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ORIGINAL ARTICLE

Incidence, microbial profile and antimicrobial resistance trends of CLABSI in adult ICUs: a longitudinal prospective study

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ABSTRACT

Background and Objectives: Central line-associated bloodstream infections (CLABSIs) remain a major cause of healthcare-associated mortality, prolonged hospitalization, and increased healthcare costs, especially in resource-poor settings where surveillance data are scarce. This study aimed to determine CLABSI incidence, risk factors, causative organisms, and antimicrobial resistance (AMR) patterns across adult intensive care units (ICUs).

Materials and Methods: A prospective longitudinal study was conducted amongst 200 adult ICU patients with central line (CL) in-situ for >2 calendar days. CLABSI surveillance followed definitions by The Centers for Disease Control and Prevention, National Healthcare Safety Network. Microbiological identification and antimicrobial susceptibility testing were performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Results: The overall CLABSI incidence was 19.25/1,000 catheter days. CLABSI patients demonstrated significantly extended hospitalization (20.22 vs 9.09 days, p<0.001) and CL duration (16.17 vs 7.85 days, p<0.001). Femoral lines had the highest infection rate (42.85%). The median time from CL insertion to the onset of CLABSI was 7.5 days. Gram-negative organisms predominated (75%), with *Acinetobacter* species being most frequent (36.1%), followed by *Candida* species (22.23%). Comorbidities such as hypertension, type 2 diabetes mellitus, tuberculosis, and drug abuse showed no significant association with CLABSI. Antimicrobial resistance (AMR) was extensive; all isolates were resistant to most antibiotic classes, including penicillins, cephalosporins, and carbapenems. In contrast, colistin retained 100% susceptibility. CLABSI was associated with significantly higher mortality (69.4% vs. 47%; p = 0.014) and a lower rate of discharge/transfer to a healthy setting (p = 0.0112) compared to non-CLABSI patients.

Conclusion: The study demonstrates high CLABSI incidence and alarming levels of AMR, underscoring the urgent need for strengthening infection prevention practices and antimicrobial stewardship in ICUs.

Keywords: Healthcare associated infections; Catheter-associated infections; Bloodstream infection; Central venous catheter; Antimicrobial resistance

INTRODUCTION

The World Health Organisation (WHO) defines healthcare-associated infection (HAI) as an infection acquired by patients during the care process (including preventive, diagnostic and treatment services) in hospitals or other health-care facilities, which was not present or incubating at the time of admission. HAIs may also manifest after discharge (1). Developing countries bear a disproportionately

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high burden of HAI— with nearly double the prevalence and triple the incidence in intensive care units (ICUs) compared with high-income countries, despite similar device utilisation rates (2). The risk of acquiring HAI is substantial in both developed and developing nations. This risk is influenced by multiple factors, including the healthcare system's infrastructure, clinical interventions, and patient-specific factors (3). Critically ill hospitalised patients are at increased risk of developing hospital-acquired bloodstream infections (BSI); the majority of these BSIs are primary and are commonly associated with intravascular devices (2). Although substantial progress has been made in reducing HAIs in many regions, no country has been able to eliminate the risk entirely (3). CLABSIs remain a leading cause of death in hospitalised patients; however, their incidence in low-resource countries has not been studied in detail (4). CLABSIs impose the highest economic burden amongst all the healthcare-associated Infections (5).

An additional concern is the global threat of AMR as antimicrobials are the treatment of choice for these infections (4). Emerging AMR among pathogens causing CLABSI represents a major challenge worldwide (6). Notably, CLABSIs have the highest mortality rate of any type of nosocomial infection, ranging from 12% to 25% (6). Patients with CLABSI have longer hospital stays, increased health care costs, and attributable mortality. Low nurse-to patient ratios, inadequately trained health care workers, and the use of open intravenous infusion systems contribute to the increased incidence of CLABSIs and consequently higher morbidity and mortality in developing countries. Furthermore, limited awareness and resource constraints hinder effective implementation of basic infection prevention and control measures (6).

Therefore, this study aimed to assess the incidence, risk factors, causative organisms and antibiotic susceptibility pattern of CLABSI isolates in adult ICUs of a tertiary care hospital.

MATERIALS AND METHODS

This study aimed to determine the incidence, risk factors, causative microorganisms, and antibiotic susceptibility patterns of CLABSI isolates in an adult ICU of a tertiary care hospital.

This longitudinal prospective study included all patients admitted to intensive care units (ICUs) who had a central line (CL) in situ. Surveillance of CLABSI was conducted in accordance with the Centers for Disease Control and Prevention (CDC), National Healthcare Safety Network (NHSN) (7). Inclusion criteria mandated the presence of a CL for a minimum of two calendar days.

Blood cultures were obtained for microbiological evaluation from patients with clinical signs of bloodstream infection to confirm or exclude bacteremia or fungemia. Bacterial identification was performed using both conventional phenotypic methods and automated systems (VITEK-2, bioMérieux). Antibacterial susceptibility testing was done via standardized Kirby-Bauer disk diffusion method as per CLSI guidelines. Colistin susceptibility was determined using the validated colistin agar test. Fungal characterization was performed using multiple diagnostic modalities, including the germ tube test, chromogenic media differentiation (CHROMagar™ Candida), and the Dalmau plate technique for morphological analysis. Antifungal susceptibility profiles were established using automated methods (VITEK-2 YST). Patients with confirmed secondary bloodstream infections were excluded from the study. The final study population consisted of 200 patients who met all predefined inclusion criteria. The sample size was calculated using the Taro Yamane formula. The incidence of CLABSI and the device utilization ratio (DUR) were calculated (8, 9). Interpretive breakpoints established by CLSI M 100 guidelines for bacterial isolates and CLSI M60 guidelines for fungal isolates were used to define susceptibility (10, 11).

Statistical analysis. Data were collected using a standardized proforma and entered into Microsoft Excel 2019. Analysis was performed using Jamovi 2.3.28. Continuous variables, such as age and length of hospital stay, were expressed as mean (standard deviation) or median (interquartile range). Categorical variables, including gender and diabetes status, were expressed as proportions (percentages). The incidence of CLABSI was expressed as a proportion. Differences in the mean or median values of continuous variables between patients with and without CLABSI were analyzed using an independent samples t-test. Associations between categorical variables and CLABSI status were tested using Pearson's chi-square test or Fisher's exact test. A p-value of <0.05 was considered statistically significant.

RESULTS

Of the 200 adult ICU patients with a CL in situ for more than two calendar days, 36 (18%) met the surveillance criteria for CLABSI. Of the 36 patients who met CLABSI criteria, 32 had no other identifiable source of infection and were classified as ICU-acquired CLABSIs. In the remaining 4, the infection was attributed to another healthcare facility. The other 160 patients showed no evidence of bloodstream infection and were categorized as non-CLABSI cases. A total of 1,870 CL days were present, which yielded an overall CLABSI incidence rate of 19.25 per 1,000 catheter days. The highest CLABSI incidence was observed in the surgical ICU (36.86 per 1,000 catheter days); in contrast, the anesthesia ICU demonstrated the highest CL utilization ratio (DUR) at 0.93, indicating that nearly all patient-days had an indwelling catheter. Incidence and DUR for all ICUs are shown in Table 1.

Males accounted for two-thirds of CLABSIs (24/36). CLABSI patients were also older, on average, than non-CLABSI patients (53.2 vs. 50.7 years). The most common age group for CLABSI patients was 61–70 years (n=10). The femoral site had the highest proportion of CLABSIs (42.85%; 3 of 7 insertions), suggesting that infection risk varies by catheter location. Comorbid conditions analysed as risk factors for CLABSI in the cohort are presented in Table 2.

CLABSI patients demonstrated a significantly prolonged ICU stay with a mean of 20.22 days compared to mean ICU stay of 9.09 days for non-CLABSI patients over the surveillance period. These patients also demonstrated a significantly higher mean CL exposure duration (16.17 days) compared to the non-CLABSI patients. An independent t-test yielded a p-value <0.001, indicating that the more than two-fold differences in mean ICU stay and CL duration between the groups are statistically significant.

Among CLABSI patients, the maximum number of events occurred between days 3 and 6 (peaking on day 5) and on day 12 (n=4), as shown in Fig. 1. The median interval between CL placement and CLABSI development was 7.5 days. Additional sporadic cases arose in the latter half of the surveillance period.

The distribution of microbial organisms cultured from the 36 confirmed CLABSIs in the ICU population is shown in Table 3. Gram-negative bacteria were the majority, with *Acinetobacter* species being the most common organism, accounting for 36.1% (13/36) of cases.

Analysis of antimicrobial susceptibility patterns revealed varying resistance profiles among CLABSI isolates. The isolates demonstrated concerning resistance patterns to multiple antibiotic classes. Notably, all were completely resistant (100%) to ampicillin. Cephalosporin efficacy was markedly diminished, with negligible susceptibility to all agents except for a 7.7% susceptibility to ceftazidime in *Acinetobacter* species and a 16.67% susceptibility to cefepime in *Escherichia coli.* Of particular concern was the emergence of carbapenem resistance, with only 7.7% of *Acinetobacter* species isolates and 33.33% of *E. coli* isolates retaining susceptibility to both imipenem and meropenem. Aminoglycoside susceptibility varied among species. Amikacin demonstrated moderate activity, with susceptibility rates of 15.38% in *Acinetobacter* species, 14.27% in *Klebsiella pneumoniae*, and 50% in *E. coli.* Gentamicin showed slightly higher but still suboptimal susceptibility: 23% in *Acinetobacter* species, 28.57% in *K. pneumoniae*, and 66.70% i*n E. coli*. Among fluoroquinolones, ciprofloxacin susceptibility was limited to 23% in *Acinetobacter* species and 14.27% in *K. pneumoniae* isolates. Colistin emerged

Table 1. CLABSI Incidence and device utilization ratio for various ICU's

Location Attribution (Total = 36)	ClABSI Cases	CL Days	ICU Days	Incidence (per 1000 catheter days)	DUR (CL Days/ICU Days)
Surgery ICU	8	217	251	36.86	0.86
Anaesthesia ICU	2	77	82	25.97	0.93
Trauma ICU	17	769	929	22.10	0.82
Medicine ICU	8	709	818	11.28	0.86
Neurosurgery ICU	1	98	138	10.20	0.71

CLABSI- Central Line Associated Blood Stream Infection; ICU- Intensive Care Unit; CL- Central Line; DUR- Device Utilization Ratio

Table 2. Detailed description of all the patients admitted to adult ICUs having CLABSI and not having CLABSI

		CLABSI (36)	Non CLABSI (164)	P Value
Demography				
Male		24	94	0.3
Female		12	70	
Median age		53.2	50.7	0.439
Site				
Subclavian vein		18	93	0.2
Internal Jugular vein		15	67	
Femoral vein		3	4	
Course of Hospitalization				
Mean ICU Stay		20.22	9.09	<0.001*
Mean CL days		16.17	7.85	<0.001*
Comorbidities				
Hypertension	Present	10	46	0.973
	Absent	26	118	
Diabetes Mellitus	Present	6	36	0.48
	Absent	30	128	
Tuberculosis	Present	3	16	1
	Absent	33	148	
Substance Abuse	Present	1	15	0.313
	Absent	35	149	
COPD	Present	1	4	1
	Absent	35	160	
Hypothyroidism	Present	0	11	0.219
	Absent	36	153	
Heart disease	Present	3	4	0.111
	Absent	33	160	
Cerebrovascular Accident	Present	0	6	0.593
	Absent	36	158	
Outcome				
In-hospital mortality		25	77	0.014*
Others (Transferred out + LAMA)		11	87	

CLABSI- Central Line Associated Blood Stream Infection; ICU- Intensive Care Unit; CL- Central Line; COPD- Chronic Obstructive Pulmonary Disorder; LAMA- Leave Against Medical Advice

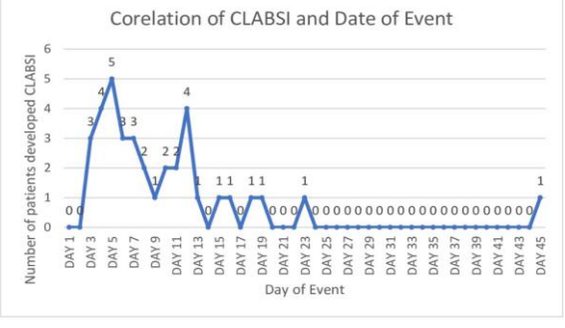

Fig. 1. Distribution of date of event in patients who developed CLABSI

Table 3. Microorganisms isolated among CLABSI patients

Microorganisms	No. of isolates (N = 36)	Percentage
Acinetobacter species	13/36	36.12%
Candida species	8/36	22.23%
Klebsiella pneumoniae	7/36	19.45%
Escherichia coli	6/36	16.67%
Pseudomonas aeruginosa	1/36	2.78%
Enterococcus faecium	1/36	2.78%

as the only consistently effective and reliable therapeutic antimicrobial agent, maintaining 100% susceptibility across all isolated species (MIC ≤0.5 µg/mL). Table 4 presents antibiotic susceptibility testing results for all gram-negative bacterial isolates.

Enterococcus faecium was isolated in 1 of 36 (2.8%) CLABSI cases. The isolate demonstrated lack of susceptibility to ampicillin and erythromycin. Resistance to High-level gentamicin made synergy unlikely. The strain retained full vancomycin and linezolid activity.

Among 36 clinical isolates, 8 *Candida* (C.) species were identified, comprising *C. tropicalis* (n=4, 11.1%), *C. guilliermondii* (n=3, 8.3%), and *C. albicans* (n=1, 2.8%). Antifungal susceptibility testing revealed distinct patterns across different drug classes. The azole antifungals demonstrated excellent activity, with both fluconazole and voriconazole showing 100% susceptibility across all *Candida* species. Similarly, the echinocandins (caspofungin and micafungin) maintained complete efficacy against all tested isolates, with 100% susceptibility. Flucytosine also demonstrated uniform activity, with all isolates (100%) remaining susceptible across all three *Candida* species. Amphotericin B showed variable effectiveness: *C. tropicalis* was fully susceptible (100%), *C. guilliermondii* showed reduced susceptibility (66.67%), and *C. albicans* was completely resistant (0%). Antifungal susceptibility testing results for the fungal isolates are depicted in Table 5.

Among CLABSI patients, 25 of 36 (69.4%) died prior to discharge, compared to 77 of 164 (47%) non-CLABSI patients. The case fatality rate was significantly higher in the CLABSI group (69.4% vs. 47%). This difference was statistically significant (chi-square test, p = 0.014), highlighting the association between CLABSI and excess mortality.

Furthermore, patients without CLABSI had significantly higher rates of discharge to home/a healthy setting and a healthy outcome compared to CLABSI patients (chi-square test, p = 0.0112).

DISCUSSION

CLABSI incidence in our study was 19.25 per 1,000 catheter-days which is similar to studies from various parts of India (6, 12). Reported Indian ICU CLABSI rates range widely from 0.48 to 27 per 1,000 line-days, substantially exceeding benchmarks from developed nations (13). CLABSIs continue to be a significant yet preventable HAI, with the incidence in United States ICUs in 2020 being 0.87 per 1,000 CL days, a rate substantially lower than that reported from Indian hospital settings (14). A 2010-2016 Taiwanese study found a mean CLABSI incidence of 3.47 per 1,000 catheter-days, which falls in between the U.S. and Indian estimates (13).

Analysis of intensive care duration reveals CLAB-

Table 4. Antibiotic susceptibility testing results for all gram-negative bacterial isolates

Antibiotics	***Acinetobacter* species (13/36)**	***Klebsiella pneumoniae* (7/36)**	***Escherichia coli* (6/36)**	***Pseudomonas aeruginosa* (1/36)**
Ampicillin	IR	IR	0%	IR
Cefuroxime	IR	0%	0%	IR
Cefotaxime or ceftriaxone	0%	0%	0%	IR
Ceftazidime	7.70%	0%	0%	0%
Cefepime	7.70%	0%	16.67%	0%
Aztreonam	IR	0%	0%	0%
Imipenem	7.70%	0%	33.33%	0%
Meropenem	7.70%	0%	33.33%	0%
Piperacillin-tazobactam	0%	0%	0%	0%
Amikacin	.38%	14.27%	50%	NBP
Gentamicin	23%	28.57%	66.70%	NBP
Ciprofloxacin	23%	14.27%	0%	0%
Trimethoprim-sulfamethoxazole	30.77%	14%	50%	IR
Colistin (MIC<=0.5)	100%	100%	100%	100%

IR- Intrinsic Resistant; NBP- No Breakpoints available; MIC- Minimum Inhibitory Concentration

Table 5. Antifungal susceptibility testing results for the fungal isolates

Antifungals	*Candida tropicalis* (4/36)	*Candida guilliermondii* (3/36)	*Candida albicans* (1/36)
Fluconazole	100%	100%	100%
Voriconazole	100%	100%	100%
Caspofungin	100%	100%	100%
Micafungin	100%	100%	100%
Amphotericin B	100%	66.67%	0%
Flucytosine	100%	100%	100%

SI patients had significantly longer lengths of hospital stay compared to non-infected patients in critical care unit included in surveillance. Similarly, CLABSI patients in the rigorously monitored population had prolonged central line dwell times compared with their non-infected counterparts. These results suggest CLABSIs may be an independent predictor of prolonged intensive care requirements as well as prolonged central line days among critically ill patients.

Early clustering of CLABSIs within the first two weeks of ICU admission and catheter insertion provides preliminary evidence that breaches in aseptic technique, suboptimal barrier precautions, or reduced staff vigilance in line maintenance practices during the initial device implantation period may contribute to heightened infection acquisition vulnerability in a patient's ICU course.

CLABSI most commonly occurred in patients with femoral lines, consistent with findings from other studies (15, 16). This risk gradient likely stems from anatomic vulnerability, proximity to higher microbial bioburden and mechanical complications varying due to location-dependent structural factors. The outcomes suggest a clear association between certain insertion sites and subsequent bloodstream infection risk.

In the current study, the association between diabetes mellitus (DM) and CLABSI risk was not significant ($p = 0.48$), a finding consistent with another Indian study ($p = 0.06$). In contrast, a study by Alwazzeh et al. reported a significant association ($p < 0.01$) (6, 17). While a study by Alwazzeh et al. in Saudi Arabia found hypertension to be significantly associated with CLABSIs (87/244 patients; $p < 0.05$), it was not a significant predictor in our data ($p = 0.97$) (17). Similarly, neither COPD nor CVA were significant risk factors in our study, a finding consistent with other reports (17).

Microbiological profile analysis in the current study revealed a predominance of Gram-negative organisms, accounting for 75% of all isolates cultured from CLABSIs. Specifically, *Acinetobacter* species represented 36.1% of CLABSI episodes, while *K. pneumoniae* comprised 19.5% of all the CLABSI cases. This distribution aligns with other studies reporting Gram-negative isolates in device-associated BSIs (18) particularly driven by Acinetobacter species (25-30%) (5, 19). Consistent with other studies, antimicrobial susceptibility profiling of our 36 CLABSI isolates revealed concerning resistance rates to several first-line antibiotics (20).

CONCLUSION

CLABSIs continue to pose a critical threat in intensive care settings, and the high incidence demonstrated in our study underscores an urgent call for action. Targeted surveillance, early identification of modifiable risks, and real-time tracking of pathogen profiles and resistance trends are essential to break the cycle of preventable infections. With the alarming rise of multidrug-resistant organisms, stringent adherence to central line insertion and maintenance bundles, meticulous hand hygiene, and reinforced staff competency must become non-negotiable standards of care. Strengthening antimicrobial stewardship and resistance monitoring will be pivotal for guiding effective empirical therapy and safeguarding last-line antibiotics. Understanding local incidence, risk factors, and antimicrobial susceptibility patterns is fundamental for optimizing prevention strategies and improving outcomes in critically ill patients. Ultimately, empowering ICUs with robust prevention strategies and data-driven decision-making is the

key to reducing morbidity, mortality, and the growing burden of antimicrobial resistance associated with CLABSIs.

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