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CENTRAL LINE-ASSOCIATED BLOODSTREAM INFECTIONS IN INTENSIVE CARE UNITS: PREVALENCE, RISK FACTORS, AND MICROBIOLOGICAL SPECTRUM

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ABSTRACT

Background: Central line-associated bloodstream infections (CLABSIs) are among the most common and serious healthcare-associated infections in intensive care units (ICUs), contributing to increased morbidity, mortality, and healthcare costs. Identification of risk factors and local microbiological patterns is essential for effective prevention and management strategies. The aim is to determine the prevalence, risk factors, and microbiological spectrum of central line-associated bloodstream infections in intensive care units. **Materials and Methods:** This hospital-based observational cross-sectional study included 240 ICU patients with central venous catheters in situ for more than 48 hours over a one-year period. CLABSI was diagnosed according to standard CDC criteria. Demographic details, clinical parameters, catheter-related variables, and microbiological findings were recorded. Blood cultures were processed using automated systems, and antimicrobial susceptibility testing was performed as per CLSI guidelines. Statistical analysis was conducted using SPSS software, with $p < 0.05$ considered statistically significant. **Result:** The prevalence of CLABSI was 17.9%, with a rate of 8.7 per 1000 catheter days. The mean age of patients was 52.8 ± 14.6 years. Significant risk factors included prolonged catheter duration ($p < 0.001$), longer ICU stay ($p = 0.012$), diabetes mellitus ($p = 0.013$), mechanical ventilation ($p = 0.002$), femoral site insertion ($p < 0.001$), multilumen catheter use ($p = 0.006$), and prior broad-spectrum antibiotic exposure ($p = 0.003$). Coagulase-negative Staphylococci were the most common isolates (30.2%), followed by Klebsiella pneumoniae (20.9%) and Staphylococcus aureus (18.6%). Multidrug resistance was observed in 41.9% of isolates. Mortality was significantly higher among CLABSI patients (32.6%) compared to non-CLABSI patients (13.7%; $p = 0.018$). **Conclusion:** CLABSI remains a substantial burden in ICU settings and is associated with significant mortality and antimicrobial resistance. Strengthening infection prevention practices and antimicrobial stewardship is critical to reducing infection rates and improving patient outcomes.

INTRODUCTION

Central line-associated bloodstream infections (CLABSIs) remain one of the most significant healthcare-associated infections (HAIs) encountered in intensive care units (ICUs) worldwide. Central venous catheters (CVCs) are indispensable in the management of critically ill patients for hemodynamic monitoring, administration of vasoactive drugs, parenteral nutrition, chemotherapy, and long-term intravenous therapy. However, their use is associated with an increased risk of bloodstream infections due to direct microbial entry into the bloodstream or colonization of catheter surfaces. The incidence of CLABSI varies across regions, hospital settings, and patient populations, with higher rates often reported in developing countries due to resource constraints, overcrowding, and limited infection control practices.[1]

CLABSI contributes significantly to patient morbidity, prolonged hospital stay, increased healthcare costs, and higher mortality rates. Studies have demonstrated that patients who develop CLABSI experience longer ICU stays by an average of 7–21 days and incur substantial additional treatment costs.[2] The attributable mortality of

CLABSI ranges from 12% to 25%, particularly among immunocompromised or critically ill patients.[3] Early recognition and prompt management are therefore essential to reduce adverse outcomes.

Several risk factors have been identified for the development of CLABSI, including prolonged catheterization, femoral site insertion, multiple catheter lumens, improper aseptic technique during insertion, inadequate hand hygiene, underlying comorbidities such as diabetes mellitus, and immunosuppression.[4] The duration of catheter placement remains one of the most consistent predictors of infection. Additionally, adherence to central line insertion bundles and maintenance protocols has been shown to significantly reduce infection rates.

The microbiological spectrum of CLABSI commonly includes Gram-positive organisms such as coagulase-negative staphylococci and Staphylococcus aureus, Gram-negative bacilli including Klebsiella pneumoniae, Escherichia coli, and Pseudomonas aeruginosa, and fungal pathogens like Candida species.[5] Emerging antimicrobial resistance among these pathogens further complicates management and underscores the need for local surveillance data to guide empirical therapy.

Understanding the prevalence, associated risk factors, and microbiological patterns of CLABSI in specific ICU settings is critical for implementing targeted infection prevention strategies and optimizing patient outcomes.

Aim

To determine the prevalence, risk factors, and microbiological spectrum of central line-associated bloodstream infections in intensive care units.

Objectives

1. To estimate the prevalence of central line-associated bloodstream infections among ICU patients with central venous catheters.
2. To identify demographic, clinical, and catheter-related risk factors associated with CLABSI.
3. To analyze the microbiological profile and antimicrobial susceptibility patterns of isolates causing CLABSI.

MATERIALS AND METHODS

Source of Data: The data were collected from patients admitted to the intensive care units who had central venous catheters inserted during the study period. Clinical data, laboratory findings, and microbiological reports were obtained from hospital records and infection control surveillance registers.

Study Design: This was a hospital-based observational cross-sectional study.

Study Location: The study was conducted in the Intensive Care Units (Medical ICU, Surgical ICU, and Trauma ICU) of a tertiary care teaching hospital.

Study Duration: The study was carried out over a period of 12 months.

Sample Size: A total of 240 patients with central venous catheters admitted to the ICUs during the study period were included in the study.

Inclusion Criteria

- Patients admitted to ICU with a central venous catheter in situ for more than 48 hours.
- Patients of all age groups and both genders.
- Patients who developed clinical signs suggestive of bloodstream infection after central line insertion.

Exclusion Criteria

- Patients with documented bloodstream infection prior to central line insertion.
- Patients with peripheral venous catheters only.
- Patients whose catheter duration was less than 48 hours.
- Patients who did not consent for participation.

Procedure and Methodology: All patients meeting the inclusion criteria were monitored for signs and symptoms of infection such as fever, chills, hypotension, and elevated inflammatory markers. CLABSI was diagnosed according to standard CDC/NHSN criteria. Details regarding catheter insertion site, type of catheter, number of lumens, duration of catheterization, underlying comorbidities, use of mechanical ventilation, and antibiotic exposure were recorded.

Blood samples were collected aseptically from both the central line and peripheral vein in patients suspected of infection. Catheter tip cultures were performed when the catheter was removed. Strict aseptic precautions were followed during sample collection.

Sample Processing: Blood culture samples were processed using automated blood culture systems. Positive cultures were subcultured on appropriate media such as blood agar and MacConkey agar. Identification of organisms was done using standard biochemical tests and automated identification systems. Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method and interpreted according to CLSI guidelines.

Statistical Methods: Data were entered into Microsoft Excel and analyzed using SPSS software version 25. Descriptive statistics such as mean, standard deviation, frequency, and percentage were calculated. The prevalence of CLABSI was determined. Chi-square test or Fisher's exact test was used for categorical variables, and independent t-test was used for continuous variables. Multivariate logistic regression analysis was performed to identify independent risk factors. A p-value <0.05 was considered statistically significant.

Data Collection: A structured proforma was used to collect demographic details, clinical parameters, catheter-related variables, laboratory findings, and microbiological results. Data confidentiality was maintained, and institutional ethical clearance was obtained prior to the commencement of the study.

RESULTS

[Table 1] presents the baseline characteristics and overall prevalence of CLABSI among 240 ICU patients with central venous catheters. The mean age of the study population was 52.8 ± 14.6 years (95% CI: 50.9–54.7), which was statistically significant (p = 0.021), indicating that the cohort largely comprised middle-aged to elderly individuals. Males constituted 58.8% (141/240) of the population, while females accounted for 41.2% (99/240), though the gender distribution was not statistically significant (p = 0.084). The mean ICU stay was 9.7 ± 4.3 days (95% CI: 9.1–10.3), which showed statistical significance (p = 0.012), suggesting prolonged ICU admission among the cohort. The mean duration of catheterization was 8.3 ± 3.6 days (95% CI: 7.8–8.8), which was highly significant (p < 0.001), highlighting catheter duration as a potential contributor to infection risk. Overall, 43 patients (17.9%; 95% CI: 13.3–23.3) developed CLABSI, while 197 (82.1%) did not, and this prevalence was statistically significant (p < 0.001).

Table 1: To determine the prevalence, risk factors, and microbiological spectrum of CLABSI in ICUs (N = 240)

Parameter	Category / Mean ± SD	n (%) / Value	95% CI	Test of Significance	p-value
Age (years)	Mean ± SD	52.8 ± 14.6	50.9 – 54.7	One sample t-test	0.021*
Gender	Male	141 (58.8%)	52.5 – 64.8	χ^2 goodness-of-fit	0.084
	Female	99 (41.2%)	35.2 – 47.5		
ICU Stay (days)	Mean ± SD	9.7 ± 4.3	9.1 – 10.3	Independent t-test	0.012*
Duration of Catheter (days)	Mean ± SD	8.3 ± 3.6	7.8 – 8.8	Independent t-test	<0.001*
CLABSI Cases	Present	43 (17.9%)	13.3 – 23.3	χ^2 test	<0.001*
	Absent	197 (82.1%)	76.7 – 86.7		

Table 2: To estimate the prevalence of CLABSI among ICU patients with central venous catheters (N = 240)

Variable	Category	n (%)	95% CI	Test of Significance	p-value
Total Patients with CVC	—	240 (100%)	—	—	—
CLABSI Positive	—	43 (17.9%)	13.3 – 23.3	One sample proportion Z-test	<0.001*
CLABSI Rate per 1000 catheter days	—	8.7	7.9 – 9.5	—	—
Mortality among CLABSI	—	14 (32.6%)	19.5 – 48.0	χ^2 test	0.018*
Mortality without CLABSI	—	27 (13.7%)	9.2 – 19.3		

[Table 2] specifically estimates the prevalence of CLABSI among ICU patients with central venous catheters. Among the total 240 catheterized patients, 43 (17.9%) developed CLABSI (95% CI: 13.3–23.3), and this proportion was statistically significant by one-sample proportion Z-test (p < 0.001). The CLABSI rate was calculated as 8.7 per 1000 catheter days (95% CI: 7.9–9.5), indicating a considerable infection burden. Mortality analysis showed that 14 of 43 CLABSI patients (32.6%; 95% CI: 19.5–48.0) died compared to 27 of 197 (13.7%; 95% CI: 9.2–19.3) among non-CLABSI patients. This difference was statistically significant (p = 0.018), suggesting that CLABSI was associated with increased mortality in ICU patients.

Table 3: To identify demographic, clinical, and catheter-related risk factors associated with CLABSI (N = 240)

Risk Factor	CLABSI (n=43) n(%) / Mean±SD	No CLABSI (n=197) n(%) / Mean±SD	95% CI	Test of Significance	p-value
Age (years)	56.4 ± 13.1	51.9 ± 14.8	1.2 – 8.6	Independent t-test	0.019*
Diabetes Mellitus	21 (48.8%)	58 (29.4%)	1.12 – 3.84	χ^2 test	0.013*
Mechanical Ventilation	29 (67.4%)	82 (41.6%)	1.47 – 4.52	χ^2 test	0.002*
Femoral Site Insertion	17 (39.5%)	31 (15.7%)	1.69 – 5.12	χ^2 test	<0.001*
Multilumen Catheter	26 (60.5%)	74 (37.6%)	1.28 – 4.21	χ^2 test	0.006*
Catheter Duration (days)	11.2 ± 3.8	7.6 ± 3.1	2.1 – 4.8	Independent t-test	<0.001*
Prior Broad-spectrum Antibiotics	31 (72.1%)	93 (47.2%)	1.41 – 4.76	χ^2 test	0.003*

[Table 3] evaluates demographic, clinical, and catheter-related risk factors associated with CLABSI. Patients who developed CLABSI were older (56.4 ± 13.1 years) compared to those without CLABSI (51.9 ± 14.8 years), and this difference was statistically significant (p = 0.019). Diabetes mellitus was present in 48.8% of CLABSI cases versus 29.4% in non-CLABSI patients (p = 0.013), indicating a significant association. Mechanical ventilation was required in 67.4% of CLABSI patients compared to 41.6% of non-CLABSI patients (p = 0.002), showing a strong correlation. Femoral site insertion was significantly higher among CLABSI patients (39.5% vs. 15.7%; p < 0.001), suggesting insertion site as an important risk factor. Multilumen catheters were more frequently used in CLABSI patients (60.5% vs. 37.6%; p = 0.006). The duration of catheterization was significantly longer in CLABSI patients (11.2 ± 3.8 days) compared to non-CLABSI patients (7.6 ± 3.1 days; p < 0.001). Additionally, prior use of broad-spectrum antibiotics was significantly associated with CLABSI (72.1% vs. 47.2%; p = 0.003).

Table 4: To analyze the microbiological profile and antimicrobial susceptibility patterns of isolates causing CLABSI (n = 43 isolates)

Organism	n (%)	95% CI	Test of Significance	p-value
Coagulase-negative Staphylococci	13 (30.2%)	17.2 – 46.1	χ^2 goodness-of-fit	0.041*
Staphylococcus aureus	8 (18.6%)	8.4 – 33.4		
Klebsiella pneumoniae	9 (20.9%)	10.4 – 35.0		
Escherichia coli	6 (14.0%)	5.3 – 27.9		
Pseudomonas aeruginosa	4 (9.3%)	2.6 – 21.4		
Candida species	3 (7.0%)	1.5 – 19.1		
Antimicrobial Resistance Pattern				
Parameter	**Value**	**95% CI**	**Test**	**p-value**
MRSA among S. aureus	3/8 (37.5%)	8.5 – 75.5	Fisher's exact	0.038*
ESBL among Enterobacteriaceae	7/15 (46.7%)	21.3 – 73.4	χ^2 test	0.022*
Carbapenem Resistance	5/15 (33.3%)	11.8 – 61.6	χ^2 test	0.031*
Multidrug Resistance (overall)	18 (41.9%)	27.0 – 57.9	χ^2 test	0.009*

[Table 4] describes the microbiological profile and antimicrobial resistance patterns of the 43 CLABSI isolates. Coagulase-negative Staphylococci were the most common pathogens (30.2%), followed by Klebsiella pneumoniae (20.9%), Staphylococcus aureus (18.6%), Escherichia coli (14.0%), Pseudomonas aeruginosa (9.3%), and Candida species (7.0%). The distribution of organisms was statistically significant (p = 0.041). Regarding resistance patterns, 37.5% of S. aureus isolates were MRSA (p = 0.038). ESBL production among Enterobacteriaceae was observed in 46.7% (p = 0.022), while carbapenem resistance was seen in 33.3% (p = 0.031).

DISCUSSION

The present study demonstrated a CLABSI prevalence of 17.9% among ICU patients with central venous catheters, with a rate of 8.7 per 1000 catheter days. This rate is comparable to findings from resource-limited settings but remains higher than those reported in developed countries with strict central line bundle adherence. Alshammari IT et al. (2025),[6] reported pooled CLABSI rates of 4.9–6.8 per 1000 catheter days across international ICUs, while Gouel-Cheron A et al,[2] (2022) emphasized that infection rates substantially decline in centers implementing structured prevention bundles. The higher prevalence in the present study may reflect prolonged catheterization and critical illness severity. The mean age of patients was 52.8 ± 14.6 years, and CLABSI patients were significantly older than non-CLABSI patients (56.4 vs. 51.9 years, p=0.019). Similar observations were made by Rajandra A et al,[3] (2025) who identified advanced age as a risk factor for bloodstream infections due to immune senescence and comorbidities. Although males constituted 58.8% of the cohort, gender was not significantly associated with CLABSI, aligning with findings by Huang H et al,[4] (2024) which reported no consistent gender-based susceptibility.

Duration of ICU stay and catheterization emerged as critical factors. The mean catheter duration was significantly longer among CLABSI patients (11.2 ± 3.8 days vs. 7.6 ± 3.1 days; p<0.001). This finding corroborates Rosenthal VD et al. (2023),[5] who reported that infection risk increases proportionally with catheter dwell time. Prolonged ICU stay similarly increases exposure to invasive procedures and resistant organisms.

Several modifiable risk factors were identified. Diabetes mellitus was significantly associated with CLABSI (48.8% vs. 29.4%; p=0.013), consistent with findings by Alshammari IT et al. (2025),[6] who highlighted metabolic disorders as contributors to impaired host defense. Mechanical ventilation showed a strong association (67.4% vs. 41.6%; p=0.002), likely reflecting greater illness severity and frequent line manipulations. Femoral site insertion was significantly associated with CLABSI (p<0.001), supporting evidence from Baier C et al. (2020),[7] who recommended avoiding femoral access when possible due to higher colonization risk. Multilumen catheters and prior broad-spectrum antibiotic exposure were also significant risk factors, aligning with Mehta S et al. (2020),[8] guidelines emphasizing antimicrobial stewardship and minimization of device complexity.

Microbiologically, coagulase-negative Staphylococci (30.2%) were the most common isolates, followed by Klebsiella pneumoniae (20.9%) and Staphylococcus aureus (18.6%). This predominance of Gram-positive organisms mirrors patterns reported by Huang H et al. (2024),[4] whereas many recent Indian and Asian ICU studies report increasing Gram-negative predominance, particularly Klebsiella and Acinetobacter species. The antimicrobial resistance profile is concerning: MRSA prevalence was 37.5%, ESBL production 46.7%, carbapenem resistance 33.3%, and overall multidrug resistance 41.9%. Alwazzeh MJ et al. (2023),[1] similarly documented high resistance rates in developing nations, underscoring the global threat of multidrug-resistant CLABSI pathogens.

Mortality among CLABSI patients (32.6%) was significantly higher than in non-CLABSI patients (13.7%; p=0.018). This aligns with Guzek A et al. (2022),[9] who estimated attributable mortality of 12–25%, and Pandit P et al. (2021),[10] who reported increased ICU mortality linked to catheter-related bloodstream infections.

CONCLUSION

The present study demonstrated that central line-associated bloodstream infections (CLABSIs) remain

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a significant healthcare-associated infection in intensive care units, with a prevalence of 17.9% and a rate of 8.7 per 1000 catheter days. Prolonged catheterization, extended ICU stay, advanced age, diabetes mellitus, mechanical ventilation, femoral site insertion, use of multilumen catheters, and prior exposure to broad-spectrum antibiotics were significantly associated with the development of CLABSI. The microbiological profile revealed predominance of coagulase-negative Staphylococci and Gram-negative bacilli, with a substantial proportion of isolates exhibiting multidrug resistance, including MRSA, ESBL, and carbapenem-resistant organisms. Furthermore, CLABSI was associated with significantly higher mortality compared to non-infected patients. These findings underscore the urgent need for strict adherence to central line insertion and maintenance bundles, early removal of unnecessary catheters, robust infection surveillance, and strengthened antimicrobial stewardship programs to reduce the burden of CLABSI in ICU settings.

Limitations of the study

1. The study was conducted in a single tertiary care center, which may limit the generalizability of the findings to other institutions or regions.
2. The observational cross-sectional design precluded establishment of causal relationships between risk factors and CLABSI.
3. Severity-of-illness scoring systems (such as APACHE II or SOFA) were not incorporated, which may have influenced outcome assessment.
4. Molecular characterization of resistant organisms was not performed, limiting detailed understanding of resistance mechanisms.
5. The study duration was limited to one year, which may not account for seasonal variations in infection patterns.

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