e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(5); 146-150

Original Research Article

Bacteriological Profile and Antimicrobial Susceptibility Pattern of Surgical Site Infection: A Cross Sectional Study at Tertiary Care Hospital, Kachchh

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Received: 01-02-2026 / Revised: 15-03-2026 / Accepted: 21-04-2026

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Conflict of interest: Nil

Abstract

Background: Surgical site infections (SSIs) are a major cause of postoperative morbidity and are associated with increased healthcare burden. The changing bacteriological profile and rising antimicrobial resistance necessitate continuous surveillance.

Aim: To determine the incidence, bacteriological profile, and antimicrobial susceptibility pattern of surgical site infections in a tertiary care hospital.

Methods: A cross-sectional study was conducted on 150 patients with SSIs. Samples were collected aseptically and processed for bacterial identification and antibiotic susceptibility testing using standard microbiological methods.

Results: The overall culture positivity rate was 64%. Staphylococcus aureus (29.09%) was the most common isolate, followed by Escherichia coli (20%) and Pseudomonas aeruginosa (16.36%). Gram-positive cocci showed high sensitivity to Linezolid, Teicoplanin, and Vancomycin, while Gram-negative bacilli were most sensitive to Piperacillin-tazobactam and Meropenem. Increasing resistance to commonly used antibiotics was observed.

Conclusion: SSIs remain a significant healthcare challenge with a diverse microbial profile and rising antimicrobial resistance. Regular surveillance and rational antibiotic policies are essential for effective management.

Keywords: Surgical Site Infection, Antibiogram, Antimicrobial Resistance, Bacteriological Profile.

DOI: 10.25258/ijcpr.18.5.22

Introduction

Surgical site infections (SSIs) are among the most common healthcare-associated infections and continue to represent a major burden on healthcare systems worldwide. They are associated with increased postoperative morbidity, prolonged hospital stay, higher healthcare costs, and increased mortality rates. Despite advances in surgical techniques, aseptic measures, and antimicrobial prophylaxis, SSIs remain a persistent challenge, particularly in developing countries where infection control practices and surveillance systems may be inconsistent [1,2].

The incidence of SSIs varies widely depending on the type of surgical procedure, patient-related risk factors, and hospital settings. Recent studies have reported SSI rates ranging from 5% to 20% in tertiary care hospitals, with higher rates observed in low- and middle-income countries [3,4]. Factors such as poor nutritional status, diabetes mellitus, prolonged preoperative hospital stay, and inappropriate antibiotic use significantly contribute to the increased risk of infection [5].

Microbiologically, SSIs are caused by a wide range of pathogens, including both Gram-positive and Gram-negative organisms. Traditionally, Staphylococcus aureus has been considered the most common causative organism; however, recent studies have shown a shift toward Gram-negative bacilli such as Escherichia coli, Pseudomonas aeruginosa, and Klebsiella species [6,7]. This shift is attributed to changes in hospital flora, increased use of invasive procedures, and widespread use of broad-spectrum antibiotics [8]. The emergence of antimicrobial resistance (AMR) among SSI pathogens has further complicated their management. Multidrug-resistant (MDR) organisms, including methicillin-resistant Staphylococcus aureus (MRSA) and extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacteria, Carbapenem-Resistant Enterobacterales (CRE) are increasingly being reported in hospital settings [9]. These resistant strains not only limit therapeutic options but also lead to treatment failure, increased complications, and higher mortality rates [10].

Understanding the bacteriological profile and antimicrobial susceptibility patterns of SSIs is essential for guiding empirical antibiotic therapy and developing effective infection control strategies. Local epidemiological data are particularly important, as microbial patterns and resistance profiles vary significantly across regions and institutions. Therefore, continuous surveillance and antibiogram analysis are crucial for optimizing antibiotic stewardship and improving patient outcomes.

Material and Methods

This cross-sectional study was conducted in the Department of Microbiology in collaboration with the Department of Surgery at a tertiary care hospital in Kachchh. The study was carried out over a period of one year, during which patients who developed surgical site infections (SSIs) following various surgical procedures were included. A total of 150 patients clinically diagnosed with SSIs, based on standard criteria such as purulent discharge from the surgical wound, signs of inflammation including redness, warmth, swelling, pain, or wound dehiscence, were enrolled in the study.

All patients of either gender and of all age groups who developed SSIs after undergoing surgical procedures were included in the study. Patients those unwilling to participate were excluded. After obtaining informed consent, detailed clinical history including demographic details, type of surgery, duration of hospital stay, and associated risk factors such as diabetes mellitus and immunocompromised status were recorded in a predesigned proforma.

Wound samples were collected aseptically by aspirating pus from the infected surgical site, which is considered superior to pus swab sampling, or by using sterile cotton swabs when aspiration was not feasible. The samples were transported immediately to the microbiology laboratory for further processing. Direct microscopy was performed using Gram staining to identify the preliminary morphology of organisms. The specimens were then inoculated onto appropriate culture media such as blood agar and MacConkey agar and incubated aerobically at 37°C for 24–48 hours. The isolates obtained were identified based on colony characteristics, Gram staining, and standard biochemical tests.

Antimicrobial susceptibility testing of the isolated organisms was carried out using the Kirby–Bauer disk diffusion method on Mueller-Hinton agar, in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines. A panel of commonly used antibiotics was tested, and the results were interpreted as sensitive, intermediate, or resistant based on CLSI criteria. Detection of multidrug-resistant organisms, including methicillin-resistant Staphylococcus aureus (MRSA) and extended-spectrum beta-lactamase (ESBL) producers, was performed using standard phenotypic methods.

All collected data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software version 25.0. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were used to summarize the data. The association between categorical variables was analyzed using the Chi-square test, and a p-value of less than 0.05 was considered statistically significant.

Prior to the commencement of the study, ethical clearance was obtained from the Institutional Ethics Committee of the tertiary care hospital. Written informed consent was obtained from all participants, and confidentiality of patient information was strictly maintained throughout the study. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Results

Table 1 shows the distribution of surgical cases and culture positivity among 150 patients. Out of 150 cases, clean contaminated surgeries constituted the largest group with 60 cases, followed by contaminated surgeries with 50 cases, clean surgeries with 25 cases, and dirty surgeries with 15 cases. A total of 96 samples showed culture positivity. Clean contaminated surgeries contributed the highest number of positive cultures (40 cases, 41.66%), followed by contaminated surgeries (32 cases, 33.33%), clean surgeries (14 cases, 14.58%), and dirty surgeries (10 cases, 10.41%). The difference in culture positivity across different surgical categories was found to be statistically insignificant ($p>0.05$). Table 2 illustrates the distribution of bacterial isolates recovered from surgical site infections. A total of 110 bacterial isolates were obtained from 150 cases. Among these, 85 isolates (77.27%) were pure isolates, while 25 isolates (22.72%) were part of mixed infections. Staphylococcus aureus was the most commonly isolated organism with 32 isolates (29.09%), followed by Escherichia coli with 22 isolates (20%) and Pseudomonas aeruginosa with 18 isolates (16.36%). Coagulase negative Staphylococci accounted for 14 isolates (12.72%), while Klebsiella pneumoniae and Acinetobacter baumannii contributed 8 (7.27%) and 6 (5.45%) isolates respectively. Enterococcus faecalis, Proteus mirabilis, and Streptococcus pyogenes were less commonly isolated organisms, contributing 5 (4.54%), 3 (2.72%), and 2 (1.81%) isolates respectively.

Antibiotic susceptibility pattern of gram-positive cocci: The antimicrobial susceptibility profile of gram-positive cocci isolated from surgical site infections is presented in Table 3. Among the 53 gram-positive isolates, Staphylococcus aureus was the predominant pathogen (n=32), followed by coagulase-negative staphylococci (CoNS) (n=14), Enterococcus faecalis (n=5), and Streptococcus pyogenes (n=2). Most gram-positive isolates demonstrated excellent susceptibility to higher antibiotics such as Linezolid, Vancomycin, Teicoplanin, Tigecycline, and Daptomycin. Staphylococcus aureus showed very high sensitivity to vancomycin (96.9%), linezolid (96.9%), teicoplanin (96.9%), and tigecycline (96.9%). CoNS also demonstrated high susceptibility to vancomycin (92.9%), linezolid (100%), teicoplanin (92.9%), and tigecycline (100%). Moderate sensitivity was observed to fluoroquinolones, clindamycin, and gentamicin, while lower sensitivity was seen with benzylpenicillin and oxacillin, indicating resistance among some isolates.

Antibiotic susceptibility pattern of gram-negative bacilli: The antimicrobial susceptibility pattern of gram-negative bacilli is summarized in Table 4. Among the 57 isolates, Escherichia coli was the most common pathogen (n=22), followed by Pseudomonas aeruginosa (n=18), Klebsiella pneumoniae (n=8), Acinetobacter baumannii (n=6), and Proteus mirabilis (n=3). Most gram-negative isolates exhibited high susceptibility to Piperacillin/Tazobactam, Carbapenems (Imipenem, Meropenem), Colistin, Amikacin, and Tigecycline. E. coli showed excellent sensitivity to piperacillin/tazobactam (95.5%), imipenem (90.9%), meropenem (90.9%), and colistin (90.9%). Pseudomonas aeruginosa demonstrated 100% susceptibility to piperacillin/tazobactam and high sensitivity to carbapenems and colistin. Lower susceptibility rates were observed with ceftriaxone, amoxicillin/clavulanic acid, and ciprofloxacin, suggesting increasing resistance to commonly used antibiotics.

Table 1: Distribution of samples and culture positivity based on type of surgeries (n = 150)

Type of surgery	No. of cases	No. of samples showing culture positivity	% of culture positivity
Clean	25	14	14.58%
Clean contaminated	60	40	41.66%
Contaminated	50	32	33.33%
Dirty	15	10	10.41%
Total	150	96	100%

Table 2: Distribution of total (pure and mixed) bacterial isolates (n = 110)

Organism	Total No.	Total %	Pure No.	Pure %	Mixed No.	Mixed %
Staphylococcus aureus	32	29.09%	25	22.72%	7	6.36%
Pseudomonas aeruginosa	18	16.36%	14	12.72%	4	3.63%
Escherichia coli	22	20%	17	15.45%	5	4.54%
Coagulase negative Staphylococci	14	12.72%	11	10%	3	2.72%
Klebsiella pneumoniae	8	7.27%	6	5.45%	2	1.81%
Acinetobacter baumannii	6	5.45%	5	4.54%	1	0.90%
Enterococcus faecalis	5	4.54%	4	3.63%	1	0.90%
Proteus mirabilis	3	2.72%	2	1.81%	1	0.90%
Streptococcus pyogenes	2	1.81%	1	0.90%	1	0.90%
Total	110	100%	85	77.27%	25	22.72%

Table 3: Antibiotic susceptibility pattern of gram-positive cocci (n = 53)

Organism	BEN	CXS	CIP	CD	DAP	ERY	GEN	LE	LZ	NIT	OXA	RIF	TEI	TET	TGC	SXT	VA
Staphylococcus aureus (n=32)	8 (25.0%)	26 (81.3%)	29 (90.6%)	28 (87.5%)	32 (100%)	25 (78.1%)	30 (93.8%)	30 (93.8%)	31 (96.9%)	24 (75.0%)	26 (81.3%)	30 (93.8%)	31 (96.9%)	26 (81.3%)	31 (96.9%)	27 (84.4%)	31 (96.9%)
CoNS (n=14)	4 (28.6%)	11 (78.6%)	13 (92.9%)	12 (85.7%)	14 (100%)	10 (71.4%)	13 (92.9%)	13 (92.9%)	14 (100%)	11 (78.6%)	10 (71.4%)	13 (92.9%)	13 (92.9%)	11 (78.6%)	14 (100%)	12 (85.7%)	13 (92.9%)
Streptococcus pyogenes (n=2)	2 (100%)	-	2 (100%)	2 (100%)	-	2 (100%)	-	2 (100%)	2 (100%)	-	-	-	-	2 (100%)	-	2 (100%)	2 (100%)
Enterococcus faecalis (n=5)	5 (100%)	-	3 (60%)	-	5 (100%)	3 (60%)	4 (80%)	4 (80%)	5 (100%)	5 (100%)	-	-	5 (100%)	3 (60%)	5 (100%)	4 (80%)	5 (100%)

Table 4: Antibiotic susceptibility pattern of gram-negative bacilli (n = 57)

Isolate	AK	AMC	CPM	CFS	CTR	CXM	CIP	CL	ETP	FOS	GEN	IMP	MRP	PIT	TGC	SXT
Pseudomonas aeruginosa (n=18)	11 (61.1%)	2 (11.1%)	13 (72.2%)	15 (83.3%)	5 (27.8%)	-	13 (72.2%)	16 (88.9%)	-	-	10 (55.6%)	16 (88.9%)	16 (88.9%)	18 (100%)	14 (77.8%)	-
Escherichia coli (n=22)	19 (86.4%)	7 (31.8%)	18 (81.8%)	19 (86.4%)	15 (68.2%)	14 (63.6%)	11 (50.0%)	20 (90.9%)	20 (90.9%)	18 (81.8%)	18 (81.8%)	20 (90.9%)	20 (90.9%)	21 (95.5%)	19 (86.4%)	16 (72.7%)
Klebsiella pneumoniae (n=8)	6 (75.0%)	3 (37.5%)	6 (75.0%)	8 (100%)	3 (37.5%)	2 (25.0%)	3 (37.5%)	7 (87.5%)	6 (75.0%)	5 (62.5%)	6 (75.0%)	6 (75.0%)	6 (75.0%)	8 (100%)	6 (75.0%)	4 (50.0%)
Proteus mirabilis (n=3)	3 (100%)	1 (33.3%)	2 (66.7%)	3 (100%)	2 (66.7%)	2 (66.7%)	2 (66.7%)	3 (100%)	3 (100%)	2 (66.7%)	3 (100%)	3 (100%)	3 (100%)	3 (100%)	2 (66.7%)	2 (66.7%)
Acinetobacter baumannii (n=6)	2 (33.3%)	1 (16.7%)	2 (33.3%)	3 (50.0%)	1 (16.7%)	1 (16.7%)	2 (33.3%)	5 (83.3%)	-	-	2 (33.3%)	5 (83.3%)	5 (83.3%)	6 (100%)	3 (50.0%)	1 (16.7%)

Discussion

The present study evaluated the bacteriological profile and antimicrobial susceptibility pattern of surgical site infections (SSIs) among 150 patients in a tertiary care hospital setting. The overall culture positivity rate observed in this study was 64% (96/150), which is comparable to recent studies reporting SSI positivity rates between 55% and 70% in similar hospital settings [11,12].

The highest culture positivity was observed in clean contaminated (41.66%) and contaminated surgeries (33.33%), reflecting the increased risk of infection due to endogenous microbial flora and operative exposure. However, the association between type of surgery and infection rate was not statistically significant (p>0.05), indicating that other host and procedural factors may play a contributory role.

The bacteriological profile revealed that Staphylococcus aureus was the most predominant organism (29.09%), followed by Escherichia coli (20%) and Pseudomonas aeruginosa (16.36%). This finding aligns with contemporary literature, which continues to report Staphylococcus aureus as the leading cause of SSIs, particularly in clean and clean contaminated surgeries [13]. However, the significant presence of Gram-negative bacilli such as E. coli and Pseudomonas indicates a shifting trend toward mixed flora and hospital-acquired pathogens. Similar observations have been reported in recent multicentric studies highlighting the increasing role of Gram-negative organisms in SSIs [12,14]. In the present study, 77.27% of isolates were obtained as pure cultures, whereas 22.72% were from mixed infections.

The presence of mixed infections suggests polymicrobial involvement, particularly in contaminated and dirty surgeries. This emphasizes the importance of broad-spectrum empirical therapy in severe infections until culture reports are available. The diversity of organisms isolated reflects the complexity of SSIs and the need for continuous microbiological surveillance [14]. Among gram-positive organisms, Staphylococcus aureus was the predominant isolate, which is consistent with previous studies identifying it as the leading pathogen in postoperative wound infections. The high sensitivity of S. aureus and CoNS to vancomycin, linezolid, teicoplanin, tigecycline, and daptomycin indicates that these agents remain highly effective against gram-positive cocci, including resistant strains. The observed reduced susceptibility to benzylpenicillin and oxacillin may indicate beta-lactam resistance and possible methicillin-resistant staphylococcal strains.

Among gram-negative bacilli, Escherichia coli and Pseudomonas aeruginosa were the most frequently isolated organisms. Both organisms demonstrated excellent susceptibility to piperacillin/tazobactam, carbapenems, colistin, and aminoglycosides. These findings suggest that reserve antibiotics continue to retain efficacy against gram-negative pathogens in the present setting.

However, reduced susceptibility to third-generation cephalosporins, amoxicillin/clavulanic acid, and fluoroquinolones may indicate emerging multidrug resistance, likely due to widespread and irrational antibiotic use [14,15]. The high effectiveness of vancomycin and linezolid among gram-positive isolates and carbapenems among gram-negative isolates supports their judicious use in severe or complicated surgical site infections. Nevertheless, overuse of these higher antibiotics should be avoided to prevent the development of future resistance. Periodic surveillance of institutional antibiograms is essential to guide empirical therapy and formulate antibiotic stewardship policies.

These findings emphasize the importance of obtaining culture and sensitivity reports before initiating definitive therapy. Early targeted treatment based on microbiological evidence can significantly reduce morbidity, shorten hospital stay, and improve surgical outcomes.

Conclusion

The present study concludes that surgical site infections remain a significant concern in tertiary care settings, with a high prevalence observed particularly in clean contaminated and contaminated surgeries. The present study demonstrates that surgical site infections are caused by a mixed spectrum of gram-positive cocci and gram-negative bacilli, with Staphylococcus aureus and Escherichia coli being the most commonly isolated pathogens. Gram-positive isolates showed highest sensitivity to vancomycin, linezolid, teicoplanin, tigecycline, and daptomycin, whereas gram-negative bacilli were most sensitive to piperacillin/tazobactam, carbapenems, colistin, amikacin, and tigecycline. Reduced susceptibility to commonly used antibiotics such as penicillins, cephalosporins, and fluoroquinolones indicates an increasing trend of antimicrobial resistance.

Therefore, routine microbiological culture and susceptibility testing should be encouraged in all surgical site infections to ensure rational antibiotic use. Implementation of hospital antibiotic stewardship programs, strict infection control measures, and continuous monitoring of resistance patterns are essential to improve patient outcomes and preserve the efficacy of existing antimicrobial agents.

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