Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.69980/ee6pkn41

STUDY OF CENTRAL LINE-ASSOCIATED BLOODSTREAM INFECTIONS (CLABSI)

Dr.Agnijeet Palit [1*]

[1*]Assistant Professor, Department of Mcrobiology, Gouri Devi Institute of Medical Sciences & Hospital, Durgapur. agnijeet49@gmail.com

Abstract

Background:

Central line-associated bloodstream infections (CLABSI) are among the most serious and preventable healthcare-associated infections, carrying attributable mortality of 12–25% and disproportionately higher rates in ICUs of low- and middle-income countries, including India. Institution-specific surveillance is essential to guide targeted prevention in resource-limited tertiary care settings.

Materials and Methods:

An observational, cross-sectional study was conducted over six months (January–June 2019) at Gouri Devi Institute of Medical Sciences & Hospital (GIMSH), Durgapur, West Bengal. Thirty-five adult patients (≥18 years) developing CLABSI during hospitalization were enrolled. Pathogen identification and antimicrobial susceptibility testing (AST) were performed using standard microbiological methods and the Kirby-Bauer disk diffusion technique per CLSI guidelines. Demographic, catheter-related, and clinical outcome data were systematically recorded and analyzed using descriptive statistics.

Results:

The cohort was predominantly male (57.1%) with a mean age of 54.2 ± 16.5 years; 80.0% of infections occurred in ICU patients. Diabetes mellitus (51.4%) was the most prevalent comorbidity. Emergency catheter insertion (68.6%) and catheterization duration exceeding seven days (77.1%; mean: 12.4 ± 5.6 days) were the principal procedural risk factors. Gram-negative bacilli predominated (57.1%), with *Klebsiella pneumoniae* (22.9%) and *Acinetobacter baumannii* (17.1%) as the leading pathogens. Alarming resistance rates were observed: 83.3% carbapenem resistance in *A. baumannii*, 87.5% ceftriaxone resistance (ESBL phenotype) and 50.0% carbapenem resistance in *K. pneumoniae*, and MRSA in 66.7% of *S. aureus* isolates. CVC removal was required in 91.4% of cases, 40.0% progressed to septic shock, direct CLABSI-attributable mortality was 14.3%, and mean total hospital stay was 26.5 ± 11.3 days.

Conclusion:

CLABSI imposes a severe and preventable burden predominantly in ICU patients, driven by MDR Gram-negative pathogens and suboptimal catheter practices. Urgent implementation of evidence-based prevention bundles, real-time catheter surveillance, institution-specific antibiograms, and antimicrobial stewardship programs is critical to reducing CLABSI-related morbidity and mortality in resource-limited tertiary care settings.

Keywords: Central line-associated bloodstream infection, Carbapenem resistance, Intensive care unit, Antimicrobial stewardship

Introduction

Healthcare-associated infections (HAIs) represent a major global patient safety challenge, and among them, central line-associated bloodstream infections (CLABSI) constitute one of the most serious, life-threatening, and economically burdensome complications encountered in modern clinical practice. A CLABSI is formally defined as a laboratory-confirmed bloodstream infection in a patient who had a central venous catheter (CVC) in place at the time of, or within 48 hours before, the onset of the infection, and where the infection cannot be attributed to another source.[1] Central venous catheters are indispensable tools in the management of critically ill patients, providing reliable vascular access for administration of fluids, blood products, medications, parenteral nutrition, and hemodynamic monitoring.[2] However, their placement inherently breaches the body's primary defense the skin barrier creating a direct conduit for microbial entry into the bloodstream.

The global burden of CLABSI is substantial. Estimates from resource-rich nations indicate that CLABSI is associated with attributable mortality ranging from 12% to 25%, prolonged hospital length of stay, and considerable excess costs - with individual cases incurring additional healthcare expenditure estimated at approximately $46,000 per episode in the United States alone.[3] The rates of CLABSI in intensive care units (ICUs) of low- and middle-income countries are reported to be three to five times higher than those in developed nations, with CLABSI rates in developing country ICUs ranging from 1.6 to 44.6 per 1,000 central line days, compared to 0.5–1.8 per 1,000 central line days in high-income settings[4]. In India specifically, CLABSI rates in tertiary care hospitals have been reported to range from 3.9 to 17.04 per 1,000 central line days — far exceeding benchmarks established in developed nations — owing to overcrowded wards, high patient-to-nurse ratios, suboptimal infection control compliance, and limited access to antimicrobial-impregnated catheters.[5,1]

The pathogenesis of CLABSI is multifactorial.[2] Micro-organisms may gain access to the catheter through extraluminal migration from the skin insertion site, intraluminal contamination via catheter hubs during manipulation, hematogenous seeding from a distant focus of infection, or contaminated infusates.[6] Among the identifiable risk factors, prolonged catheter dwell time, femoral catheter site selection, use of multilumen catheters, inadequate hand hygiene by healthcare workers, and total parenteral nutrition have been consistently identified as independent predictors of CLABSI development. Gram-positive organisms, particularly coagulase-negative staphylococci and *Staphylococcus aureus*, have historically dominated the microbiological profile of CLABSI, although Gram-negative bacilli and *Candida* species have emerged as increasingly prevalent and therapeutically challenging causative agents, particularly in ICU settings.[7]

The preventability of CLABSI has been demonstrated convincingly. The landmark Michigan Keystone project by Pronovost et al.[8] demonstrated that implementation of a simple five-component evidence-based bundle — including hand hygiene, full barrier precautions at insertion, chlorhexidine skin antisepsis, avoidance of the femoral site, and prompt catheter removal — was associated with a sustained reduction of up to 66% in CLABSI rates across 103 Michigan ICUs. These findings were further reinforced by the guidelines for prevention of intravascular catheter-related infections issued jointly by the Centers for Disease Control and Prevention (CDC) and the Healthcare Infection Control Practices Advisory Committee (HICPAC), which provided evidence-based category IA recommendations for catheter insertion, maintenance, and replacement practices. [9] Despite these advances, implementation of such prevention bundles remains inconsistent across resource-limited settings, particularly in government tertiary care hospitals in India, where systemic barriers in infrastructure, staffing, and surveillance capacity continue to impede sustained CLABSI reduction. This underscores the urgent need for institution-specific CLABSI surveillance, localized risk stratification, and targeted quality improvement initiatives in critical care environments.

Materials and Methods

Study Design and Setting

An observational, cross-sectional study was conducted over a period of six months, from January 2019 to June 2019. The study was carried out at the Gouri Devi Institute of Medical Sciences & Hospital (GIMSH), located at NH-2, Rajbandh, Durgapur-713212, Dist. Paschim Bardhaman (W.B.). Prior to the commencement of data collection, approval was obtained from the Institutional Ethics Committee (IEC). Patient confidentiality and data privacy were strictly maintained throughout the study in accordance with ethical guidelines.

Study Population

The study included a cohort of 35 adult patients who developed Central Line-Associated Bloodstream Infections (CLABSI) during their hospital admission. Patients were monitored across both the Intensive Care Unit (ICU) and general medical/surgical wards.

Inclusion and Exclusion Criteria

- **Inclusion Criteria:** Patients aged 18 years and above who had a central venous catheter (CVC) in place for more than 48 calendar days and developed a primary bloodstream infection, defined by at least one positive blood culture yielding a recognized pathogen, accompanied by clinical signs of systemic infection (e.g., fever > 38°C, chills, or hypotension).
- **Exclusion Criteria:** Patients with positive blood cultures deemed to be contaminants (e.g., single positive culture for common skin flora like coagulase-negative Staphylococci without corresponding clinical signs), and patients whose bloodstream infection was secondary to an infection at another primary site (such as pneumonia or a urinary tract infection).

Microbiological Identification and Susceptibility Testing

Blood samples were collected aseptically from both the central line and a peripheral vein before the administration of new empiric antimicrobial therapy. The samples were inoculated into automated blood culture systems and incubated. Positive bottles were subcultured onto standard media, including Blood agar and MacConkey agar, and incubated at 37°C for 24 to 48 hours.

Pathogen identification was performed using standard microbiological and biochemical techniques. Antimicrobial Susceptibility Testing (AST) was conducted using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, and the results were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines applicable during the study period.

Data Collection

Clinical, demographic, and catheter-related data were systematically extracted from patient medical records. The variables collected included patient age, gender, underlying comorbidities (e.g., diabetes mellitus, chronic kidney disease), unit of admission, indication for CVC placement, site of insertion, type of catheter, and duration of catheterization prior to the onset of CLABSI. Clinical outcome measures, such as the need for mechanical ventilation, development of septic shock, length of stay, and in-hospital mortality, were also recorded.

Statistical Analysis

Data were tabulated in a standard spreadsheet and analyzed using appropriate statistical software. Descriptive statistics were utilized to summarize the findings. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages.

Results

Among the 35 patients diagnosed with central line-associated bloodstream infections (CLABSI), the cohort was predominantly male (57.1%) with a mean age of 54.2 years, heavily concentrated in the intensive care unit (80.0%), and frequently required catheterization for hemodynamic monitoring in the context of significant underlying comorbidities like diabetes mellitus (**Table 1**). Analysis of catheter-specific variables revealed that emergency insertions (68.6%) and prolonged

catheterization durations exceeding seven days (77.1%), predominantly utilizing double-lumen lines in the internal jugular vein, were the primary mechanical and temporal risk factors preceding infection (**Table 2**). Microbiological evaluation demonstrated a predominance of Gram-negative bacilli (57.1%), led by *Klebsiella pneumoniae* and *Acinetobacter baumannii*, while Gram-positive organisms—particularly coagulase-negative Staphylococci (CoNS)—accounted for a substantial 34.3% of the identified isolates (**Table 3**). Susceptibility testing of these major pathogens exposed alarming resistance profiles, notably an 83.3% carbapenem resistance rate among *A. baumannii* isolates, a 50.0% carbapenem resistance rate in *K. pneumoniae*, and high levels of methicillin resistance across Staphylococcal species (**Table 4**). Consequently, the clinical impact of these multidrug-resistant infections was severe, necessitating immediate central venous catheter removal in 91.4% of cases, driving a 40.0% progression to septic shock, and resulting in a direct CLABSI-attributable mortality rate of 14.3% alongside significantly prolonged hospital stays (**Table 5**).

Table 1: Baseline Demographic and Clinical Characteristics (N = 35)

Characteristic	**n (%) or Mean ± SD**
Age (years), Mean ± SD	54.2 ± 16.5
Gender	
Male	20 (57.1%)
Female	15 (42.9%)
Unit of Admission at Time of Infection	
Intensive Care Unit (ICU)	28 (80.0%)
Non-ICU / General Wards	7 (20.0%)
Major Comorbidities	
Diabetes Mellitus	18 (51.4%)
Hypertension	15 (42.9%)
Chronic Kidney Disease (CKD)	8 (22.9%)
Malignancy	5 (14.3%)
Primary Indication for Central Line	
Hemodynamic Monitoring / Inotropes	16 (45.7%)
Intravenous Antibiotics / Fluids	10 (28.6%)
Hemodialysis	6 (17.1%)
Total Parenteral Nutrition (TPN)	3 (8.6%)

Table 2: Central Venous Catheter (CVC) Characteristics and Risk Factors

Catheter Variable	**n (%) or Mean ± SD**
Site of Insertion	
Internal Jugular Vein	15 (42.9%)
Subclavian Vein	12 (34.3%)
Femoral Vein	8 (22.9%)
Number of Catheter Lumens	
Single Lumen	5 (14.3%)
Double Lumen	18 (51.4%)
Triple / Multi-Lumen	12 (34.3%)
Setting of Insertion	
Elective (Operation Theatre/Procedure Room)	11 (31.4%)
Emergency (ICU/Emergency Department)	24 (68.6%)
Duration of Catheterization Prior to CLABSI	
Mean Duration (days) ± SD	12.4 ± 5.6
≤ 7 days	8 (22.9%)
> 7 days	27 (77.1%)

Table 3: Microbiological Profile of CLABSI Isolates (N = 35)

Pathogen Category / Isolate	Number of Isolates (n = 35)	Percentage (%)
Gram-Negative Bacilli (GNB)	**20**	**57.1%**
Klebsiella pneumoniae	8	22.9%
Acinetobacter baumannii	6	17.1%
Escherichia coli	4	11.4%
Pseudomonas aeruginosa	2	5.7%
Gram-Positive Cocci (GPC)	**12**	**34.3%**
Coagulase-Negative Staphylococci (CoNS)	7	20.0%
Staphylococcus aureus	3	8.6%
Enterococcus spp.	2	5.7%
Fungi (Yeast)	**3**	**8.6%**
Candida spp. (Non-albicans)	2	5.7%
Candida albicans	1	2.9%

Table 4: Key Antimicrobial Resistance Patterns Among Major Isolates

Pathogen (Total n)	Key Resistance Marker	Resistant Isolates n (%)
A. baumannii **(n = 6)**	Carbapenem Resistance (CRAB)	5 (83.3%)
K. pneumoniae **(n = 8)**	Carbapenem Resistance (CRE)	4 (50.0%)
	Ceftriaxone Resistance (ESBL phenotype)	7 (87.5%)
S. aureus **(n = 3)**	Methicillin Resistance (MRSA)	2 (66.7%)
CoNS (n = 7)	Methicillin Resistance (MRSE)	5 (71.4%)
Pseudomonas aeruginosa **(n = 2)**	Piperacillin-Tazobactam Resistance	1 (50.0%)

Table 5: Clinical Interventions and Patient Outcomes (N = 35)

Clinical Outcome / Intervention	n (%) or Mean ± SD
Management Interventions	
CVC Removal Required	32 (91.4%)
Escalation to Reserve Antibiotics (e.g., Colistin, Linezolid)	22 (62.9%)
Initiation / Escalation of Vasopressors	16 (45.7%)
Morbidity Markers	
Progression to Septic Shock	14 (40.0%)
Post-Infection Length of Stay (days)	14.2 ± 7.8
Total Hospital Length of Stay (days)	26.5 ± 11.3
Mortality	
All-cause In-Hospital Mortality	9 (25.7%)
Mortality Directly Attributable to CLABSI*	5 (14.3%)

Discussion

The present study evaluated the clinico-microbiological profile and outcomes of central line-associated bloodstream infections (CLABSI) among 35 patients at a tertiary care medical college hospital. The findings highlight the critical burden of CLABSI, particularly in the ICU, and reflect the broader epidemiological challenge posed by drug-resistant organisms in resource-limited settings.The study cohort had a mean age of 54.2 years with a male predominance (57.1%), findings consistent with previously reported CLABSI series from tertiary care settings, where critically ill, middle-aged male patients with significant comorbidities constitute the highest-risk demographic. Notably, 80.0% of CLABSI cases in this study occurred in the ICU, which aligns with the global observation by Wisplinghoff et al. [7] that nosocomial bloodstream infections, including those caused by CoNS and *Staphylococcus aureus*, are significantly more prevalent in critical care environments. The high prevalence of diabetes mellitus (51.4%) among infected patients in this study further corroborates the findings of Mermel et al.,[1] who established that underlying immunosuppressive comorbidities — including diabetes, chronic kidney disease, and malignancy

— independently elevate the risk of intravascular catheter-related infections by impairing cellular immunity and predisposing to microbial colonization of catheter surfaces. The 22.9% prevalence of CKD in this cohort is particularly noteworthy, as hemodialysis-related catheterization was the indication for central line placement in 17.1% of cases — a subgroup well-recognized to carry disproportionately high CLABSI risk due to the frequency and duration of catheter manipulation.

The present study identified emergency catheter insertion (68.6%) and prolonged catheterization duration exceeding seven days (77.1%, mean: 12.4 ± 5.6 days) as the primary procedural risk factors for CLABSI development. These findings are strongly corroborated by the landmark Michigan Keystone Project of Pronovost et al.,[8] which demonstrated that adherence to a five-component insertion bundle — including optimal site selection, full-barrier precautions, and chlorhexidine antisepsis — reduced catheter-related bloodstream infections by up to 66% in 103 ICUs, implicitly confirming that deviations from these standards, as occur during emergency insertions, significantly escalate infection risk. The internal jugular vein was the most commonly utilized insertion site (42.9%), followed by subclavian (34.3%) and femoral (22.9%). This distribution is clinically significant; O'Grady et al.,[2] in their comprehensive CDC/HICPAC guidelines, specifically recommend the subclavian vein as the preferred site for non-tunneled catheters in adult patients to minimize infection risk, and explicitly advise avoiding the femoral site due to its higher colonization rate. The predominant use of double- and multi-lumen catheters (51.4% and 34.3%, respectively) further compounds infection risk, as multiple lumens increase the frequency of hub manipulation and have been independently associated with higher CLABSI rates.

The microbiological findings of this study demonstrated a predominance of Gram-negative bacilli (57.1%), led by *Klebsiella pneumoniae* (22.9%) and *Acinetobacter baumannii* (17.1%), followed by Gram-positive cocci (34.3%) and fungi (8.6%). This Gram-negative dominance contrasts with the classic microbiological profile reported in developed nations, where Gram-positive organisms - particularly CoNS — have historically predominated. Wisplinghoff et al. [7] reported that in a large multicenter US surveillance study of 24,179 nosocomial bloodstream infections, CoNS accounted for 31% and *Staphylococcus aureus* for 20% of isolates, with Gram-positive organisms responsible for 65% of all BSIs. The reversal of this microbiological pattern in the present study -with Gram-negative organisms accounting for the majority -is consistent with the epidemiological shift observed across South and Southeast Asian tertiary care settings, attributed to endemic carbapenem-resistant *Enterobacteriaceae* and *Acinetobacter* strains in ICU environments. Rosenthal et al.,[4] in their landmark INICC report summarizing data from 43 countries including India, similarly identified a shift toward Gram-negative dominance in CLABSI isolates from developing-country ICUs.

The antimicrobial resistance profiles documented in this study are particularly alarming. *A. baumannii* demonstrated a carbapenem resistance (CRAB) rate of 83.3%, while *K. pneumoniae* showed 50.0% carbapenem resistance (CRE) and 87.5% cephalosporin resistance consistent with an ESBL phenotype. Among Gram-positive organisms, MRSA accounted for 66.7% of *S. aureus* isolates, and methicillin-resistant CoNS (MRSE) was detected in 71.4% of CoNS isolates. These resistance rates substantially exceed those reported in resource-rich settings and are consistent with patterns documented by Jaggi et al.[5] in their multicentric Indian study, which reported that high CLABSI rates in Indian ICUs were compounded by increasing carbapenem resistance among Gram-negative pathogens, necessitating escalation to colistin-based regimens. The presence of *Candida* spp. in 8.6% of isolates — predominantly non-*albicans* species (5.7%) — is consistent with prior data highlighting total parenteral nutrition (TPN) and broad-spectrum antibiotic use as key fungal CLABSI risk factors, as documented by Mermel et al.[1] in there study.

The clinical consequences of CLABSI in this study were severe. CVC removal was required in 91.4% of cases, and 62.9% of patients necessitated escalation to reserve antibiotics including colistin and linezolid — a reflection of the extreme resistance profiles observed. Progression to septic shock occurred in 40.0% of patients, and direct CLABSI-attributable mortality was 14.3%, with overall in-hospital mortality reaching 25.7%. These findings are broadly consistent with estimates from Mermel et al.,[1] who reported attributable CLABSI mortality ranging from 12% to

25% in multiple prospective studies. The post-infection length of stay in this study (14.2 ± 7.8 days) and total hospital stay (26.5 ± 11.3 days) represent a significant resource burden. Pronovost et al.[8] demonstrated that each episode of CLABSI adds 7 to 21 days to hospital stay and entails substantial costs - reinforcing that prevention, not treatment, is the most cost-effective strategy. In the context of a government tertiary care hospital operating under resource constraints, each additional inpatient day depletes bed availability, increases nursing workload, and imposes pharmaceutical costs, particularly when multidrug-resistant pathogens mandate expensive reserve agents.

The inherent limitations of this study include a modest sample size of 35 CLABSI cases and a single-center retrospective design, which may limit statistical precision and generalizability to other institutional settings. Prospective multicentric surveillance studies with standardized CLABSI definitions are warranted to generate robust national data. Nevertheless, the study findings carry compelling clinical relevance: the unacceptably high rates of emergency-setting catheter insertion, prolonged catheterization duration, and MDR pathogens demand an immediate institutional response. The evidence-based CLABSI prevention bundle proposed by Pronovost et al.[8] and codified by the CDC/HICPAC guidelines of O'Grady et al. must be implemented as a non-negotiable standard of care. Additionally, Jaggi et al.[5] demonstrated that a multidimensional INICC-based intervention in Indian tertiary hospitals reduced CLABSI rates from 6.4 to 3.9 per 1,000 catheter days, with sustained benefit over 36 months — providing a directly applicable and evidence-validated model for Indian government hospitals. Structured nursing education, dedicated insertion checklists, real-time catheter day tracking, and institution-specific antibiograms must be integrated into a comprehensive CLABSI prevention and management framework.

Conclusion

The present study establishes a significant burden of CLABSI predominantly in ICU patients, with emergency catheter insertion and prolonged catheterization duration identified as the principal modifiable risk factors. MDR Gram-negative pathogens, particularly carbapenem-resistant *Acinetobacter baumannii* and ESBL-producing *Klebsiella pneumoniae*, dominated the microbiological profile, reflecting an alarming regional resistance trend. These infections resulted in severe clinical consequences, including 40.0% progression to septic shock, 14.3% direct attributable mortality, and significantly prolonged hospital stays. Urgent implementation of evidence-based CLABSI prevention bundles, real-time catheter surveillance, and robust antimicrobial stewardship programs is imperative to reduce this preventable yet life-threatening complication in resource-limited tertiary care settings.

References

1. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. Clin Infect Dis. 2009;49(1):1–45.
2. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis. 2011;52(9):e162–93.
3. Zimlichman E, Henderson D, Tamir O, Franz C, Song P, Yamin CK, et al. Health care-associated infections: a meta-analysis of costs and financial impact on the US health care system. JAMA Intern Med. 2013;173(22):2039–46.
4. Rosenthal VD, Maki DG, Mehta Y, Leblebicioglu H, Memish ZA, Al-Mousa HH, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 43 countries for 2007–2012. Am J Infect Control. 2014;42(9):942–56.
5. Jaggi N, Rodrigues C, Rosenthal VD, Todi SK, Shah S, Saini N, et al. Impact of an international nosocomial infection control consortium multidimensional approach on central line-associated bloodstream infection rates in adult intensive care units in eight cities in India. Int J Infect Dis. 2013;17(12):e1218–24.
6. Safdar N, Maki DG. The pathogenesis of catheter-related bloodstream infection with noncuffed short-term central venous catheters. Intensive Care Med. 2004;30(1):62–7.

7. Wisplinghoff H, Bischoff T, Tallent SM, Seifert H, Wenzel RP, Edmond MB. Nosocomial bloodstream infections in US hospitals: analysis of 24,179 cases from a prospective nationwide surveillance study. Clin Infect Dis. 2004;39(3):309–17.
8. Pronovost P, Needham D, Berenholtz S, Sinopoli D, Chu H, Cosgrove S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med. 2006;355(26):2725–32.