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Bacterial Isolates and Their Resistance Pattern in Central Line Device-Associated Infection in a Tertiary Care Centre – A Retrospective Study

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ABSTRACT

Background and Aims: Central line-associated infections (CLAI) pose a significant threat to critically ill patients, that lead to increased mortality with morbidity. This research estimated the frequency of gram-positive as well as gram-negative bacterial isolates and their antibiotic resistance patterns in those having central line device-associated infections.

Materials and Methods: A retrospective analytical study was done at Mahatma Gandhi Medical College and Research Institute, analyzing medical records from January 2018 to December 2022. A total of 45 central line tip cultures were reviewed to identify bacterial isolates and assess resistance patterns.

Results: Of the 45 positive cultures, 89% (40/45) were gram-negative, with Klebsiella pneumoniae (32.5%), non-fermenting gram-negative bacilli (22.5%), and Pseudomonas aeruginosa (17.5%) being the most prevalent. MDR was observed in 100% of non-fermenting bacilli (gram-negative), 57% of Pseudomonas aeruginosa, and 50% of Escherichia coli. CRE rates were highest in Enterobacter aerogenes and Citrobacter species (100%). All Staphylococcus aureus isolates exhibited MRSA resistance.

Conclusion: Gram-negative microorganisms were predominant in central line-associated infections, with high resistance rates to commonly used antibiotics.

Keywords: *Central line-associated infections, multidrug resistance, carbapenem resistance, gram-negative bacteria, tertiary care hospital, infection control.*

INTRODUCTION

Central line-associated infections (CLAI) represent a major challenge in modern healthcare, particularly in critical care settings where the management of invasive medical procedure is indispensable [1]. These infections contribute to heightened illness severity, increased fatality rates, and escalated medical expenses, posing a significant challenge for both healthcare professionals and policymakers. Critically ill individuals frequently require central venous catheters (CVCs) for the delivery of intravenous fluids, medications, blood transfusions, and parenteral nutrition, along with facilitating hemodynamic monitoring [2].

Hospital-acquired infections (HAIs) play a substantial role in extending hospital stays and driving up medical costs. Research findings suggest that death rates associated with these infections vary between 12% and 25%, influenced by factors such as the patient's pre-existing health status, the pathogen responsible, and the promptness of appropriate therapeutic intervention [3].

The occurrence of catheter-related bloodstream infections (CLABSIs) differs across regions, with intensive care units (ICUs) reporting higher incidence rates due to extended use of invasive medical equipment, immune suppression, and the severity of existing medical conditions [4]. These infections are frequently caused by gram-positive and gram-negative bacteria, with commonly identified pathogens including *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Acinetobacter baumannii*, *Staphylococcus aureus*, and coagulase-negative staphylococci (CONS) [5].

Pathogenesis involves the adherence of microorganisms to the catheter surface, forming a biofilm that protects them from host immune defenses and antibiotic therapy. The biofilm facilitates persistent infection and increases the likelihood of antibiotic resistance, complicating treatment efforts. The source of infection can be endogenous, arising from the patient's skin flora, or exogenous, resulting from healthcare personnel, contaminated equipment, or intravenous fluids [6].

The rise of antibiotic resistance among pathogens responsible for central line-associated infections has emerged as a major concern, making treatment more challenging and resulting in unfavorable clinical outcomes. Frequently identified resistant strains include multidrug-resistant (MDR) organisms, extended-spectrum beta-lactamase (ESBL) producers, methicillin-resistant *Staphylococcus aureus* (MRSA), and carbapenem-resistant Enterobacteriaceae (CRE). Among these, MDR bacteria such as carbapenem-resistant *Klebsiella pneumoniae* and *Acinetobacter baumannii* present significant therapeutic difficulties due to limited treatment options and an increased risk of mortality [7].

Several factors contribute to the development of CLAIs, including patient-related and procedural factors. Patient-related factors include underlying comorbidities such as diabetes mellitus, immunosuppression, malignancies, and prolonged hospital stays. Procedural factors involve the duration of catheterization, the anatomical site of insertion, adherence to aseptic techniques during catheter placement, and the type of catheter used. Moreover, frequent handling of the catheter, inadequate hand hygiene practices among healthcare workers, and breaches in sterile technique can further increase the risk of CLAIs [8].

Diagnosing central line-associated infections (CLAIs) requires a strong clinical suspicion, especially in critically ill patients exhibiting fever, leukocytosis, and systemic infection signs. A conclusive diagnosis is achieved through microbiological analysis of blood samples and catheter tip cultures. Commonly utilized diagnostic methods include the semi-quantitative roll plate technique and quantitative catheter segment culture, which aid in distinguishing colonization from actual infection [9].

Blood culture testing remains the gold standard for confirming central line-associated bloodstream infections (CLABSIs), involving paired blood samples drawn from both a peripheral vein and the catheter lumen to evaluate the differential time to positivity. Furthermore, advanced molecular diagnostics, such as polymerase chain reaction (PCR) and matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometry, are increasingly employed for rapid and precise pathogen identification, as well as for detecting antimicrobial resistance markers [10].

Despite the availability of robust infection control guidelines, CLAIs remain a persistent challenge in healthcare settings. The increasing burden of antibiotic-resistant pathogens necessitates continuous surveillance to identify emerging resistance trends. This study aims to estimate the frequency of gram-positive along with gram-negative bacterial isolates associated with central line device infections and assess their antibiotic resistance patterns, including MDR, ESBL, MRSA, and carbapenem resistance.

MATERIALS AND METHODS

Study Setting: This retrospective analytical study aimed to evaluate the bacterial isolates and their antibiotic resistance patterns in infections associated with central line devices. Conducted over a five-year span from January 2018 to December 2022, the research took place at Mahatma Gandhi Medical College and Research Institute, a tertiary care hospital with advanced critical care units and well-equipped microbiology laboratory facilities.

Study Participants: Patients who had undergone central line catheterization and had positive central line tip cultures during their hospital admission within the study period were included. Both male and female patients of all age groups admitted to critical care units were considered eligible.

Patients with incomplete medical records or missing laboratory reports, those with suspected but unconfirmed central line-associated bloodstream infections (CLABSI), and those who received empirical antibiotic therapy prior to sample collection without microbiological confirmation were excluded from the study.

Sampling Technique: About 45 central line tip culture-positive cases were identified and included based on retrospective data collection from the hospital's electronic medical records and laboratory database. Purposive sampling technique was done to select cases meeting the inclusion criteria.

Study Tools: The study utilized data collection sheets to extract relevant information from hospital medical records, including patient demographics, clinical history, duration of catheterization, and microbiological reports.

Study Methodology: Medical records and laboratory reports of patients who underwent central line catheterization between January 2018 and December 2022 were reviewed. Microbiological data, including central line tip culture reports, were examined to identify bacterial isolates and assess their antibiotic resistance profiles. The prevalence of multidrug-resistant (MDR) organisms, extended-spectrum beta-lactamase (ESBL) producers, methicillin-resistant *Staphylococcus*

aureus (MRSA), and carbapenem-resistant Enterobacteriaceae (CRE) was evaluated. Bacterial identification and antimicrobial susceptibility testing were performed using standard microbiological techniques, incorporating both automated systems like VITEK-2 and manual Kirby-Bauer disk diffusion methods, in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines.

Ethical Issues: Institutional Ethics Committee of Mahatma Gandhi Medical College and Research Institute approved the study proposal. Since this study was retrospective, informed consent from individual patients was waived; however, patient confidentiality was strictly maintained by anonymizing the data during analysis and reporting.

Statistical Analysis: Data were entered and analyzed using SPSS version 25. Descriptive statistics were used to summarize categorical variables as frequencies and percentages. The prevalence of antibiotic resistance patterns was expressed as proportions.

RESULTS

The study evaluated 45 central line tip cultures to assess the distribution and resistance patterns of bacterial isolates. *Klebsiella pneumoniae* emerged as the most prevalent pathogen, representing 32.5% (n=13) of the total isolates. Non-fermenting gram-negative bacilli (NFGNB) were the next most common, comprising 22.5% (n=9), followed by *Pseudomonas aeruginosa*, which accounted for 17.5% (n=7) of the cases. *Acinetobacter baumannii* and *Escherichia coli* were identified in 12.5% (n=5) and 10% (n=4) of the cultures, respectively. Among gram-positive bacteria, coagulase-negative *Staphylococcus* (CONS) and *Staphylococcus aureus* were each detected in 4.5% (n=2) of the samples (Table 1).

Table 1: Distribution of Bacterial Isolates from Central Line Tip Cultures.

Bacteria	Frequency (n)	Percentage (%)
Klebsiella pneumoniae	13	32.5%
Non-fermenting gram-negative bacilli	9	22.5%
Pseudomonas aeruginosa	7	17.5%
Acinetobacter baumannii	5	12.5%
Escherichia coli	4	10%
Coagulase-negative Staphylococcus	2	4.5%
Staphylococcus aureus	2	4.5%

The prevalence of multidrug-resistant (MDR) bacteria was notably high, with NFGNB demonstrating a concerning 100% (n=9) MDR rate. Among gram-negative pathogens, Pseudomonas aeruginosa exhibited highest MDR rate at 57% (n=4), followed by Escherichia coli at 50% (n=2), Acinetobacter baumannii at 40% (n=2), and Klebsiella pneumoniae at 39% (n=5). Similarly, all CONS isolates (100%, n=2) displayed multidrug resistance (Table 2).

Table 2: Prevalence of Multidrug-Resistant (MDR) Bacteria.

Bacteria	MDR Cases (n)	Percentage (%)
Klebsiella pneumoniae	5	39%
Acinetobacter baumannii	2	40%
Pseudomonas aeruginosa	4	57%
Escherichia coli	2	50%
Non-fermenting gram-negative bacilli	9	100%
Coagulase-negative Staphylococcus	2	100%

Carbapenem resistance was also significant, particularly in Citrobacter species and Enterobacter aerogenes, where 100% (n=1 each) of isolates exhibited carbapenem resistance. Among the more frequently isolated gram-negative bacteria, Klebsiella pneumoniae showed carbapenem resistance in 54% (n=7) of cases, while Escherichia coli and Acinetobacter baumannii exhibited resistance rates of 50% (n=2) and 40% (n=2), respectively (Table 3).

Table 3: Prevalence of Carbapenem-Resistant Enterobacteriaceae (CRE).

Bacteria	CRE Cases (n)	Percentage (%)
Klebsiella pneumoniae	7	54%
Acinetobacter baumannii	2	40%
Escherichia coli	2	50%
Citrobacter species	1	100%
Enterobacter aerogenes	1	100%

Extended-spectrum beta-lactamase (ESBL) production was identified in 8% of *Klebsiella pneumoniae* (n=1) and *Acinetobacter baumannii* (n=1) isolates. Regarding methicillin-resistant *Staphylococcus aureus* (MRSA), all

Staphylococcus aureus isolates (100%, n=2) exhibited methicillin resistance, underscoring a major challenge in the treatment of gram-positive infections (Table 4).

Table 4: Prevalence of ESBL and MRSA Resistance.

Bacteria	ESBL Cases n (%)	MRSA Cases n (%)
Klebsiella pneumoniae	1 (8%)	---
Acinetobacter baumannii	1 (8%)	---
Staphylococcus aureus	---	2 (100%)

These results emphasize the significant challenge posed by antimicrobial resistance in bacterial isolates linked to central line-associated infections, particularly the high prevalence of multidrug-resistant gram-negative organisms and the concerning levels of carbapenem resistance. Implementing stringent infection control strategies and robust antibiotic stewardship programs is crucial to curbing the spread of resistant pathogens and enhancing treatment outcomes in critically ill patients.

DISCUSSION

The high prevalence of gram-negative microorganisms among the isolates was alarmingly high, with 89% (n=40) of the positive cultures, while gram-positive bacteria accounted for only 11% (n=5). Klebsiella pneumoniae emerged as the predominant pathogen, constituting 32.5% (n=13) of the isolates, followed by non-fermenting gram-negative bacilli (NFGNB) at 22.5% (n=9), and Pseudomonas aeruginosa at 17.5% (n=7). Other notable gram-negative organisms included Acinetobacter baumannii (12.5%, n=5) and Escherichia coli (10%, n=4). The gram-positive bacteria identified in the study included coagulase-negative Staphylococcus (CONS) and Staphylococcus aureus, both accounting for 4.5% (n=2) each.

A concerning observation from our study was the high prevalence of MDR bacteria. NFGNB exhibited an alarming 100% (n=9) MDR rate, making them the most resistant group in our cohort. Pseudomonas aeruginosa followed with a 57% (n=4) MDR rate, while Escherichia coli and Acinetobacter baumannii showed resistance in 50% (n=2) and 40% (n=2) of cases, respectively. Klebsiella pneumoniae, despite being the most frequently isolated pathogen, exhibited a relatively lower MDR rate of 39% (n=5). Among gram-positive organisms, all isolates of CONS (100%, n=2) demonstrated multidrug resistance, indicating a significant challenge in managing these infections.

Carbapenem resistance was another major concern identified in our study, particularly among Citrobacter species and Enterobacter aerogenes, both of which displayed 100% (n=1 each) resistance. Klebsiella pneumoniae exhibited the highest carbapenem resistance among the frequently isolated gram-negative bacteria, with 54% (n=7) of isolates being resistant. Escherichia coli and Acinetobacter baumannii exhibited carbapenem resistance rates of 50% (n=2) and 40% (n=2), respectively. These findings align with global trends indicating an increasing prevalence of carbapenem-resistant Enterobacteriaceae (CRE), as previously reported by Savanur et al. (2019) [11].

ESBL production was identified in 8% of Klebsiella pneumoniae (n=1) and Acinetobacter baumannii (n=1) isolates. ESBL-producing bacteria poses a significant therapeutic challenge, limiting the effectiveness of commonly used antibiotics and necessitating the use of broader-spectrum agents, which may further contribute to antibiotic resistance [12].

The high prevalence MRSA with all isolates (100%, n=2) being resistant to methicillin. This finding emphasizes the critical need for stringent infection control practices to stop the range of MRSA within the healthcare setting [12].

While our study predominantly identified gram-negative organisms as the major contributors to central line-associated infections, Darji et al. (2023) reported a predominance of gram-positive bacteria in central line-associated bloodstream infections (CLABSI) [13]. This discrepancy may be attributed to differences in patient populations, infection control practices, and antibiotic stewardship programs across various healthcare settings [14].

The considerable presence of multidrug-resistant and carbapenem-resistant pathogens observed in this study underscores the pressing need for robust antimicrobial stewardship initiatives and stringent infection control protocols. Ensuring strict compliance with aseptic practices during central line placement and upkeep, along with the prudent use of antibiotics, is essential in reducing the impact of these infections [15].

Our study's findings emphasize the necessity for regular surveillance of antimicrobial resistance patterns to guide empirical therapy effectively. The increasing resistance among gram-negative bacteria, particularly Klebsiella pneumoniae and Acinetobacter baumannii, necessitates the adoption of targeted antibiotic policies to optimize treatment outcomes and reduce the emergence of further resistance [16].

While this study provides important insights, certain limitations must be considered. The relatively small sample size of 45 positive cultures limits the applicability of the findings to a wider population. Furthermore, the retrospective design prevents the determination of direct causal links between risk factors and infection outcomes. To gain a more comprehensive understanding of the epidemiology of central line-associated infections and to formulate evidence-based management strategies, future prospective studies with larger cohorts and rigorous methodologies are necessary.

CONCLUSION

This study highlights the significant burden of gram-negative bacterial infections in central line-associated hospital-acquired infections. The alarming rates of multidrug resistance, carbapenem resistance, and MRSA among the isolates call for urgent action in terms of infection prevention and control. Enhanced surveillance, stringent adherence to infection control protocols, and rational antibiotic prescribing are imperative to combat the rising threat of antimicrobial resistance in critically ill patients.

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