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Original Research Article

Assessing the Risk and Antibiotic Resistance Profile of Hospital-Acquired Infections in Postoperative Patients with Surgical Wounds

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Abstract

Background: Surgical site infections (SSIs) pose a significant threat, accounting for 15% of hospital-acquired infections. Worryingly, gram-negative bacteria, often resistant to antibiotics, are increasingly causing these infections. This study aimed to understand the types of bacteria causing SSIs and their antibiotic susceptibility patterns to inform better treatment strategies.

Methods: Pus samples were collected either using sterile cotton swabs or through aspiration and promptly transported to the laboratory. Standard procedures, including Gram staining and culture on blood agar and MacConkey agar plates, were followed, with the plates then being incubated at 37°C for 48 hours. Organisms that grew were identified using established techniques, and any ambiguous results were confirmed using the automated VITEK 2-compact system (BioMerieux, France) following the manufacturer's instructions.

Results: S. aureus and Enterococcus showed high resistance to common antibiotics like penicillin, ampicillin, and ciprofloxacin. Levofloxacin, gentamicin, and linezolid emerged as effective options. Similarly, Gram-negative bacteria displayed significant resistance, particularly to amoxicillin/clavulanic acid and cephalosporins like cefotaxime. Notably, imipenem remained effective against most tested bacteria, highlighting its potential as a broad-spectrum choice.

Conclusion: In conclusion, despite modern surgical and sterilization techniques and prophylactic antimicrobial use, SSIs remain clinically challenging, with MRSA posing a significant threat in healthcare settings. Understanding the microbial epidemiology of SSIs within each institution is crucial for establishing appropriate empirical treatment and antimicrobial policies.

Keywords: Surgical Site Infections (SSI), Nosocomial infections, Methicillin-Resistant Staphylococcus aureus (MRSA), Antibiotic resistance.

Introduction

Surgical site infections (SSIs), occurring within 30 days of a surgical procedure, constitute a significant source of morbidity and mortality in surgical settings. They contribute to approximately 15% of all nosocomial infections and represent the most common form of nosocomial infection among surgical patients [1]. These infections stem from microbial colonization at the surgical site, often due to factors such as inadequate preoperative preparation, wound contamination, inappropriate antibiotic choices, or compromised host immune responses. Ranging from minor surface infections to severe systemic diseases, SSIs present a spectrum of severity [2].

Typically, infected surgical wounds manifest with symptoms such as pain, tenderness, warmth, erythema, swelling, and purulent discharge [3, 4]. Postoperative infections lead to prolonged hospital stays, increased healthcare costs, higher rates of readmission, and compromised patient outcomes, earning them the moniker "The Silent Killer: Nosocomial Infections" [5]. Bacteriological studies have revealed that SSIs are pervasive, with causative agents varying geographically, across different surgical procedures, among surgeons, and even within different hospital wards [6]. In recent years, there has been a notable increase in the prevalence of Gram-negative organisms as causative agents of serious infections in many healthcare settings. Furthermore, the indiscriminate use of broad-spectrum antibiotics has contributed to antimicrobial resistance, exacerbating the challenge of combating SSIs. Developing countries face additional complexities due to suboptimal infection control practices, overcrowded healthcare facilities, and inappropriate antimicrobial use [7]. The current study aimed to identify the bacteria responsible for surgical site infections and their resistance to antibiotics, informing the development of effective treatment plans.

Material and methods

This is a cross-sectional study. Written consent was obtained from all the participants in the study. All patients postoperatively diagnosed with surgical site infections across various wards (including Orthopaedics, General Surgery, Gynaecology, ENT, and ICUs) were enrolled in the study. Pus samples were collected either using sterile cotton swabs or through aspiration and promptly transported to the laboratory. Standard procedures, including Gram staining and culture on blood agar and MacConkey agar plates, were followed, with the plates then being incubated at 37°C for 48 hours [8]. Organisms that grew were identified using established techniques, and any ambiguous results were confirmed using the automated VITEK 2-compact system (BioMerieux, France) following the manufacturer's instructions. Antibiotic susceptibility testing was conducted on Mueller Hinton agar using antibiotics from various classes, including beta-lactams, glycopeptides, aminoglycosides, macrolides, and fluoroquinolones, by CLSI guidelines.

Methicillin-resistant Staphylococcus aureus (MRSA) detection: The presence of MRSA was determined via the disc diffusion test using a cefoxitin (30µg) disc on Mueller–Hinton Agar. Any strain exhibiting an inhibition zone of ≤19 mm was considered methicillin-resistant Staphylococcus aureus according to CLSI guidelines [9]. *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922, *Klebsiella pneumoniae* ATCC 700603, *Pseudomonas aeruginosa* ATCC 27853, and *S.aureus* ATCC 29213 (MRSA) were employed as control strains for antibiotic susceptibility testing. All dehydrated media, reagents, and antibiotic discs were procured from Hi Media Laboratories Pvt. Ltd., Mumbai, India.

Statistical Analysis: All available data was compiled into an Excel spreadsheet and imported into SPSS software (version 19, Windows format) for statistical analysis. For continuous variables, we reported both mean values with standard deviations and percentages to capture both central tendency and spread. Categorical variables were compared using chi-square tests, while unpaired t-tests were employed for continuous variables with two groups. A significance level of $p < 0.05$ was applied to all statistical tests.

Results

A total of n=62 case samples were included in the study during the duration of the study period. Out of n=62 cases n=40(64.52%) were males and n=22(35.48%) were females. The age range was 27 years to 77 years the mean age of the cohort was 55.46 ± 10.75 years. Table 1 shows the distribution of pus samples collected for microbiological examination from patients in different hospital wards within a study of 62 participants. *Predominant source*: General Surgery contributed the most significant number of samples (35), accounting for over half (56.45%) of the total.*Other contributing wards*: Orthopedics followed with 11 samples (17.74%), followed by Gynecology (5 samples, 8.06%), ENT (4 samples, 6.45%), and ICU (7 samples, 11.29%).The presence of samples from various wards suggests the study encompasses a diverse range of potential infection sources.

Table 1: Showing the frequency of pus samples collected for microbiological examination

Ward	Samples	Percentage
General Surgery	35	56.45
Orthopedics	11	17.74
Gynecology	5	8.06
ENT	4	6.45
ICU	7	11.29

Table 2 shows the distribution of different microorganisms isolated from pus samples of 62 patients with surgical site infections (SSIs) in the study. *S. aureus:* The most frequent isolate, found in 21 cases (33.87%), highlighting its continued significance in SSIs.*P. aeruginosa:* Another major pathogen, present in 18 cases (29.03%), emphasizing the concern for gram-negative infections.*E. coli:* A notable representative of Enterobacteriaceae, identified in 10 cases (16.13%).The findings align with established knowledge about common bacterial causes of SSIs, with *S. aureus* and *P. aeruginosa* being well-recognized culprits.The presence of less frequent organisms highlights the diverse microbial landscape associated with SSIs and the need for broad-spectrum diagnostic approaches.

Table 2: Frequency of isolated microorganisms from n=62 cases of surgical site infections included in the study

Organism	No. of isolates	Percentage (%)
S.aureus	21	33.87
CONS	3	4.84
Enterococcus	2	3.22
E.coli	10	16.13
K.pneumoniae	2	3.22
Proteus mirabilis	2	3.22
P.aeruginosa	18	29.03
Acinetobacter	4	6.45

Out of 21 isolates of *Staphylococcus aureus*, isolated in this study n=12 (57.14%) were found to be methicillin-resistant depicted in Figure 1.

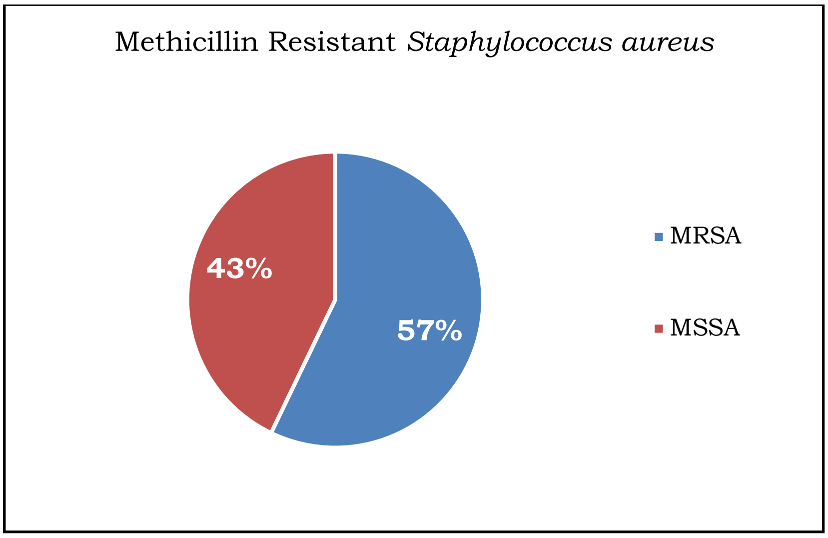

Figure 1: Showing the distribution of Methicillin resistant *Staphylococcus aureus*

Table 3 : Antibiotic sensitivity pattern of Gram-positive bacteria

Antibiotics	S.aureus (n=21)	CONS (n=3)	Enterococcus (n=2)
Penicillin	23.80%	0	0
Ampicillin	NT	NT	0
Ciprofloxacin	NT	NT	0
Levofloxacin	95.23%	66.66%	100%
Chloramphenicol	NT	NT	0
Gentamicin	66.67%	66.66%	50%
Linezolid	95.23%	0	100%
Cefoxitin	47.62%	0	NT
Erythromycin	69.23%	66.66%	NT
Clindamycin	76.19%	0	NT
Vancomycin	100%	100%	100%
Teicoplanin	95.23%	33.33%	NT

Table 3 shows the antibiotic sensitivity patterns of three types of Gram-positive bacteria: *S. aureus* (n=21), CONS (coagulase-negative *staphylococci*, n=3), and *Enterococcus* (n=2). **Penicillin, Ampicillin, and Ciprofloxacin:** No isolates of *S. aureus, CONS,* or *Enterococcus* were sensitive to penicillin or ampicillin, indicating high resistance to these first-line antibiotics. Similarly, no *Enterococcus* isolates were sensitive to ciprofloxacin. **Levofloxacin, Gentamicin, and Linezolid:** These antibiotics showed good activity against most isolates. Levofloxacin was effective against *S. aureus* and *Enterococcus*, while gentamicin was effective against all three species. Linezolid showed excellent activity against both *S. aureus* and *Enterococcus.* **Cefoxitin:** While effective against almost half of *S. aureus* isolates, it showed no activity against CONS and unknown effectiveness against *Enterococcus*.

Erythromycin and Clindamycin: Moderate activity was observed against *S. aureus*, but sensitivity data for other species was missing or unknown.

Vancomycin and Teicoplanin: These broad-spectrum antibiotics were highly effective against all three bacterial types.

Table 4 : Antibiotic sensitivity pattern of Gram-negative bacteria

Antibiotics	E.coli (n=10)	Klebsiella (n=2)	Proteus (n=2)	P.aeruginosa (n=18)	Acinetobacter (n=4)
Amoxicillin/ clavulanic acid	0	0	100%	22.22%	0
Amikacin	60%	50%	100%	5.56%	33.33%
Tobramycin	70%	50%	100%	55.56%	100%
Gentamicin	90%	0	100%	44.44%	0
Levofloxacin	80%	50%	100%	22.22%	NT
Tetracycline	20%	50%	50%	50.00%	NT
Ticarcillin	7%	0	50%	55.56%	NT
Cefotaxime	20%	0	50%	55.56%	0
Ceftriaxone	7%	0	50%	22.22%	0
Ceftazidime	20%	0	0	72.22%	100%
Cefepime	7%	0	0	NT	0
Aztreonam	7%	0	50%	NT	0
Imipenem	100%	100%	100%	77.78%	100%

Table 4 summarizes the antibiotic susceptibility patterns of five types of Gram-negative bacteria: *E. coli* (n=10), *Klebsiella* (n=2), *Proteus* (n=2), P. *aeruginosa* (n=18), and *Acinetobacter* (n=4). Highly resistant Gram-negative bacteria: Most antibiotics display significant resistance among some or all species, particularly: Amoxicillin/clavulanic acid: No activity against *E. coli*, *Klebsiella, or P. aeruginosa*, highlighting the limitations of this commonly used first-line antibiotic. Ticarcillin, Cefotaxime, Ceftriaxone, Ceftazidime, and Cefepime: Variable activity across species, but generally low effectiveness against several bacteria. Effective antibiotics: Some options showed good activity against various species: Amikacin, Tobramycin, and Gentamicin: Effective against most isolates of *E. coli*, *Proteus*, and *P. aeruginosa*, but variable against *Klebsiella* and *Acinetobacter*. Levofloxacin: Good activity against *E. coli*, *Proteus*, and *P. aeruginosa*, but limited data for other species. Imipenem: Highly effective against all tested bacteria, suggesting its potential as a broad-spectrum option.

Discussion

Despite advancements in surgical techniques and a better understanding of wound infection pathogenesis, managing Surgical Site Infections (SSIs) remains a significant concern in healthcare facilities. Patients with SSIs are exposed to microbial populations circulating within hospitals, which are increasingly resistant to available antimicrobials, exacerbating the problem [6]. In this study, a total of 62 isolates of various organisms were obtained from pus samples collected from different hospital wards, with the majority originating from the general surgery ward. Gender statistics revealed a male predominance, consistent with findings from other studies [10, 11].

During the investigation of the relationship between surgical site infections (SSI) and preoperative hospitalization duration, it was noted that an extended preoperative stay is linked to a higher incidence of wound infections. Specifically, patients who remained hospitalized for more than 5 days exhibited a heightened infection rate of 30%, in contrast to those with shorter stays. This observation aligns with previous research conducted by Patel et al. [12] and PJE Cruse [13]. Bacteriological profiling identified *Staphylococcus aureus* (33.87%) as the predominant organism, followed by *Pseudomonas aeruginosa* (28.92%) and *Escherichia coli* (16.13%). These results were consistent with findings by More et al. [14] and Khyati et al. [15] *S. aureus* infection likely arises from endogenous sources, including skin and nasal flora, as well as contamination from the hospital environment, surgical instruments, or healthcare workers' hands [6]. Notably, a considerable proportion of *S. aureus* isolates in our study were methicillin-resistant (57.14%), mirroring findings by Kaye et al. [16] and Khyati et al. [15] but differing from those reported by Negi et al. [6] and Aggarwal et al. [17] In terms of antimicrobial sensitivity, vancomycin, linezolid, and teicoplanin were identified as the most effective drugs against Gram-positive organisms, while penicillin showed the least sensitivity, consistent with findings by Negi et al. [6] Sasikumari et al. [11] and Khyati et al. [15] Among Gram-negative isolates, imipenem exhibited maximum sensitivity (100%), consistent with studies by Sasikumari et al. [11] and More et al. [14] Levofloxacin also showed good sensitivity, whereas cephalosporins demonstrated significant resistance, in line with findings by More et al. [14] and Kakati B et al. [17] Additionally, non-fermenters showed high sensitivity to imipenem, as reported by Budhani et al. Sasikumari et al. [11] and Domingo et al. [18] The occurrence of surgical site infections (SSIs) is more prevalent in surgeries classified as contaminated, underscoring the necessity for thorough preparation in such cases. Upon examining the risk factors associated with SSIs, it became evident that patients with extended preoperative hospital stays, longer surgical durations, emergency procedures, and those in older age groups exhibited elevated rates of SSIs.

Conclusion

In conclusion, despite modern surgical and sterilization techniques and prophylactic antimicrobial use, SSIs remain clinically challenging, with MRSA posing a significant threat in healthcare settings. Understanding the microbial epidemiology of SSIs within each institution is crucial for establishing appropriate empirical treatment and antimicrobial policies. This study contributes valuable insights that can inform initiatives aimed at improving hospital antimicrobial policies and prescribing guidelines while emphasizing the importance of judicious antibiotic use to prevent the development of antimicrobial resistance.

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