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Central line-associated bloodstream infections (CLABSI) in critical care: understanding incidence, and risk factors in Palestine

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Abstract

Introduction Central line-associated bloodstream infections (CLABSIs) represent a major source of morbidity and mortality, particularly in developing countries. Central venous catheters (CVCs) are an essential part of managing critically ill patients. This study seeks to describe the epidemiology of central line-associated bloodstream infections CLABSI among ICU patients in Palestine and to identify the specific organism involved.

Methods This retrospective descriptive study included 323 ICU patients with 490 central venous catheters. The electronic medical records were reviewed to identify patients with CLABSIs hospitalized from January 2018 through December 2021. Comparative analysis was conducted to assess associations between various variables and the incidence of CLABSI.

Result A total of 19 CLABSI episodes in 323 patients yielded an incidence of CLABSI of approximately 5.9%, with a rate of 8.91 per 1,000 device days. CLABSI patients had significantly more CVC utilization ratio and insertions compared to non-CLABSI patients. No significant differences were observed in age, gender, or overall mortality. The most predominant bacteria was Acinetobacter baumannii (21%).

Conclusion This study highlights the importance of minimizing CVC use and limiting the number of insertions to reduce CLABSI risk. Effective management strategies should focus on reducing CVC duration and frequency.

Keywords Intensive care unit, Central line-associated bloodstream infections, Central venous catheters (CVC)

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Introduction

Central line-associated bloodstream infections (CLABSIs) are the most common complication of central venous catheters (CVCs), with an incidence of 4.1 per 1000 central line days [1]. It leads to prolonged hospital stays and increased healthcare costs and mortality. In the United States, an estimated 250,000 bloodstream infections occur annually, and most are related to the presence of intravascular devices. The CLABSI rate in ICU is estimated to be 0.8 per 1000 catheter days [2]. On the other hand, in North India, the overall rate of CLABSI was 17.04 per 1000 catheter days [1]. While in some high-income countries, such as China, the overall rate of CLABSI per 1000 catheter days was 1.50 [3].

A meta-analysis showed that patients with CLABSI have a 2.75 times higher risk for hospital death than those without CLABSI. CLABSIs are largely preventable when evidence-based guidelines are followed, such as hand washing, using full-barrier precautions during CVC insertion, cleaning the skin with chlorhexidine, and removing unnecessary catheters. Most intensive care units (ICUs) in developed countries now report CLABSI rates of zero or close to zero, but the overall incidence of CLABSIs in ICUs in China is about 2.81 [4].

The results of a retrospective observational chart review study showed that the infection developed in catheterized patients at a median of 14 days, with the highest infection rate in the femoral region. In patients with Candida infection, mortality was significantly higher [5].

In contrast, a study in northern India at a tertiary care referral medical center showed that Klebsiella pneumoniae was the most common organism. The immunosuppressed state and duration of the central venous catheters (CVC) of more than 10 days were significant factors for developing CLABSI [6]. In another study that was done in China, Staphylococcus spp. was the most common organism isolated, followed by Enterobacteriaceae [4].

In Palestine, there is limited information regarding the prevalence, characteristics, and risk factors of central line-associated bloodstream infections (CLABSI) in ICU patients. Therefore, our research aims to explore and describe the epidemiology of CLABSI among ICU patients in this region.

Methodology

Study design and setting

This retrospective study was conducted at An-Najah National University Hospital and included all adult patients admitted to the ICU with a central venous catheters (CVC) between 2018 and 2022.

The Seldinger technique was employed for the insertion of central venous catheters under ultrasound guidance. The insertion procedure was carried out under complete aseptic conditions using sterile gloves, gowns, masks, and drapes. Skin antisepsis was performed with chlorhexidine 2%. For the dressing, 3 M™ Tegaderm™ CHG Chlorhexidine was used, which was changed every 48 h. The CVCs used in this study were B.Braun Certofix® Trio Triple-lumen catheters. Blood cultures were drawn from each lumen of the central venous catheter in addition to peripheral vein. CLABSI was verified when a blood culture obtained from the central catheter became positive at least two hours earlier than the blood culture obtained from a peripheral vein. A positive catheter tip culture obtained through the semiquantitative roll plate technique (with ≥ 15 colony-forming units) without matching pathogens in simultaneously drawn blood cultures indicates catheter colonization.

Identification and antibiotic susceptibility testing of bacteria isolated from blood culture samples submitted to the microbiology laboratory of An-Najah National University Hospital were performed using the automated Vitek 2 Compact system (bioMérieux, France). For susceptibility testing, fresh bacterial colonies were prepared as an inoculum in sterile saline, adjusted to a turbidity equivalent to 0.5 McFarland. AST-GP 67 cards were employed to evaluate susceptibility to antimicrobial agents, including ampicillin, benzylpenicillin, ciprofloxacin, levofloxacin, vancomycin, tigecycline, linezolid, tetracycline, high-level gentamycin, high-level streptomycin, nitrofurantoin, quinupristin/dalfopristin, clindamycin, and erythromycin. The minimum inhibitory concentration (MIC) of each antibiotic was determined and interpreted following the Clinical and Laboratory Standards Institute (CLSI) M100-S30 document breakpoints.

Data were collected from hospital records, including demographic data (such as age, and gender)comorbidities like cardiovascular disease, hypertension, diabetes mellitus, smoking, and history of surgeries. In addition to data regarding central venous catheters as type, site of insertion, utilization ratio, and causative organisms in case of CLABSI.

Definitions

CLABSI is defined according to the Centers for Disease Control and Prevention (CDC) as the isolation of a pathogen from a blood culture (a single blood culture for a pathogen not commonly present on the skin and two or more blood cultures for a pathogen commonly present on the skin) in a patient who had an infection within 48 h of central venous catheter (CVC) placement [2]. The CLABSI rate was calculated as follows: number of CLABSIs / number of central venous catheters (CVC) days $\times 1{,}000$, and the Central venous catheters (CVC) utilization ratio was calculated as follows: dividing the

number of central venous catheter (CVC) days by the number of patient days [6]. The insertion rate refers to the number of new central venous catheter placements per patient day. It measures how frequently central catheters are being inserted and is often used to evaluate procedural practices [6].

Statistical analysis

The data collected for this study were analysed using Statistical Package for the Social Sciences (SPSS), version 27.0. Data was presented as percentages and frequencies for categorical variables, and mean ± standard deviation (SD) for numerical variables.

The association between variables and CLABSI was assessed using an independent t-test for numerical data and chi-square or Fisher's exact test for categorical data. Based on the univariate analysis, a regression model was developed to evaluate risk factors for CLABSI. A significance level of $p < 0.05$ was utilized to determine statistical significance.

Ethical approval

All procedures performed in this study have been carried out following the Declaration of Helsinki and relevant national guidelines and regulations. Ethical approval was obtained from the Institutional Review Board (IRB) at An-Najah National University. IRB number: med.July 2023/17. Assuring confidentiality of data, that was used for this study only. Privacy, beneficence, and efforts to minimize bias, were closely monitored throughout the research.

Results

The study involved 323 patients and a total of 490 central venous catheters (CVC) attempts. Among these patients, the mean age was 52 ± 17.6 years. Among these 57% were males. About 27% had coronary heart disease, 28% were smokers, 37% had diabetes mellitus, and 45% had hypertension. The mean duration of central venous catheter (CVC) use was 5.8 ± 4.9. The mean length of hospitalization was 18.8 ± 18.5 days (Table 1). Central venous catheter types included 236 (73%) jugular catheters, 52 (16%) femoral catheters, and 35 (11%) subclavian catheters (Fig. 1).

The incidence of CLABSI was 19 out of 323 central venous catheter attempts, corresponding to an incidence rate of approximately 5.9%. The CLABSI rate was calculated as approximately 8.91 per 1,000 device days.

A comparison of characteristics between CLABSI and non-CLABSI patients is shown in Table 1, The mean age was similar between CLABSI (56.1 ± 12.7 years) and non-CLABSI patients (52 ± 17.9 years), with no significant difference ($p = 0.28$). Gender distribution, prevalence of coronary heart disease, smoking status, diabetes mellitus, hypertension, and surgical procedures history were comparable between the two groups. However, a significantly higher proportion of CLABSI patients had a history of COVID-19 (10% vs. 1%, $p = 0.03$). CLABSI patients also had a significantly higher CVC utilization ratio (9.7 ± 5.1

Table 1 Baseline characteristics and comparisons between patient with and without CLABSI

Variables	All participants ($n = 323$)	CLABSI ($n = 19$)	Non-CLABSI ($n = 304$)	*P* value
Age, years, mean ± SD	52 ± 17.6	56.1 ± 12.7	52 ± 17.9	0.28
Gender, n(%)				
Male	184 (57%)	11 (57%)	173 (57%)	0.93
Female	139 (43%)	8 (43%)	131 (43%)	
Coronary heart disease, n(%)	87 (27%)	6 (31%)	81 (26%)	0.64
Smoking, n(%)	91 (28%)	7 (36%)	84 (27%)	0.38
Diabetes mellitus, n(%)	120 (37%)	7 (36%)	113 (37%)	0.97
Hypertension, n(%)	144 (45%)	10 (52%)	134 (44%)	0.46
Surgical procedures, n(%)	140 (43%)	11 (57%)	129 (42%)	0.18
COVID-19, n(%)	5 (1.5%)	2 (10%)	3 (1%)	0.03
CVC utilization ratio,mean ± SD	6.4 ± 5.1	9.7 ± 5.1	6.3 ± 5	0.008
Number of CVC insertions, mean ± SD	1.5 ± 0.97	3.4 ± 1.4	1.4 ± 0.8	< 0.001
CVC **type**				
Internal jugular catheter	236 (73.1%)	15 (78.9%)	221 (72.7%)	0.34
Femoral catheter	52 (16.1%)	3 (15.8%)	49 (16.1%)	0.34
Subclavian catheter	35 (10.8%)	1 (5.3%)	34 (11.2%)	0.019

SD Standard deviation, *CVC* Central venous catheter

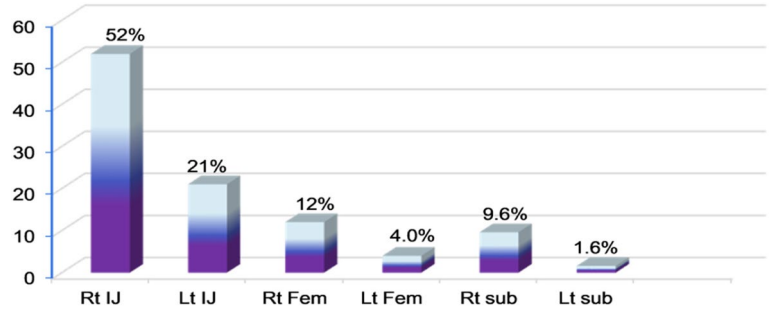

Fig. 1 Percentage of central venous catheters (CVC) insertion sites

Table 2 Length of stay and mortality among all CVC attempts

Variables	TOTAL ($n=323$)	CLABSI	Non-CLABSI	*P* value
Length of hospitalization, days, mean ± SD	18.8 ± 18.5	33.45 ± 22.8	17.6 ± 17.8	0.07
Mortality	109 (34%)	8 (42%)	101 (33%)	0.43

SD Standard deviation, *CVC* Central venous catheter

Table 3 Multivariate analysis for CLABSI risk factors

Variables	Odds ratio	95% CI	*P* value
Length of hospitalization	0.9-	0.9–1.02	0.87
CVC utilization ratio	1.1	1.01–1.12	0.025
Number of CVC insertions	1.9	1.39–2.6	< 0.001
Underwent surgery	2	0.79–5.3	0.14
Femoral catheter	0.59	0.15–2.2	0.43
Subclavian catheter	0.25	0.03–2.2	0.25

CVC Central venous catheter

vs. 6.3 ± 5.0 days, $p=0.008$) and a higher number of CVC insertions (3.4 ± 1.4 vs. 1.4 ± 0.8 insertions, $p<0.001$). The type of CVC used did not significantly differ between the groups, except for a higher prevalence of subclavian lines in non-CLABSI patients ($p=0.019$ (Table 1).

The length of hospitalization was longer for CLABSI patients (33.45 ± 22.8 days) compared to non-CLABSI patients (17.6 ± 17.8 days), though this difference did not reach statistical significance ($p=0.07$). Mortality rates were similar between the two groups, with no significant difference ($p=0.43$) (Table 2).

In multivariate analysis, the Increased CVC utilization ratio (OR = 1.1, 95% CI: 1.01–1.12, $p=0.025$) and a higher number of CVC insertions (OR = 1.9, 95% CI: 1.39–2.6, $p<0.001$) were significantly associated with CLABSI. Conversely, length of hospitalization, undergoing surgery, and the type of CVC (femoral or subclavian) did not show significant associations with CLABSI risk (all $p>0.14$). These findings suggest that both the duration and frequency of CVC use are critical factors in the development of CLABSI (Table 3).

Among CLABSI patients, the most common organism was *Acinetobacter baumannii*, accounting for 21% of cases. This was followed by *Staphylococcus haemolyticus* and Vancomycin-Resistant *Enterococcus* (VRE), each representing 16% of cases. Both *Staphylococcus epidermidis* and *Staphylococcus aureus* were observed in 10.5% of cases. In contrast, Carbapenem-Resistant *Enterobacteriaceae* (CRE), *Enterococcus faecium*, *Pseudomonas aeruginosa*, *Nakaseomyces glabratus* (*Candida glabrata*), and *Staphylococcus hominis* each accounted for 5% of the total cases (Fig. 2).

Discussion

We had a higher incidence of CLABSI than the rate noted in high-income countries, such as China, where the overall rate of CLABSI per 1000 catheter days in the ICU was 1.50 (0.15%) [3]. Rosenthal et al. reported results from 55 ICUs in 8 developing countries, where CLABSIs constituted 30% of all device-associated infections, equating to 12.5 cases (range 7.8–18.5 cases) per 1000 catheter days [7]. The higher CLABSI rates observed in this study warrant further investigation into potential contributing factors, such as nurse-to-patient ratios in the ICU, adherence to barrier precautions, and compliance with the CLABSI prevention bundle. However, specific quality improvement data such as nurse-to-patient ratios, adherence to barrier precautions, and compliance with the CLABSI bundle were not collected in this study, limiting our ability to draw definitive conclusions. Future studies should address these variables to better understand their impact on CLABSI rates.

The mean age of patients was 52 ± 17.6 years, with 57% being male. The mortality rate was 33%. Similarly, Atilla et al.' study involved a total of 166 episodes of CLABSIs from 158 patients and showed that 54% of the patients were male with a mean age of 67, a median

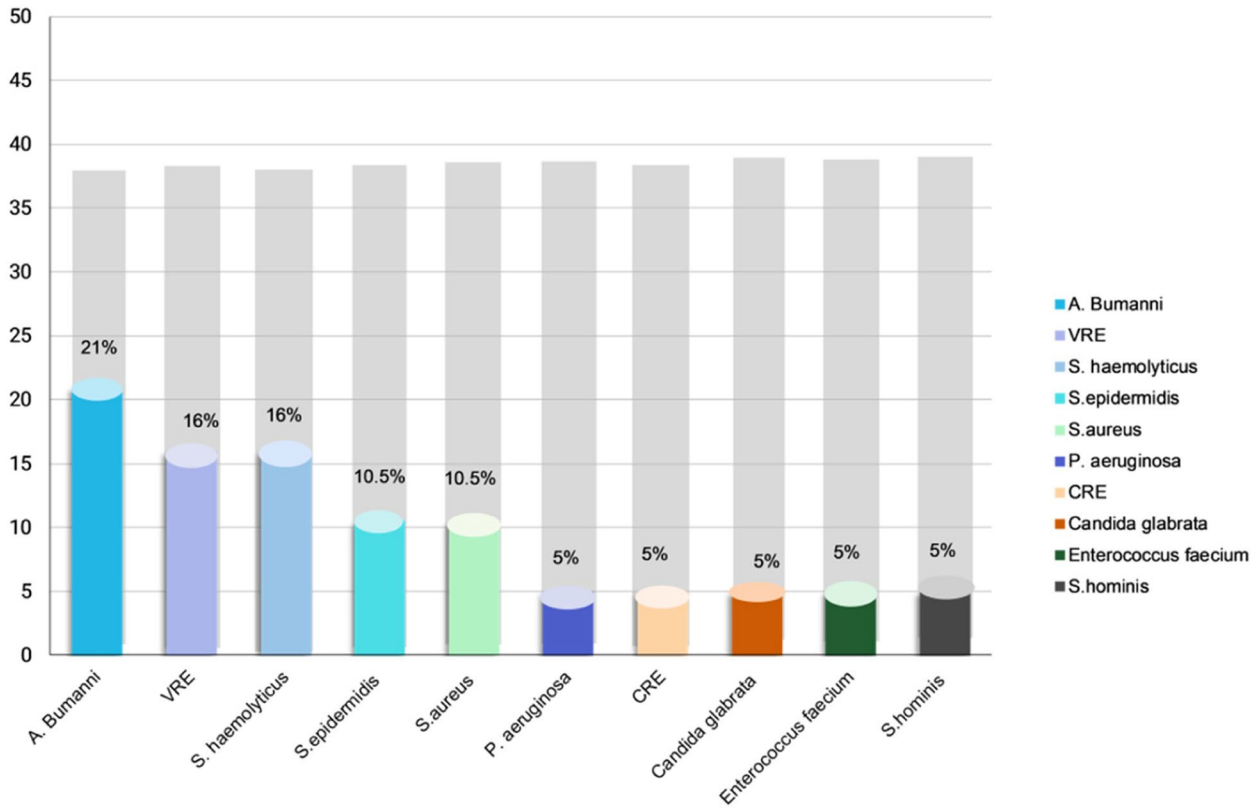

Fig. 2 Commonly isolated organisms among CLABSI patients

hospitalization period of 43 days, a median catheter day for infection of 14 days, and the primary region for catheter insertion was the femoral region in 13.4% of cases. The mortality rate was 45.6% which is higher than our rate [8].

A higher prevalence of CLABSI in the ICU was found with internal jugular insertion (81%), while subclavian catheters were at the least risk for infection (4.8%). In contrast, the CDC has recommended against the use of femoral central venous catheters whenever possible in adult patients because they have found a higher prevalence of CLABSI with femoral catheters and recommended the use of the subclavian site, which has the lowest prevalence of CLABSI with subclavian catheters [9]. In our study the femoral catheters was selected for insertion in patients who were in critical condition, particularly those experiencing respiratory distress and coagulopathy issues, as it allowed for easier and faster vascular access without requiring patients to lie flat, a position often intolerable in cases of respiratory compromise.

Additionally, the majority of our patients were hematology and oncology patients with coagulopathy. For these individuals, the femoral site offered a safer alternative, minimizing the risks of complications such as pneumothorax or difficult-to-manage hematomas associated with central catheters placement in other sites like the internal jugular or subclavian veins, especially due to of lack resources, ultrasound device is not available for most of the times.

In the present study, patients with CLABSI had CVCs inserted for an average number of 9.66 catheter days. This differed from other research which found that patients with CLABSI had CVCs inserted for a range of five to 92 days, with the average number of catheter days being 29 days [1]. This early occurrence of infections may be attributed to several factors, such as limited adherence to preventive measures, including insufficient compliance with maximum barrier precautions and infection prevention protocols, which could promote early colonization. Additionally, increased patient vulnerability due to a higher prevalence of conditions and comorbidities within the cohort may contribute to the early onset of infections.

We found that the most predominant bacterial isolate was Acinetobacter baumannii (21%), similar to Atilla et al. followed by Staphylococcus haemolyticus and vancomycin-resistant Enterococcus (VRE) (16%) [8]. A

possible explanation for these findings is that the majority of our patients were hematological tumour patients.

Regarding COVID-19 disease, results showed that 10% had this infection. It was a significant risk factor for CLABSI, however, due to the very small size these results need to be evaluated in a larger COVID-19 patient study. According to previous literature, there was a significant increase in CLABSI incidence/rates during the pandemic [10].

We also found that 52% had hypertension, 31% had chronic heart disease, and 38.1% of CLABSI episodes occurred in patients with diabetes mellitus, which were not determined to be independent risk factors for CLABSI. Another study showed that comorbid conditions can increase the risk of surgical site infections and the acquisition of antibiotic-resistant bacteria, suggesting that patients with specific comorbidities may have a higher risk of developing CLABSI compared to others [11, 12].

Regarding surgical procedures, we found that 57% had undergone surgery, which was not determined to be an independent risk factor for CLABSI. Our results are similar to other studies that did not find a significant relationship between surgical procedures and CLABSI [5]. Moreover, smoking was not significantly associated with CLABSI, in contrast to other studies that showed that being a smoker and having respiratory system-related disorders were significant predictors of CLABSIs [13].

This study showed that an Increased CVC utilization ratio and a higher number of CVC insertions were significantly associated with CLABSI. Previous studies showed that the number of central venous catheters (CVCs) correlates positively with CLABSI incidence. For example, having multiple concurrent CVCs significantly raises infection rates, as each catheter adds a potential infection site [14]. Additionally, minimizing unnecessary catheter placements is crucial, as the risk of infection increases with the number of lumens in a single catheter [15].

Concerning the duration of hospitalization, we found that the number of days was not determined to be an independent risk factor for CLABSI. Moriyama et al. revealed a significant association between severe illness, prolonged hospital stays, and higher rates of CLABSI [16].

There are several limitations to our study, primarily related to incomplete documentation of the patient's therapy used for CLABSI, patient status in ICU in terms of SOFA score or other mortality-related scores, need for vasopressor, and ventilation. Due to the unavailability of data, this study was unable to compare CLABSI rates across different geographical regions and ICU settings, which could provide further insights into the variability of CLABSI incidence. Secondary lack of specific data on nurse-to-patient ratios, adherence to barrier precautions, and compliance with the CLABSI bundle were not collected in this study, limiting our ability to draw definitive conclusions. Additionally, our study was limited to one tertiary hospital in Palestine (NNUH) which limits the generalizability of the findings to other settings. Due to the small number of CLABSI patients we identified, all the variables measured in the research yielded a p-value greater than 0.05, which was considered insignificant. Therefore, our research focused on the description of these variables rather than their correlation.

Conclusion

The study highlights that prolonged CVC duration and repeated CVC insertions substantially increase the risk of central line-associated bloodstream infections (CLABSIs). Preventive measures should focus on reducing the length of CVC use and minimizing the frequency of catheter insertions.

Abbreviations

CLABSI	Central Line-Associated Bloodstream Infections
CVC	Central Venous Catheters
COVID-19	Corona Virus Disease 19
ICU	Intensive Care Unit
IRB	Institutional Review Board
NNUH	An-Najah National University Hospital
SOFA	The Sequential Organ Failure Assessment score

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Authors' contributions

All authors substantially contributed to the reported work; AE, DA, and WB participated in conceiving the idea and study design, supervised data collection, data analysis, and manuscript writing. SA, MH, NA, KT, and HD performed the material preparation, data collection, and analysis. All authors interpreted the results. RR, SA, and MH wrote the first draft of the manuscript, and all authors commented on previous versions of the manuscript. All authors revised the final version of the manuscript and approved its submission.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on request.

Declarations

Ethics approval and consent to participate

All procedures performed in this study have been carried out following the Declaration of Helsinki and relevant national guidelines and regulations. Ethical approval was obtained from the Institutional Review Board (IRB) at An-Najah National University. IRB number: med.July 2023/17. Assuring confidentiality of data, that was used for the purpose of this study only. Privacy, beneficence, and efforts to minimize bias, were closely monitored throughout the research.

Considering that retrospective data in medical records were used, the IRB of An-Najah National University waived the need for informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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