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Incidence, Risk Factors, And Microbial Spectrum Of Central Line-Associated Bloodstream Infections In ICU Patients: A Prospective Observational Study

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A B S T R A C T

Background: Central venous catheterization is commonly performed in intensive care units (ICUs), providing essential vascular access but posing a risk of bloodstream infections. This study evaluates the incidence and microbial profile of central line-associated bloodstream infections (CLABSI) in critically ill patients.

Material and Methods: 150 ICU patients requiring central venous catheters were observed. Relevant investigations were performed before and 48 hours after insertion. In suspected infections, clinical evaluations and laboratory tests were conducted to rule out other sources and confirm CLABSI.

Results: Among 150 patients (mean age 42.1±14.3 years), CLABSI/CRBSI was identified in 52 cases (34.6%). Fever was the most common sign (80.8%), followed by tachypnea (76.9%) and hypotension (63.5%). The most frequently isolated organism was Staphylococcus aureus (34.6%). Femoral access and prolonged catheter days were significantly associated with infection.

Conclusions: Proper aseptic techniques and catheter care can significantly reduce CLABSI risk. Identification of high-risk factors aids in improving patient outcomes.

Keywords: Central venous catheter, CLABSI, CRBSI, ICU, bloodstream infection.

INTRODUCTION

Central venous catheterization (CVC) is a fundamental intervention in intensive care units (ICUs), enabling the administration of vasoactive drugs, parenteral nutrition, hemodynamic monitoring, and frequent blood sampling. Despite its clinical indispensability, CVC use carries a notable risk of central line-associated bloodstream infections (CLABSIs), which can significantly impact morbidity, mortality, hospital length of stay, and healthcare costs [1].

CLABSI is defined as a primary bloodstream infection occurring in a patient with a central line in place for more than 48 hours before the development of infection, and for which no other source of infection is identifiable [2]. The Centers for Disease Control and Prevention (CDC) and the National Healthcare Safety Network (NHSN) emphasize rigorous surveillance and standardized definitions for accurate diagnosis and reporting [3]. These infections are largely preventable, and their occurrence serves as a marker of hospital care quality.

Globally, CLABSI rates in ICUs vary from 0.5 to 6.8 per 1,000 catheter-days in high-income countries, whereas rates in low- and middle-income countries (LMICs) are often several folds higher, ranging from 5.1 to 22.7 per 1,000 catheter-days [4,5]. This disparity is attributed to variations in catheter handling, infection prevention protocols, staffing ratios, and antimicrobial stewardship practices [6]. In India, the incidence ranges from 2.5 to 16.2 per 1,000 catheter-days, reflecting inconsistencies in adherence to aseptic techniques and monitoring standards [7].

Numerous risk factors contribute to CLABSI development, including prolonged catheterization duration, site of insertion (femoral > jugular >subclavian), underlying comorbidities (renal failure, diabetes, malignancy), mechanical ventilation, total parenteral nutrition, and breaches in catheter care protocols [8,9]. Among the insertion sites, femoral catheters are particularly prone to infection due to their proximity to the groin and difficulty in maintaining hygiene [10].

The pathogenesis of CLABSI involves microbial colonization of the catheter hub, intraluminal contamination during manipulation, and biofilm formation on the catheter surface [11]. Once colonized, the catheter becomes a nidus for bloodstream infections, often involving multidrug-resistant (MDR) organisms. The most frequently isolated pathogens in CLABSI cases include Staphylococcus aureus, coagulase-negative staphylococci (CoNS), Pseudomonas aeruginosa, Klebsiellapneumoniae, Escherichia coli, and Candida spp. [12–14].

Diagnosis of CLABSI requires a high index of suspicion in febrile ICU patients with no apparent source of infection. Blood cultures from peripheral veins and catheter lumens, along with simultaneous catheter tip culture, help differentiate between colonization, contamination, and true infection. The differential time to positivity (DTP) method and quantitative culture techniques are frequently employed for confirmation [15,16].

Treatment entails prompt catheter removal and initiation of empiric broad-spectrum antibiotics, which are later tailored based on culture sensitivity reports. The emergence of MDR organisms and fungal pathogens necessitates a judicious approach to antimicrobial use [17].

This study aims to assess the incidence, clinical presentation, microbiological profile, and risk factors associated with CLABSI in ICU patients with central venous catheterization at a tertiary care hospital. Understanding these aspects is crucial to inform infection control policies and improve patient outcomes.

MATERIAL AND METHODS

This prospective observational study was conducted in the Intensive Care Unit (ICU) of a tertiary care hospital over a period of 12 months. The study was approved by the Institutional Ethics Committee.

Study Population:

A total of 150 adult patients (age ≥18 years) requiring central venous catheter (CVC) insertion for clinical management were enrolled after obtaining informed consent.

Inclusion Criteria:

1. ICU patients requiring CVC placement for ≥48 hours.
2. Patients with no evidence of bloodstream infection at the time of catheter insertion.
3. Willingness to participate with informed consent from patient or next of kin.

Exclusion Criteria:

1. Pre-existing bloodstream infection or sepsis from another source.
2. Catheter dwell time <48 hours.
3. Incomplete data or refusal to consent.

Procedure:

CVCs were inserted under strict aseptic precautions, using sterile gowns, gloves, drapes, and chlorhexidine skin preparation. Preferred insertion sites included the internal jugular, subclavian, and femoral veins, based on patient condition and anatomical considerations. All catheters were triple lumen polyurethane catheters.

Monitoring and Sample Collection:
Patients were monitored for signs of infection (fever, tachypnea, hypotension, tachycardia, altered sensorium). In case of suspected CLABSI, peripheral and catheter blood cultures were obtained, along with catheter tip culture upon removal. Samples were processed in the microbiology laboratory using standard protocols.

Microbiological Analysis:
Blood cultures were incubated using the automated BacT/ALERT system.

CVC tips were cultured using the roll plate method.

Identification and antibiotic susceptibility testing were done using VITEK 2 Compact or conventional biochemical tests as appropriate.

Definitions Used:
CLABSI: Positive blood culture ≥48 hours after CVC insertion, no other infection source.

CRBSI: Positive blood culture plus matching positive tip culture from same pathogen.

Colonization: Positive tip culture with negative blood culture.

Statistical Analysis:
Data were analyzed using SPSS version 25.0. Categorical variables were expressed as percentages, and continuous variables as mean ± standard deviation. Chi-square test and t-test were used to identify significant associations. A p-value <0.05 was considered statistically significant.

Material and Methods
This prospective observational study was conducted over a period of 12 months in the Intensive Care Unit (ICU) of a tertiary care hospital. The aim was to evaluate the incidence, clinical presentation, risk factors, and microbiological spectrum of Central Line-Associated Bloodstream Infections (CLABSIs) in critically ill patients undergoing central venous catheterization (CVC).

Study Population
A total of 150 adult ICU patients (aged ≥18 years) who required central venous catheter insertion for more than 48 hours were enrolled. Informed consent was obtained from all participants or their legal guardians.

Inclusion Criteria
1. Adult ICU patients (≥18 years) requiring central venous catheter (CVC) insertion.
2. Duration of catheterization ≥48 hours.
3. No evidence of bloodstream infection or sepsis from other identifiable sources at the time of insertion.
4. Willingness to participate with informed consent.

Exclusion Criteria
1. Pre-existing bacteremia or sepsis from another source.
2. Duration of catheterization <48 hours.
3. Patients with incomplete clinical or laboratory data.
4. Refusal to give informed consent.

Procedure
All CVC insertions were performed under strict aseptic precautions using sterile gloves, gowns, masks, and chlorhexidine skin preparation. Triple-lumen polyurethane catheters were placed at either the internal jugular, subclavian, or femoral vein according to clinical suitability. Catheters were monitored daily for signs of infection.

Monitoring and Sample Collection
Patients were regularly assessed for fever, tachycardia, hypotension, altered mental status, and other clinical signs suggestive of infection. If CLABSI was suspected, peripheral and central blood cultures were collected, along with catheter tip cultures upon catheter removal. Blood cultures were processed using the BacT/ALERT system and catheter tips were cultured using the roll-plate method.

Microbiological Testing
Microorganisms were identified using automated VITEK 2 Compact systems and confirmed with conventional biochemical tests. Antimicrobial susceptibility was determined according to CLSI 2024 guidelines.

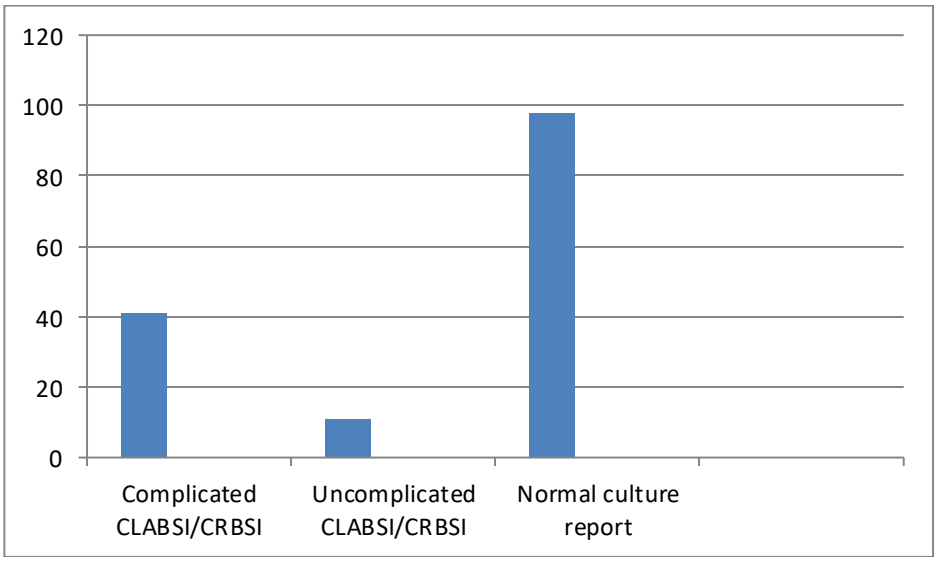
Definitions
CLABSI: Bloodstream infection occurring ≥48 hours after CVC insertion without an alternative source.
CRBSI: CLABSI with matching organism from catheter tip and blood.
Colonization: Growth on catheter tip without corresponding bloodstream infection.

Statistical Analysis
Data were analyzed using SPSS v25.0. Continuous variables were reported as mean ± SD; categorical variables as frequency and percentages. Chi-square and t-tests were used for comparisons. A p-value <0.05 was considered statistically significant.

RESULTS
A total of 150 patients were included in this prospective observational study. The majority of the study population were males (95 patients, 63.3%), while females comprised 36.7% (55 patients). The age of patients ranged from 18 to 72 years, with a mean age of 42.1 ± 14.3 years. Regarding comorbidities, renal failure was the most prevalent (51.3%), followed by diabetes mellitus (12%), anemia (9.3%), and cardiovascular disease (7.3%). Notably, 20% of patients had no comorbid conditions. These findings highlight that chronic illnesses, especially renal dysfunction, significantly predispose ICU patients to CLABSI, likely due to compromised immunity and frequent catheter use.

Table 1: Distribution of CLABSI/CRBSI (n=150)

Parameter	Number of patients	Percentage (%)
Complicated CLABSI/CRBSI	41	27.3
Uncomplicated CLABSI/CRBSI	11	7.3
Normal culture report	98	65.3
Total	150	100



Graph No. 1: Distribution of CLABSI/CRBSI (n=150)

The internal jugular vein was the most frequently used catheterization site (45.3%), closely followed by the femoral vein (43.3%) and the subclavian vein (11.3%). Catheter duration played a critical role in infection risk: patients with catheterization for ≥10 days had a notably higher incidence of CLABSI (36.5%), compared to those with duration <10 days (15.4%). This suggests a positive correlation between longer catheter dwell time and increased infection risk, consistent with global infection control data.

Of the total 150 patients, 52 developed laboratory-confirmed central line-associated bloodstream infections (CLABSI/CRBSI), representing an overall incidence rate of 34.6%. Among these, 41 cases (27.3%) were classified as complicated infections with systemic involvement or organ dysfunction, while 11 cases (7.3%) were uncomplicated infections. The remaining 98 patients (65.3%) had negative cultures and no evidence of catheter-associated bloodstream infection.

Table 2: Blood culture and CVC tip culture results (n=150)

Blood Culture	Tip Culture	Impression	No. of cases (%)
Positive	Negative	CLABSI	33 (22%)
Positive	Positive	CRBSI	7 (4.7%)
Negative	Positive	Catheter tip colonization	12 (8%)
Negative	Negative	No CLABSI/CRBSI	98 (65.3%)

Out of the 150 patients, 33 (22%) had positive blood cultures with negative catheter tip cultures, indicating CLABSI. Seven patients (4.7%) had both blood and catheter tip cultures growing the same pathogen, confirming catheter-related bloodstream infections (CRBSI). Twelve patients (8%) showed positive catheter tip cultures but negative blood cultures, suggesting colonization without bloodstream involvement. The remaining 98 patients (65.3%) had no microbial growth in either blood or catheter tip cultures, indicating no infection.

Table 3: Signs on General Physical Examination in CLABSI/CRBSI Patients (n=52)

Signs	No. of patients	Percentage (%)
Fever	42	80.8
Tachypnea	40	76.9
Hypotension	33	63.5
Tachycardia	31	59.6
Altered sensorium	27	51.9
Oliguria	20	38.5
Bradycardia	9	17.3
Hypothermia	7	13.5
Hypertension	6	11.5

The most commonly observed clinical manifestation among CLABSI/CRBSI patients was fever, present in 80.8% (42 patients). This was followed by tachypnea in 76.9% (40 patients), hypotension in 63.5% (33 patients), and tachycardia in 59.6% (31 patients). Altered sensorium was reported in 27 cases (51.9%). Less frequent signs included oliguria (38.5%), bradycardia (17.3%), hypothermia (13.5%), and hypertension (11.5%). These findings underline the non-specific but systemic nature of CLABSI presentations, requiring a high index of suspicion in ICU settings.

Table 4: Pathogens Isolated in CLABSI/CRBSI Patients (n=52)

Isolated Pathogen	No. of patients	Percentage (%)
Staphylococcus aureus	18	34.6
Pseudomonas aeruginosa	8	15.4
Klebsiellapneumoniae	7	13.5
Streptococcus spp.	6	11.5
Candida spp.	5	9.6
E. coli	5	9.6

Acinetobacter spp.	3	5.8

The predominant pathogen isolated was Staphylococcus aureus, accounting for 34.6% of infections (18 cases). Pseudomonas aeruginosa was the second most common (15.4%), followed by Klebsiellapneumoniae (13.5%), Streptococcus species (11.5%), Candida spp. (9.6%), Escherichia coli (9.6%), and Acinetobacter spp. (5.8%). The spectrum reflects a mix of gram-positive, gram-negative, and fungal organisms, indicating a polymicrobial risk in ICU settings and emphasizing the need for broad-spectrum empirical coverage and prompt de-escalation based on culture sensitivity.

DISCUSSION

The incidence of CLABSI in our study was 34.6%, which is notably higher than reported in developed nations but consistent with findings from low- and middle-income countries (LMICs) [18,19]. Several factors contributed to this elevated rate, such as femoral access, extended catheter duration, and the presence of comorbidities.

In a multicenter study by Rosenthal et al., ICU CLABSI rates in LMICs ranged from 4.1 to 14.3 per 1,000 catheter days, attributed to limited resources and poor adherence to infection control protocols [20]. Similarly, a 2024 Indian study by Batra et al. identified femoral insertion as a significant risk factor, echoing our findings where 43.3% of insertions were femoral and had the highest infection rates [21].

The most frequently isolated organism in our study was *Staphylococcus aureus* (34.6%), followed by *Pseudomonas aeruginosa* and *Klebsiellapneumoniae.* This aligns with prior reports *highlighting S. aureus*as a leading cause of CLABSI, especially in catheter dwellings beyond 7 days [22,23]. A recent study by Arora et al. (2025) emphasized the increasing burden of methicillin-resistant Staphylococcus aureus (MRSA) in catheter-related infections, necessitating early targeted therapy [24].

Biofilm formation plays a central role in the pathogenesis of CLABSI. Microbial colonization of catheter surfaces can occur within 24 hours of insertion, leading to chronic infections resistant to standard antibiotics [25]. According to Gahlot et al. (2024), over 80% of CLABSI pathogens in ICUs exhibit biofilm capabilities, complicating management and increasing mortality risk [26].

Our study showed that prolonged catheterization (>10 days) significantly increased the risk of CLABSI, corroborating the findings of Timsit et al. and a 2024 surveillance report from the National Centre for Disease Control (India), which advised routine replacement at 7–10-day intervals [27,22].

The presence of comorbidities such as renal failure and diabetes further elevated infection risk. A 2025 study by Mishra et al. involving 320 ICU patients revealed a two-fold increase in CLABSI rates among diabetics and patients on hemodialysis [28]. Moreover, a systematic review suggested that immunosuppression and hypoalbuminemia significantly predicted poor outcomes in CLABSI cases [29].

Fungal pathogens such as Candida spp. were isolated in 9.6% of cases, consistent with other Indian studies showing a rising trend in catheter-related candidemia, particularly in patients with broad-spectrum antibiotic use and TPN [30,31]. Empirical treatment was initiated based on clinical suspicion and later tailored to culture sensitivity. The increasing prevalence of multidrug-resistant organisms (MDROs) calls for urgent revision of ICU antibiotic policies. According to Jain et al. (2025), empirical regimens need region-specific customization due to varying MDRO prevalence across Indian hospitals [32].

Lastly, compliance with central line bundles, including proper hand hygiene, maximal barrier precautions, and daily assessment of catheter necessity, was found to be suboptimal in most ICUs across northern India, as reported in a recent observational study by Roy et al. (2025) [33].

CONCLUSION

This prospective study highlights a high incidence of CLABSI in ICU patients, especially among those with femoral catheter placement, prolonged catheterization, and underlying comorbidities. Staphylococcus aureus was the predominant pathogen, followed by gram-negative bacilli and Candida spp. Early identification, routine surveillance, strict adherence to aseptic protocols, and periodic staff training are critical to reducing the burden of CLABSI. The study emphasizes the need for routine microbiological monitoring and hospital-specific infection control strategies to improve patient outcomes and minimize antimicrobial resistance.

Limitations of the study

1. Single-center study, limiting generalizability.
2. Sample size was relatively small for sub-group analysis.
3. Lack of molecular analysis of MDR organisms and biofilm formation.
4. Catheter insertion practices (e.g., operator experience) were not standardized or analyzed.
5. Daily compliance with CLABSI prevention bundles was not formally audited.

DECLARATIONS:

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: There is consent to participate.

Consent for publication: There is consent for the publication of this paper.

Authors & contributions: Author equally contributed the work.

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