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Original Research Article

Central venous catheter related blood stream infection in tertiary care hospital

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ABSTRACT

Background: Central venous catheter-related bloodstream infections (CRBSIs) are associated with significant morbidity and mortality in hospitalized patients. Understanding the incidence and risk factors associated with CRBSIs is crucial for implementing effective preventive strategies. The study aimed to examine the incidence and risk factors associated with central venous CRBSIs in a tertiary care hospital setting.
Methods: A prospective observational study was conducted at a tertiary care hospital to investigate the incidence and risk factors of CRBSIs. Patients aged >18 years with a central venous catheter inserted for >48 hours were included. Clinical and microbiological data were collected, and CRBSI rates were calculated. Statistical analysis was performed using SPSS V 23.0.
Results: A total of 50 patients were recruited, with 11 diagnosed with CRBSIs. The incidence of CRBSIs was 8.1 per 1000 central line days and 5.7 per 1000 inpatient days, with a Device Utilization Ratio (DUR) of 0.7. Male gender and older age (>40 years) were significantly associated with CRBSIs ($p<0.05$). Gram-negative microorganisms were the most commonly isolated pathogens (63.63%), followed by Gram-positive organisms (27.27%) and Candida species (9.09%). Immune system status ($p=0.0372$) and duration of catheterization ($P=0.0035$) were found to have a significant association with CRBSI. Mortality was higher in patients with CRBSIs compared to those without (45.45% vs. 28.21%).
Conclusions: CRBSIs remain a significant concern in tertiary care hospitals, with Gram-negative organisms being the predominant pathogens. Male gender and older age were identified as risk factors for CRBSIs. Effective infection control measures targeting high-risk populations are warranted to reduce the incidence of CRBSIs and improve patient outcomes.

Keywords: Bacteremia, Central venous catheters, Catheter-related infections

INTRODUCTION

"Central venous catheters (CVCs)" play a vital role in treating critically ill individuals and others requiring extended medical care. They are used to administer medications, provide parenteral nutrition, draw blood samples, and monitor hemodynamics by accessing the vascular system. However, central venous catheterization is commonly associated with both infectious and non-infectious complications.[1] The usage of CVCs is recognized as a significant feature contributing to the growth of "catheter-related bloodstream infections (CRBSIs) and catheter-related local infections (CRLIs)", which have increasingly become the foremost causes of morbidity and death.[2] CRBSIs are a frequent iatrogenic complication, with a predictable occurrence rate ranging from 0.5 to 5 per 1000 catheter days.[3] The occurrence of CRBSIs varies significantly based on the type of catheter

used, how often the catheter is manipulated, and patient-related factors such as underlying medical conditions and severity of illness.[4,5]

Catheter-related infections encompass two main types: CRLIs, characterized by catheter tip colonization and local signs of infection such as redness, warmth, pain, or pus drainage; and "CRBSIs, defined as positive blood cultures from a peripheral vein along with systemic signs of infection (fever, chills), where no other source of bacteremia is identified except for the same organism isolated from the catheter tip colonization".[6]

Bloodstream infections can be instigated by both Gram-positive and Gram-negative organisms. When these bacteria proliferate and release toxins into the bloodstream, it triggers the production of cytokines, resulting in symptoms such as fever, chills, toxicity, and shock. Multiple factors increase the risk of developing CRBSIs, such as how long the catheter is in place, the type of catheter used, where it's inserted, the number of lumens, the patient's setting, the design of needleless connectors, and following correct care protocols.[2]

The predominant pathogens implicated in CRBSIs include "*Staphylococcus aureu*s, coagulase-negative *Staphylococcus*, *Enterococcus* species, *Candida* species, *Acinetobacter* species, *Pseudomonas* species, and *Klebsiella* species".[7] A CVC is considered colonized if a quantitative catheter culture shows more than 1000 colony-forming units (CFU) per milliliter. A semi-quantitative culture is deemed significant if it shows growth exceeding 15 CFU.[8] Intraluminal colonization poses a notable risk in CRBSI pathogenesis, particularly with prolonged catheter dwell times, prompting the development of CRBSI maintenance bundles. This underscores the importance of early removal of CVCs to mitigate infection risks.[9] Understanding these infections helps identify specific factors contributing to their occurrence, allowing targeted interventions to prevent BSIs and reduce allied morbidity, death, and health care expenses. There is a lack of data regarding the frequency and risk features of CRBSI. Hence, the present study was undertaken to examine the incidence and risk factors associated with central venous CRBSIs in a tertiary care hospital setting.

METHODS

The prospective observational study was carried out at department of medicine RCSM GMC and CPR Hospital, Kolhapur post obtaining institutional ethical committee approval. A total of n=50 subjects who fulfilled inclusion criteria were recruited in the study. Patients aged >18 years with a CVC inserted for >48 hours were involved in the study. Whereas, subjects presenting with positive blood culture results or clinical indicators of infection, such as fever, either upon admission or within 48 hours of admission to the investigation unit. Additionally, subjects admitted with a pre-existing CVC from another healthcare institution and cases where a solitary symbiotic organism was recognized in a lone blood sample (considered a toxin) were omitted from the study. Written informed consent was taken from all the participants.

Patient information including name, medical record number, hospital, and ICU admission date; demographic details such as gender, age, medical history, and underlying conditions; admission diagnosis; and the placement and removal dates of CVCs, along with the indication for the procedure, were documented.

We collected peripheral blood samples from all patients at the time of CVC insertion to ensure there was no existing bacteremia. Daily surveillance for signs and symptoms indicative of infection was conducted, with particular attention to clinical manifestations suggesting sepsis. Upon suspicion of sepsis, comprehensive laboratory investigations were initiated to ascertain the potential source of infection. Infection onset was deemed probable if a minimum of two of the subsequent criteria were met concurrently with suspected "sepsis: fever (>38°C), tachycardia (>90 beats per minute), tachypnea (>24 breaths per minute), leukocytosis (>12,000/mm^3), or leukopenia (<4,000/mm^3)". Blood samples were collected from peripheral venipuncture or the central line lumen, adhering to typical laboratory protocols, and forwarded to the Microbiology department for culture and sensitivity testing. To eliminate other possible sources of infection, patients underwent thorough physical examinations and additional investigations, such as urine cultures, sputum cultures, tracheal aspirates, and imaging studies, based on their clinical presentation. If no alternative infection source was identified, sepsis was strongly considered the cause.

The area surrounding the insertion site of the CVCs was meticulously disinfected using chlorhexidine, and the CVCs were removed in sterile conditions. A 5-cm distal segment (tip) from all catheters was collected in a sterile container. Subsequently, all catheter tips were transferred to the microbiology laboratory for semi-quantitative culture, following the method outlined by Maki et al.[10] In this process, the catheter tip was rotated at least four times on a blood agar medium and then incubated at 37°C for 18 to 24 hours. Microbial growth was subsequently identified using conventional methods, including Gram staining, assessment of colony morphology, and various biochemical tests, following the standard laboratory protocol.[11] Antimicrobial susceptibility testing was conducted using the "Kirby-Bauer Disc diffusion method on Muller Hinton agar (MHA), following the Clinical and Laboratory Standard Institute (CLSI) guidelines of 2019".[12]

CRBSI was defined as a laboratory-confirmed bloodstream infection resulting from a known pathogen isolated from one or more blood cultures taken at least 48 hours after vascular catheterization, and this pathogen

was not related to an infection at another site. Moreover, the presence of typical skin commensals like "diphtheroids, *Bacillus* species, *Propionibacterium* species, coagulase-negative staphylococci, or micrococci" in the presence of two or more blood cultures collected on different occasions, combined with at least one of the following signs or symptoms such as fever (>38°C) or hypotension was also regarded as suggestive of CRBSI.[13]

The CRBSI rate was established using the formula: "the total number of reported CRBSIs divided by the number of central line days, multiplied by 1000. The Device Utilization Ratio (DUR) was calculated using the formula: the number of device days divided by the number of patient days".

Statistical analysis

The data was assessed using SPSS V 23.0 (IB< Corp., Armonk, NY, USA). Continuous variables were described using mean and standard deviation, while categorical variables were presented as percentages and frequencies. The association between variables was assessed using the chi-square test, with statistical significance defined as $p<0.05$.

RESULTS

The mean age of the patients was 52.2±18.2 years. A total of 11 individuals were diagnosed with CRBSI. This occurred over 1349 catheter days and 1920 inpatient days. Consequently, the incidence of CRBSI was calculated at 8.1 per 1000 central line days and 5.7 per 1000 inpatient days, with a DUR of 0.7.

CRBSI was predominantly seen in males (72.72%, n=8) and older patients (63.64%, n=9). Sex and age were observed to be significantly related to CRBSI (P<0.05) (Table 1).

Table 1: Association between CRBSI and demographical variables.

Variables	Subcategories	Percentage (n=11)	P value
Sex	Male	72.72 (8)	0.0373
	Female	27.28 (3)	
Age (years)	18-40	18.18 (2)	0.0341
	>40	63.64 (9)	

Gram-negative microorganisms (63.63%, n=7) were most commonly present in the culture followed by Gram-positive organisms (27.27%, n=3), and candida species (9.09%, n=1). The distribution of subjects according to isolated organisms is shown in Table 2. All Gram-negative organisms were highly sensitive to polymyxin B followed by tigecycline and minocycline. Whereas, *Staphylococcus aureus* was found to be highly sensitive to vancomycin, teicoplanin, and linezolid.

Table 2: Distribution of subjects according to isolated organisms.

Organisms	Frequency (N)	Percentage (%)
S. aureus	4	36.37
***Acinetobacter* species**	2	18.18
K. pneumoniae	2	18.18
E. aerogenes	2	18.18
***Candida* species**	1	9.09

Immune system status (p=0.0372) and duration of catheterization (p=0.0035) were found to have a significant association with CRBSI. The catheter was inserted in the internal jugular vein in 63.64% of patients and in the subclavian vein in 36.36% of patients; however, this difference was not statistically significant (p=0.2113) (Table 3).

Table 3: Distribution of subjects according to risk factors.

Risk factors	Subcategory	Percentage (%)	P value
Immune system	Compromised	72.73	0.0372
	Competent	27.27	
Duration of catheterization	≤8 days	81.82	0.0035
	>8 days	18.18	
Site of insertion	Internal jugular	63.64	0.2113
	Subclavian	36.36	

The mortality of patients with CRBSI was 45.45% (n=5) whereas the mortality rate in patients without BSI was 28.21% (n=11).

DISCUSSION

CVCs are commonly used in managing severely ill patients in specialized hospitals. However, they pose a risk of bloodstream infections (BSIs), leading to improved morbidity, death, and healthcare costs. The current study aimed to investigate the occurrence and risk factors associated with CVC-related BSIs in a tertiary care hospital setting.

In this study, a total of n=50 adult patients with CVC for >48 hrs were incorporated. Among these participants,

n=11 established nosocomial bacteremia. The findings of our study revealed an incidence rate of CRBSIs at 8.1 per 1000 central line days and 5.7 per 1000 inpatient days, with a DUR of 0.7. Similarly, in the Maqbool et al study, the rate of CRBSI was 9.3 per 1000 central line days and 6.7 per 1000 inpatient days with a device utilization ratio of 0.7.[14] Meanwhile, Masih et al demonstrated an incidence of 13.35 per 1000 central line days.[15] However, these figures are notably higher in developed nations; for example, the reported incidence in the USA is as low as 1.05.[16] These statistics emphasize the critical need for ongoing surveillance and interventions to reduce the risk of CRBSIs among hospitalized patients.

The demographic analysis showed that CRBSIs were predominantly observed in male patients (72.72%) and older individuals (>40 years) (63.64%), with statistically significant associations noted between sex and age with CRBSI occurrence. These findings are similar to the study of Maqbool et al, Endimiani et al, and Dasgupta et al.[14,17,18] The elevated prevalence of CRBSI in the elderly age group could be attributed to compromised host defense mechanisms, immunosuppression, and increased severity of illness. These elements collectively render aged subjects more liable to CRBSI. This emphasizes the need for targeted preventive strategies, especially among high-risk patient groups.

In this study, microbiological analysis revealed Gram-negative organisms as the most frequently identified pathogens in CRBSIs (63.63%), followed by "Gram-positive organisms (27.27%) and candida species (9.09%)". The high prevalence of Gram-negative organisms highlights the importance of infection control measures targeting these pathogens, such as strict adherence to catheter insertion and maintenance protocols and antimicrobial stewardship programs. Moreover, in this study, *S. aureus* (36.37%) was the most common organisms responsible for CRBSI. These outcomes are equivalent to earlier reports.[14,19,20]

The antimicrobial susceptibility testing showed varying susceptibility patterns among the isolated organisms. Notably, gram-negative organisms exhibited high sensitivity to polymyxin B, tigecycline, and minocycline, whereas *Staphylococcus aureus* demonstrated high sensitivity to vancomycin, teicoplanin, and linezolid. These findings emphasize the importance of selecting appropriate empiric antimicrobial therapy based on local susceptibility patterns to optimize patient outcomes.

A statistically significant increase in CRBSI was observed in immunocompromised patients ($p<0.0001$). Various studies have highlighted that immunocompromised conditions, including malignancy, AIDS, immunodeficiency, severe burns, and malnutrition, lead to a higher infection rate.[21-23] This is attributed to the reduced functional capacity of both humoral and cell-mediated immunity in these individuals.

Another risk factor evaluated was the site of CVC insertion, comparing jugular to subclavian locations, which in the present study was not statistically significant. There is controversy regarding this, some studies report a higher rate of CRBSI with internal jugular insertions compared to subclavian, while others find no significant difference between the two sites.[23-27] In this study, the majority of patients with CRBSI had catheter insertions lasting more than 8 days. This trend is consistent with other studies, which suggest that catheter stays exceeding 10 days are associated with intraluminal contamination and a definite risk for CRBSI.[22]

The mortality rate among subjects with CRBSIs was notably greater (45.45%) than those without bloodstream infections (28.21%), underscoring the significant impact of CRBSIs on patient outcomes. These results were analogous to the study of Maqbool et al and Mishra et al.[14,28] This highlights the urgent need for effective preventive strategies, including catheter bundle protocols, antimicrobial stewardship, and staff education, to reduce the burden of CRBSIs and improve patient safety.

Our study contributes valuable insights into the prospective incidence of CRBSIs among critically ill adult patients. Additionally, we provide comprehensive data regarding the microbial etiology and antimicrobial sensitivity profiles associated with CRBSIs.

Some limitations of this study should be accredited. The study included only 50 subjects, which may limit the generalizability of the findings. A larger sample size could provide more robust data and potentially reveal more nuanced associations between risk factors and CRBSI. The study was carried out at a single tertiary care hospital, which could restrict the applicability of the outcomes to other sceneries. There may be unaccounted confounding variables such as the presence of comorbidities, variations in catheter care practices, and differences in patient management that could influence the incidence of CRBSI. Also there are many other risk factors associated with development of CRBSI, but we studied only three. Thus, more studies would contribute towards better understanding of the topic.

CONCLUSION

This study at a tertiary care hospital found an incidence of central venous catheter-related bloodstream infections (CRBSIs) of 8.1 per 1000 central line days and 5.7 per 1000 inpatient days, with significant risk factors being compromised immune status and prolonged catheterization. CRBSIs were more prevalent in males and older patients, predominantly caused by gram-negative microorganisms, which were highly sensitive to polymyxin B, tigecycline, and minocycline. Although insertion sites (internal jugular vs. subclavian) did not show a significant difference in CRBSI rates, the mortality rate for CRBSI patients was substantially higher. These findings highlight the need for careful

monitoring and management to reduce CRBSI risk. Future research should focus on larger multicenter studies to further elucidate the complex factors contributing to CRBSI occurrence and assess the effectiveness of targeted preventive measures.

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REFERENCES

1. Deb M, Mittal G, Gaind R, Verma PK. Central venous catheter related blood stream infections in an intensive care unit from a tertiary care teaching hospital. Int J Infect Control. 2016;12(1).
2. Negi N, Gupta S, Chandola I, Kataria V. Prevalence of central line associated blood stream infection (CRBSI) and catheter colonization in ICU settings of a tertiary care hospital in sub-Himalayan region. Trop J Pathol Microbiol. 2019;5(10):815-821.
3. Bell EC, Chapon V, Bessede E, Meriglier E, Issa N, Domblides C, et al. Central venous catheter-related bloodstream infections: Epidemiology and risk factors for hematogenous complications. Infect Dis Now. 2024;54(3):104859.
4. 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.
5. Sousa B, Furlanetto J, Hutka M, Gouveia P, Wuerstlein R, Mariz JM, et al. Central venous access in oncology: ESMO Clinical Practice Guidelines. Ann Oncol. 2015;26:v152-68.
6. Lorente L, Henry C, Martín MM, Jiménez A, Mora ML. Central venous catheter-related infection in a prospective and observational study of 2,595 catheters. Critical care. 2005;9:1-5.
7. Buetti N, Priore EL, Atkinson A, Widmer AF, Kronenberg A, Marschall J. Catheter-related infections: does the spectrum of microbial causes change over time? A nationwide surveillance study. BMJ open. 2018;8(12):e023824.
8. Bhavana C, Nagarathnamma T, Ambica R. Study of centralline associated blood stream infections (CLABSIs) and central-line related blood stream infections (CRBSIs) in a tertiary hospital, Bangalore, India. Int J Curr Microbiol Appl Sci. 2018;7(05):697-707.
9. Mathur P. Prevention of healthcare-associated infections in low-and middle-income countries: The 'bundle approach'. Ind J Medi Microbiol. 2018;36(2):155-62.
10. Maki DG, Weise CE, Sarafin HW. A semi-quantitative culture method for identifying intravenous-catheter related infection. New Engl J Medi. 1977;296(23):1305-9.
11. Procop GW, Church DL, Hall GS, Janda WM. Koneman's color atlas and textbook of diagnostic microbiology. Jones & Bartlett Learning; 2020.
12. Clinical and Laboratory Standards Institute (CLSI): Performance Standards for Antimicrobial Susceptibility Testing, 29th ed. Clinical and Laboratory Standards Institute, Wayne, PA; 2019.
13. Bloodstream Infection Event (Central Line-Associated Bloodstream Infection and Non-central Line Associated Bloodstream Infection), 2024. Available at: https://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf?utm_medium=email&utm_source=transaction. Accessed 29 April 2024.
14. Maqbool S, Sharma R, MAQBOOL S. Incidence of central line-associated bloodstream infection in a tertiary care hospital in Northern India: a prospective study. Cureus. 2023;15(8): e44501.
15. Masih SM, Goel S, Singh A, Khichi SK, Vasundhara, Tank R. Epidemiology and risk factors of healthcare associated infections from intensive care unit of a tertiary care hospital. Int J Res Med Sci. 2016;4(5):1706-10.
16. Centers for Disease Control and Prevention Vital signs: central line-associated blood stream infections United States, 2001, 2008, and 2009. Ann Emerg Med. 2011;58(5):447-50.
17. Endimiani A, Tamborini A, Luzzaro F, Lombardi G, Toniolo A. A two-year analysis of risk factors and outcome in patients with bloodstream infection. Jpn J Infect Dis. 2003;56(1):1-7.
18. Dasgupta S, Das S, Chawan NS, Hazra A. Nosocomial infections in the intensive care unit: Incidence, risk factors, outcome and associated pathogens in a public tertiary teaching hospital of Eastern India. Indian J Crit Care Med. 2015;19(1):14-20.
19. Mathur P, Varghese P, Tak V, Gunjiyal J, Lalwani S, Kumar S, et al. Epidemiology of blood stream infections at a level-1 trauma care center of India. J Lab Physicians. 2014;6(1):22-27.
20. Khurana S, Bhardwaj N, Kumari M, Malhotra R, Mathur P. Prevalence, etiology, and antibiotic resistance profiles of bacterial bloodstream infections in a tertiary care hospital in Northern India: a 4-year study. J Lab Physicians. 2018;10(4):426-31.
21. Goldmann DA, Pier GB. Pathogenesis of infection related to intravascular catheterization. Clin Microbiol Rev. 1993;6(2):176-192.
22. Wassil SK, Crill CM, Phelps SJ. Antimicrobial impregnated catheters in the prevention of catheter-related bloodstream infection in hospitalized patients. J Pediatr Pharmacol Ther. 2007;12(2):77-90.
23. Pandit P, Sahni AK, Grover N, Dudhat V, Das NK, Biswas AK. Catheter-related blood stream infections: prevalence, risk factors and antimicrobial resistance pattern. Medi J Arm Forc India. 2021;77(1):38-45.

24. Johnston BL, Conly JM. What do central venous catheter-associated bloodstream infections have to do with bundles? Can J Infect Dis Med Microbiol. 2005;16(4):215-218.
25. Maki DG, Kluger DM, Crnich CJ. The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. Mayo Clin Proc. 2006;81(9):1159-71.
26. Kumar A, Sharma R.M, Jaideep CN, Hazra N. Diagnosis of Central venous catheter-related bloodstream infection without catheter removal: a prospective observational study. Med J Armed Forces India. 2014;70(1):17-212.
27. Patil HV, Patil VC, Ramteerthkar MN, Kulkarni RD. Central venous catheter related bloodstream infections in the intensive care unit. Indian J Crit Care Med. 2011;15(4):213-23.
28. Mishra SB, Misra R, Azim A, Baronia AK, Prasad KN, Dhole TN, et al. Incidence, risk factors and associated mortality of central line-associated bloodstream infections at an intensive care unit in northern India. Int J Qual Heal Care. 2017;29(1):63-7.

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