirby–Bauer disc diffusion method.

Results: Out of 662 cases, 106 (16%) were culture positive. A slight male predominance (53%) was observed. The majority of cases occurred in the 31–40 years age group (28.3%). Obesity was identified as a significant associated factor (36.79%). Clinically, pus discharge (100%), pain (95.2%), redness (86.7%), and tenderness (86.7%) were the most common features. Gram-negative organisms predominated (63.2%), while Gram-positive organisms accounted for 36.7% of isolates. Staphylococcus aureus (26.4%) was the most common pathogen, followed by Pseudomonas aeruginosa (17.9%) and Escherichia coli (16.9%). Gram-positive isolates showed 100% resistance to penicillin but retained complete sensitivity to linezolid and high sensitivity to vancomycin. Gram-negative organisms demonstrated high resistance to beta-lactam antibiotics and better susceptibility to carbapenems and aminoglycosides.

Conclusion: Surgical site infections remain a significant clinical problem with a predominance of Gram-negative organisms and increasing antimicrobial resistance. Routine microbiological evaluation and rational antibiotic use are essential for effective management. Strengthening infection control practices and antibiotic stewardship programs is crucial to reduce the burden of SSI.

Keywords: Surgical site infection; Antimicrobial resistance; Staphylococcus aureus; Gram-negative bacteria; Antibiotic susceptibility; Postoperative infection; Nosocomial infection; Kirby–Bauer method.

INTRODUCTION

Surgical site infections (SSIs) are among the most common healthcare-associated infections and constitute a major cause of postoperative morbidity and mortality worldwide. An SSI is defined as an infection occurring within 30 days of a surgical procedure, or within one year if an implant is placed, provided that the infection is related to the surgical intervention.[1] These infections may involve the skin, subcutaneous tissue, deeper soft tissues, organs, or body spaces, and represent a significant complication of surgical care.[1,2]

Globally, SSIs remain a substantial public health concern despite advancements in surgical techniques, sterilization practices, and antibiotic prophylaxis. They account for a considerable proportion of hospital-acquired infections and are associated with increased morbidity, prolonged hospitalization, and higher healthcare costs.[2,3] It has been estimated that a significant proportion of postoperative deaths are directly or indirectly related to surgical site infections, highlighting their clinical importance.[3] Furthermore, SSIs can lead to long-term consequences such as poor wound healing, chronic pain, restricted mobility, and psychological distress, thereby affecting the overall quality of life of patients.[4]

SSIs also impose a significant economic burden on healthcare systems. These infections can double the duration of hospital stay and require additional interventions such as re-operation, prolonged antimicrobial therapy, and intensive nursing care, all of which contribute to increased healthcare expenditure.[5] The burden is particularly high in low- and middle-income countries, where limitations in healthcare infrastructure, infection control practices, and surveillance systems contribute to higher incidence rates.[2,6]

In developing countries, including India, the burden of SSIs remains considerably high and variable across different healthcare settings. Several Indian studies have reported SSI rates ranging from approximately 6% to 36%, reflecting differences in surgical practices, patient-related risk factors, and hospital environments.[8–10] Factors such as malnutrition, anemia, diabetes mellitus, obesity, prolonged preoperative hospital stay, and poor infection control measures further increase the susceptibility of patients to SSIs in these settings.[7]

The etiology of SSIs is multifactorial and involves both endogenous and exogenous sources of infection. The most common pathogens implicated include Staphylococcus aureus, which is frequently isolated from the patient's skin flora, followed by Gram-negative organisms such as Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa, particularly in abdominal and hospital-acquired infections.[2,6] In recent years, there has been a noticeable shift towards Gram-negative predominance in many healthcare settings.

The increasing emergence of antimicrobial resistance among these pathogens has further complicated the management of surgical site infections. Indiscriminate use of antibiotics, lack of antimicrobial stewardship, and inadequate infection control practices have contributed to the rise of multidrug-resistant organisms, including methicillin-resistant Staphylococcus aureus (MRSA) and resistant Gram-negative bacilli.[2] This evolving resistance pattern necessitates continuous monitoring of bacteriological profiles and antibiotic susceptibility patterns in different healthcare settings. In this context, the present study was undertaken to identify the various etiological agents of surgical site infections, to understand their clinical relevance, and to analyze their antibiotic susceptibility pattern in a tertiary care hospital.

Aim: This study was undertaken to identify the various etiological agents of surgical site infections, to understand their clinical relevance, and to analyse their antibiotic susceptibility pattern.

Objectives

- To isolate and identify the bacteria responsible for causing surgical site infections at MGM Hospital, Warangal.
- To determine the antibiotic susceptibility pattern of the isolated pathogens.

MATERIALS AND METHODS

Study Design and Setting: This was a prospective observational study conducted in the Department of Microbiology at Mahatma Gandhi Memorial Hospital, Warangal, a tertiary care teaching hospital. The study was carried out over a period of 1 year and 8 months from January 2018 to September 2019.

Study Population and Sample Size: A total of 662 patients with clinically suspected surgical site infections were included in the study. Pus samples obtained from these cases were subjected to microbiological analysis.

Case Definition: Surgical site infection was defined as an infection occurring within 30 days after a surgical procedure, or within one year if an implant was placed, provided that the infection appeared to be related to the surgical intervention.

Inclusion Criteria

- Patients with suspected or confirmed surgical site infections
- Infections occurring within 30 days following surgery
- Infections occurring within one year in cases with implants
- Cases where infection was clinically related to the surgical procedure

Exclusion Criteria

- Cases showing no microbial growth on culture
- Infections present at the time of surgery (PATOS)
- Patients who left against medical advice
- Patients already receiving antibiotic therapy
- Cases without clinical manifestations of infection
- Infections not related to surgical procedures
- Surgeries performed outside the hospital
- Patients diagnosed with HIV or Hepatitis B

Sample Collection: Pus samples were collected aseptically from the surgical site using sterile swabs or by aspiration prior to wound dressing. Care was taken to avoid contamination with normal skin flora. The samples were transported promptly to the microbiology laboratory for processing.

Microbiological Processing: Samples were subjected to aerobic culture using standard microbiological techniques. The isolates obtained were identified based on colony morphology, Gram staining, and relevant biochemical tests as per standard protocols.

Antibiotic Susceptibility Testing: Antibiotic susceptibility testing of the isolates was performed using the Kirby–Bauer disc diffusion method. The results were interpreted according to standard guidelines of the Clinical and Laboratory Standards Institute (CLSI).

Data Collection and Analysis: Relevant demographic, clinical, and microbiological data were recorded systematically. The data were compiled and analyzed using appropriate statistical methods. Results were expressed in terms of frequencies and percentages.

Ethical Considerations: The study was conducted after obtaining necessary institutional permissions. Patient confidentiality was maintained throughout the study, and no identifying information was disclosed.

RESULTS

Table 1: Overall Culture Positivity of Surgical Site Infections

Total cases studied	Culture positive	Culture negative	Culture positivity (%)
662	106	556	16%

Out of 662 clinically suspected surgical site infection cases, 106 were culture positive, yielding a culture positivity rate of 16%, while 556 cases (84%) showed no growth. This indicates that a relatively small proportion of clinically suspected cases had microbiologically confirmed infections.

Table 2: Department-wise Distribution of Culture Positive Cases

Department	Total cases	Culture positive	Percentage (%)
Surgery	310	70	22.59%
Orthopaedics	150	30	20%
Obstetrics & Gynaecology	202	27	13.3%

The highest proportion of culture-positive cases was observed in the surgery department (22.59%), followed by orthopaedics (20%), while the lowest was in obstetrics and gynaecology (13.3%), indicating a higher burden of SSI in major surgical procedures.

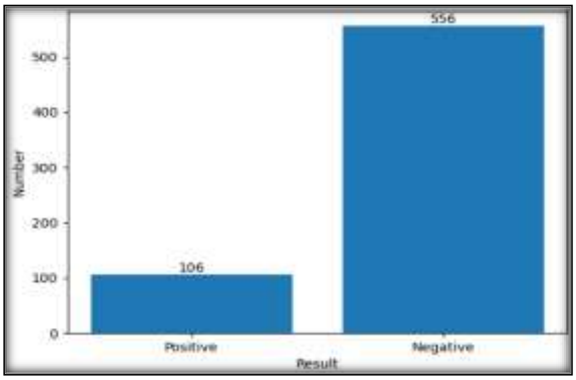

Figure 1: Culture Positivity

Legend: Distribution of culture-positive and culture-negative SSI cases.

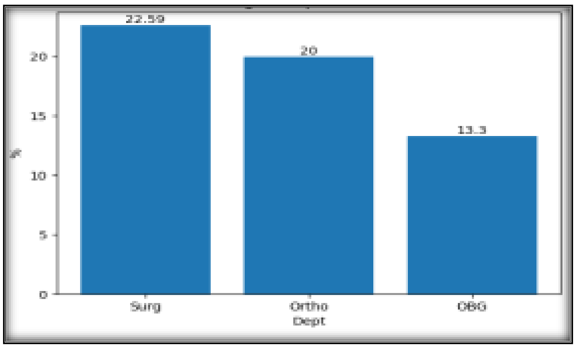

Figure 2: Department-wise Distribution

Legend: Percentage of culture-positive cases across departments (Surg = Surgery, Ortho = Orthopaedics, OBG = Obstetrics & Gynaecology).

Table 3: Sex Distribution among Culture Positive Cases

Sex	Number	Percentage (%)
Male	56	53%
Female	50	47%

Among the 106 culture-positive cases, males constituted 53% (n=56) and females 47% (n=50), showing a slight male predominance in surgical site infections.

Table 4: Age Distribution of Culture Positive Cases

Age Group (years)	Number	Percentage (%)
0–10	3	2.8%
11–20	8	7.5%
21–30	20	18.9%
31–40	30	28.3%
41–50	22	20.7%
51–60	15	14.1%
>60	8	7.5%

The majority of cases were observed in the 31–40 years age group (28.3%), followed by 41–50 years (20.7%) and 21–30 years (18.9%), indicating that middle-aged individuals were more commonly affected.

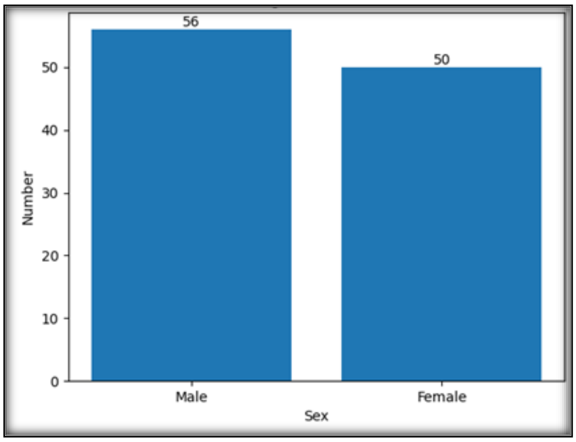

Figure 3: Sex Distribution

Legend: Distribution of SSI cases by sex.

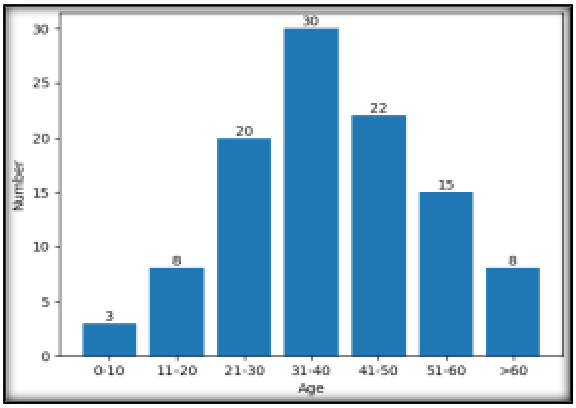

Figure 4: Age Distribution

Legend: Age-wise distribution of culture-positive SSI cases.

Table 5: BMI Distribution among Culture Positive Cases

BMI Category	Number	Percentage (%)
Underweight	12	11.3%
Normal	35	33%
Overweight	20	18.8%
Obese	39	36.79%

A higher proportion of SSI cases was observed among obese individuals (36.79%), followed by those with normal BMI (33%), suggesting obesity as an important associated risk factor.

Table 6: Clinical Manifestations of SSI

Clinical Feature	Number	Percentage (%)
Pain	101	95.2%
Redness	92	86.7%
Tenderness	92	86.7%
Pus discharge	106	100%
Swelling	88	83%
Fever	75	70.7%

Pus discharge was observed in all cases (100%), followed by pain (95.2%), redness and tenderness (86.7% each), indicating that local inflammatory signs were the predominant clinical features.

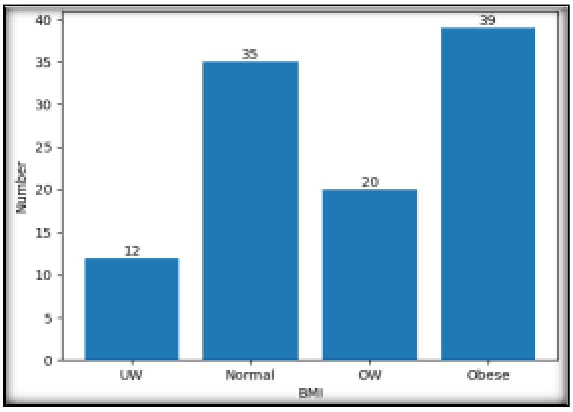

Figure 5: BMI Distribution

Legend: Distribution of SSI cases according to BMI categories (UW = Underweight, OW = Overweight).

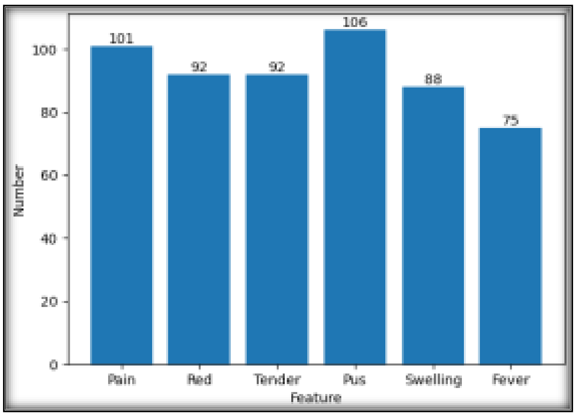

Figure 6: Clinical Features

Legend: Frequency of clinical manifestations in SSI cases.

Table 7: Distribution of Gram-positive and Gram-negative Isolates

Type of organism	Number	Percentage (%)
Gram-positive	39	36.7%
Gram-negative	67	63.2%

A predominance of Gram-negative organisms (63.2%) was observed compared to Gram-positive organisms (36.7%), suggesting a shift towards Gram-negative pathogens in SSI.

Table 8: Bacterial Profile of Isolates

Organism	Number	Percentage (%)
Staphylococcus aureus	28	26.4%
Pseudomonas aeruginosa	19	17.9%
Escherichia coli	18	16.9%
Klebsiella pneumoniae	14	13.2%
Proteus spp.	10	9.4%
Acinetobacter baumannii	9	8.5%
Others	8	7.5%

The most common organism isolated was Staphylococcus aureus (26.4%), followed by Pseudomonas aeruginosa (17.9%) and Escherichia coli (16.9%), indicating a mixed pattern of Gram-positive and Gram-negative pathogens.

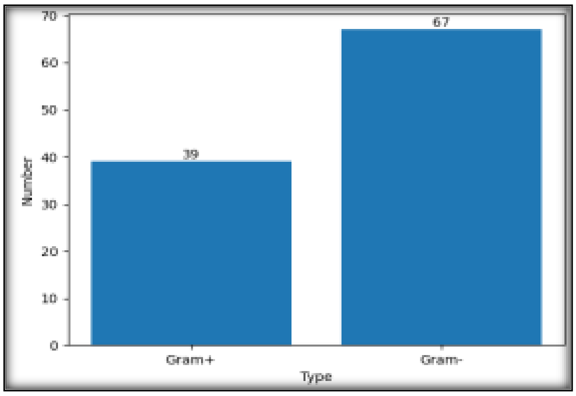

Figure 7: Organism Type

Legend: Distribution of Gram-positive and Gram-negative isolates.

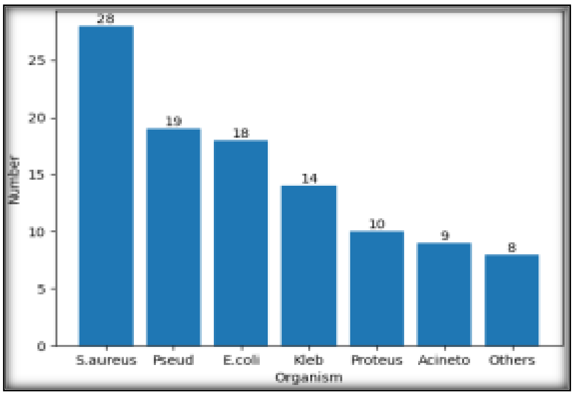

Figure 8: Bacterial Profile

Legend: Distribution of bacterial isolates in SSI cases.

Table 9: Antibiotic Susceptibility Pattern

Antibiotic Group	Gram-positive	Gram-negative
Penicillin	100% resistant	High resistance
Cephalosporins	High resistance	High resistance
Aminoglycosides	Moderate sensitivity	Moderate sensitivity
Fluoroquinolones	Moderate sensitivity	Moderate sensitivity
Carbapenems	Not applicable	High sensitivity
Linezolid	100% sensitive	Not applicable
Vancomycin	High sensitivity	Not applicable

Gram-positive isolates showed complete resistance to penicillin but 100% sensitivity to linezolid, while Gram-negative organisms demonstrated high resistance to beta-lactam antibiotics and better susceptibility to carbapenems and aminoglycosides, indicating emerging multidrug resistance.

Figure 9: -sterile cotton wool swab with sterile tube

Figure 10: collection of pus aspirate from ssi into a sterile syringe which reaches lab within 30 mins and is processed.

Figure 11: AST of staphyloccus aureus

Figure 12: cultural characteristics & biochemical reactions of K. pneumoniae

Figure 13: cultural characteristics & biochemical reactions of E. coli

Figure 14: sugar fermentation & antibiotic susceptibility pattern of E. Coli

Figure 15: cultural characteristics of proteus

Figure 16: swarming growth of proteus species

Figure 17: pseudomonas aeruginosa biochemical reactions

Figure 18: antibiotic susceptibility pattern of P. aeruginosa

DISCUSSION

Overall Incidence of Surgical Site Infection: In the present study, the culture positivity rate among clinically suspected surgical site infections was 16%, indicating a moderate burden of microbiologically confirmed SSI. This finding is consistent with previously reported studies where SSI rates ranged between 6% and 20% in similar tertiary care settings.[11–13] Anvikar et al,[11] in a large prospective analysis, demonstrated considerable variability in SSI incidence depending on wound class and surgical practices, highlighting the multifactorial nature of these infections.

The observed culture positivity rate may appear lower when compared to some studies; however, this could be attributed to prior empirical antibiotic administration, which reduces bacterial yield, or the exclusion of anaerobic organisms due to reliance on aerobic culture methods. Similar limitations have been acknowledged in earlier studies.[12,13]

Demographic and Host-related Factors: A slight male predominance (53%) was observed in the present study. Comparable findings have been reported by Ganguly et al,[12] where male patients were more frequently affected, possibly due to higher exposure to trauma and surgical interventions.

Age distribution in the present study showed a peak incidence in the 31–40 years age group, whereas other studies have reported higher susceptibility in older populations (>50 years), which may be explained by declining immunity, increased comorbidities, and delayed wound healing.[11,15]

Obesity emerged as a significant associated factor, accounting for 36.79% of cases. This observation aligns with findings by Mahesh et al,[15] and Sharan et al,[14] who identified obesity as a key risk factor due to impaired tissue perfusion, reduced oxygenation, and altered immune response. Additionally, factors such as diabetes, anemia, and prolonged hospital stay have been widely implicated in SSI pathogenesis.[14,16]

Clinical Presentation: The predominant clinical manifestations observed in the present study included pus discharge (100%), pain (95.2%), redness and tenderness (86.7%), and swelling. These findings are in accordance with established clinical patterns of SSI, where local inflammatory signs and purulent discharge are the most consistent indicators of infection.[13,16]

Previous studies have emphasized that early recognition of these clinical features is essential for prompt diagnosis and effective management. Variability in symptom presentation across studies may be influenced by the type of surgery, wound classification, and host factors.[14,17]

Microbiological Profile: The present study demonstrated a predominance of Gram-negative organisms (63.2%), reflecting a shift in the microbial pattern of SSI. Similar trends have been reported in recent studies, indicating increasing involvement of Gram-negative bacilli in hospital-acquired infections.[17,18]

Despite this, Staphylococcus aureus (26.4%) remained the most common individual isolate, consistent with classical observations reported by Lilani et al,[13] and Mahesh et al.[15] This organism continues to play a major role due to its presence in normal skin flora and its ability to colonize surgical wounds.

In contrast, some studies have reported Gram-negative organisms such as Escherichia coli as the predominant pathogens, particularly in abdominal surgeries.[17] The differences in microbial profiles across studies may be attributed to variations in surgical procedures, contamination levels, and institutional flora.

The presence of organisms such as Pseudomonas aeruginosa, Klebsiella pneumoniae, and Acinetobacter species in the present study highlights the importance of opportunistic pathogens in SSI, particularly in hospital environments.

Antibiotic Susceptibility Pattern: The antibiotic susceptibility pattern observed in the present study revealed a high level of resistance to commonly used antibiotics, particularly penicillin and cephalosporins. Gram-positive isolates exhibited 100% resistance to penicillin but retained high sensitivity to linezolid and vancomycin. Similar findings have been consistently reported in previous studies,[13,15] indicating the continued effectiveness of these agents as reserve drugs.

Gram-negative isolates showed significant resistance to beta-lactam antibiotics, while demonstrating better susceptibility to carbapenems and aminoglycosides. This pattern is consistent with findings reported by Saxena et al,[17] who highlighted the increasing prevalence of multidrug-resistant Gram-negative organisms.

The emergence of antimicrobial resistance can be attributed to indiscriminate antibiotic usage, lack of adherence to antibiotic policies, and selective pressure within hospital settings. These findings underscore the importance of rational antibiotic use and regular surveillance of susceptibility patterns.

Risk Factors and Pathogenesis: Surgical site infections are multifactorial, involving an interplay between microbial virulence and host defense mechanisms. In the present study, factors such as obesity, comorbid conditions, and type of surgery were found to be associated with SSI.

Previous studies have identified additional risk factors including prolonged duration of surgery, inadequate aseptic precautions, and poor nutritional status.[14,16] Cruse and Foord,[18] in their landmark study, emphasized that wound classification, duration of surgery, and level of contamination are critical determinants of SSI risk.

Infection occurs when microbial load exceeds host defense capacity, particularly in the presence of foreign materials such as sutures or implants, which further predispose to infection.

Clinical and Public Health Implications: The findings of the present study highlight the persistent burden of surgical site infections and the growing challenge of antimicrobial resistance. The predominance of Gram-negative organisms and resistance to first-line antibiotics complicates empirical therapy and may lead to poorer clinical outcomes.

Routine culture and sensitivity testing should be emphasized to guide targeted therapy. Empirical treatment without microbiological confirmation may contribute to the emergence of resistant strains and increased treatment failure.

Implementation of strict infection control measures, including adherence to aseptic techniques, appropriate antibiotic prophylaxis, and surveillance systems, is essential to reduce SSI incidence. Additionally, antibiotic stewardship programs should be strengthened to curb the rising trend of antimicrobial resistance.

Table 10: Comparative Analysis with Previous Studies

Parameter	Present Study	Anvikar et al. (11)	Lilani et al. (13)	Mahesh et al. (15)	Saxena et al. (17)
SSI incidence	16%	Variable	8.95%	~10–15%	~12–18%
Predominant organisms	Gram-negative	Mixed	Gram-positive dominant	Gram-positive dominant	Gram-negative dominant
Most common organism	S. aureus	S. aureus	S. aureus	S. aureus	E. coli
Gram-negative trend	High (63.2%)	Moderate	Increasing	Moderate	High
Penicillin resistance	100% (Gram +)	High	High	High	High
Effective drugs	Linezolid, Vancomycin	Similar	Similar	Similar	Carbapenems
Risk factors	Obesity, comorbidities	Surgical factors	Wound type	BMI, comorbidities	Hospital factors

CONCLUSION

Surgical site infections continue to pose a significant challenge in postoperative patient care, particularly in tertiary care settings. The present study demonstrates a moderate incidence of SSI with a predominance of Gram-negative organisms, indicating a shift in the microbial pattern. Staphylococcus aureus remains the most common individual pathogen, reflecting its persistent role in surgical wound infections.

The observed high resistance to commonly used antibiotics, especially penicillin and cephalosporins, highlights the growing problem of antimicrobial resistance. However, the preserved sensitivity to linezolid, vancomycin, and carbapenems provides important therapeutic options.

These findings emphasize the need for routine culture and sensitivity testing prior to antibiotic therapy, implementation of strict infection control measures, and strengthening of antibiotic stewardship programs. Continuous surveillance of microbial trends is essential to guide empirical therapy and improve patient outcomes.

Limitations of the study

1. The present study has certain limitations that should be considered while interpreting the findings.
2. Firstly, only aerobic bacterial cultures were performed. Anaerobic organisms, which are known contributors to surgical site infections, were not included due to methodological constraints. This may have led to an underestimation of the true microbiological spectrum of SSI.
3. Secondly, the culture positivity rate was relatively low (16%), which could be attributed to prior empirical antibiotic usage among patients before sample collection. This may have reduced bacterial yield and influenced the observed microbial profile.
4. Thirdly, the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings with different patient populations, surgical practices, and infection control protocols.
5. Fourthly, advanced microbiological techniques, such as molecular identification and detection of resistance genes (e.g., MRSA, ESBL), were not performed. Therefore, detailed characterization of antimicrobial resistance patterns could not be achieved.
6. Fifthly, the study primarily focused on bacteriological and susceptibility patterns and did not include a comprehensive analysis of procedure-related variables, such as duration of surgery, wound classification, and intraoperative factors, which are known to influence SSI risk.

Future Directions

Future research should focus on expanding the microbiological and clinical scope of surgical site infection studies.

- Inclusion of anaerobic culture techniques and molecular diagnostic methods would provide a more comprehensive understanding of the etiological agents involved in SSI and improve detection rates.
- Multicentric studies involving larger and more diverse populations are required to enhance the generalizability of findings and to establish region-specific microbial trends.
- Further studies should incorporate detailed risk factor analysis, including surgical variables, duration of procedures, antibiotic prophylaxis protocols, and hospital infection control practices, to better understand determinants of SSI.

- There is also a need to investigate the molecular mechanisms of antimicrobial resistance, including identification of resistance genes such as MRSA and ESBL-producing organisms, which will aid in developing targeted therapeutic strategies.
- Implementation and evaluation of antibiotic stewardship programs and infection control interventions should be explored to assess their effectiveness in reducing SSI rates and limiting antimicrobial resistance.

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