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Original Research Article

Etiological Spectrum and Antimicrobial Susceptibility Patterns of Catheter-Related Bloodstream Infections

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Abstract:

Introduction: Vascular access devices are most indispensable in the recent healthcare system, but are associated with catheter-related bloodstream infections (CRBSI), which is a severe nosocomial condition. CRBSI contributed to high morbidity, mortality, stay in hospital and resistance against anti-microbes. This marked the early diagnosis and the awareness of the effective antimicrobial susceptibility patterns.

Method: This was a retrospective observational study conducted in a tertiary care hospital among 80 included patients, who were diagnosed under the CRBSI per IDSA guidelines. The Differential time to positivity was calculated for diagnosis, and the MALDI-TOF was used for the identification of organisms. The Vitek 2 system was utilised to perform the antimicrobial susceptibility test.

Result: The study showed that medical alliance was predominant for CRBSI, accounted for 73.75%, 59/80. The Non-fermenting Gram-negative bacilli were observed to be Burkholderia cepacia complex (26.6%) and 23.3% for Stenotrophomonas maltophilia. Less than 30% susceptibility was observed for the third-generation cephalosporin in Enterobacterales. >85% of activity was observed by Tigecycline and colistin. Complete susceptibility was observed for vancomycin and linezolid by the gram-positive isolates.

Conclusion: The study concluded the burden of CRBSI from medical ward with a transition towards multidrug-resistance for non-fermenting Gram-negative bacilli and evidential resistance against cephalosporins, carbapenems, quinolones, and β-lactams.

Keywords: Catheter-related bloodstream infection, Non-fermenting Gram-negative bacilli, antimicrobial resistance, Central venous catheter, antimicrobial susceptibility pattern.

Introduction

Vascular access is very important in modern medical care, as it must be dependable and safe. Intravascular devices have transformed critical care through easy access. Such devices are, however, also linked to a great risk of generating iatrogenic illness that causes catheter-based bacteraemia or candidemia [1].

Catheter-related bloodstream infection (CRBSI) is a nosocomial infection, and it is a serious clinical issue that is constantly changing due to the variation of population at risk, the variation in the range of available pathogens, and the extensive application of broad-spectrum antibiotics. The Centers for Disease Control and Prevention (CDC), based on the National Nosocomial Infections Surveillance (NNIS) system claim the median of CRBSI in all intensive care units (ICUs) to be between 1.8 and 5.2 per 1000 catheter-days, with the rate of 25.6. These rates are, however, highly variable and can be anticipated to be significantly high in the case of the developing countries. Indian literature on CRBSI is sparse, and has reported incidences of the infection to be approximately 27%.3 The risk of septicaemia per new episode of CRBSI is 414 by 1225 on top of the length of stay and the exponential healthcare expenses [2, 3].

In addition to CRBSI, central venous catheters (CVCs) expose a patient to the risk of acquiring a number of local and systemic complications, including infection at the site of insertion, septic thrombophlebitis, endocarditis, metastatic infections, and other severe complications, including bacteraemia, sepsis, and death. Therefore, it becomes crucially important that a combination of clinical manifestations and quantitative culture methods3 and their antibiotic susceptibility (ABST) pattern, which represents a very important tool in helping the physician to initiate the right treatment, should be identified at the earliest and timely stage [4, 5].

The catheter-related bloodstream infections (CRBSI) caused by bacterial colonisation of an intravascular catheter are a serious clinical issue which is enhanced in recent years by the growing use of intravascular catheters in intensive care units

(ICUs). Specifically, bacteraemia and sepsis are frequently caused by the presence of central venous catheter related infections. Bloodstream infection may be caused by central venous catheters through three pathways i.e. intraluminal, extraluminal and haematogenous. The catheter-related infection symptoms and signs can be localised either at the location of insertion or the tunnel path of a tunnelled device. Instead, they may be systemic with potential complications by bacteraemia. The fear of central venous catheter-related bloodstream infection commonly causes avoidable catheter removal and reinsertion of a new central venous catheter in a new site which is likely to cause other comorbidities which are detrimental to the patient, as well as wastes time and effort by the intensivist [3].Diagnosis of the bloodstream infection caused by the central venous catheter would involve the detection of the identical microorganism in pure culture (single isolate) retrieved in blood and catheter tips. Moreover, not every central venous catheter associated bloodstream infection demands the removal of the catheter, which is why there is a need to diagnose central venous catheter-related bloodstream infection without the removal of the catheter. CRBSI should be diagnosed with clinical and microbiological criteria. Empirical therapy is highly important in the initiation of CRBSI because it is life-threatening and because, in most cases, broad-spectrum antibiotics that target the Gram-positive and the Gram-negative organisms are used [6, 7].

Method

Research Design: This was a retrospective observational study to evaluate the antimicrobial susceptibility pattern of the catheter-related bloodstream infection (CRBSI). The study was conducted in a tertiary care hospital for the duration of 1 year. Patients were selected on the basis of the criteria for CRBSI according to the Infectious Diseases Society of America (IDSA) guidelines. Duplicate isolates of the same patient were not included in the study. Certain inclusion and exclusion criteria were considered for the study. Total 80 patients were selected for the study. Ethical approval was obtained from the Institutional Ethics Committee for the study. Well-written and verbal consent were taken for the study.

Inclusion Criteria

- Patients admitted with the diagnostic criteria for the catheter-related bloodstream infection (CRBSI) under the IDSA guidelines were selected for the study.
- Patients of age more than 18 years of age were included for the study.
- Well informed consent required for the study.

Exclusion Criteria

- Patients those who did not meet the criteria for CRBSI, were excluded.
- Incomplete microbiological findings or inconsistent clinical data were not considered for the study.

Procedure: Diagnosed patients were regulated and observed for the clincila symptom and signs for the CRBSI surveillance. Two sets of blood samples were collected, the first blood sample bottle consists the aerobic, and the second bottle included the anaerobic blood sample. One set of blood was obtained from the central line, while the other set was collected from the peripheral venipuncture, and the interval should not be more than 15 minutes between the two collections. The blood culture bottles were transferred to the microbiology lab, and the blood samples were loaded into the blood culture system automatically. The Time to positivity (TTP) was measured and recorded for both the central line and the peripheral venipuncture samples. The Differential time to positivity (DTP) was estimated by comparative analysis of the TTP of the aerobic and anaerobic bottles. The diagnostic criteria for CRBSI according to the IDSA guidelines were that DTP should be ≥120 minutes. Vitek MS MALDI-TOF MS (bioMérieux, France) was utilised to isolate the organisms contained in the positive blood culture system. The Vitek 2 automated AST system (bioMérieux, France) was employed for antimicrobial susceptibility test.

Statistical Analysis: Data regarding the CRBSI were extracted from the hospital infection and laboratory system, for information related to blood culture, time to positivity, isolated microorganisms, and antimicrobial susceptibility testing (AST). Duplicate entries were detected and were not considered for the study. For each of the isolated organisms, the susceptibility percentage (S %) was calculated, which was measured by dividing the susceptible isolates by the total number of the tested isolates for a certain antimicrobial agent and was presented as a percentage. Descriptive statistics were used for summarisation of the results. Data analysis was done by SPSS version 27.

Result

The case of CRBSI demonstrated that medicine alliance was predominant, accounting for 59/80; 73.75, which was followed by the surgery alliance, which contributed to 13 cases, 16.25%. Contrastingly, the paediatric and oncology alliances showed less burden, with 4 cases. This high prevalence in the medicine alliance showed high utilisation of the central line, prolonged duration of catheter dwell, while the low rate in the paediatric and oncology services indicated short-term duration for the catheter. The distribution highlighted the medical ward as the key contributor to the CRBSI burden, revealing the significance of more targeted control of infection.

Table 1: The distribution of CRBSI cases according to the specialty alliance

Specialty Alliance	Number of CRBSI cases (n)	Percentage (%)
Medicine alliance	59	73.75%
Surgery alliance	13	16.25%
Paediatric alliance	4	5.00%
Oncology alliance	4	5.00%
Total	**80**	**100%**

Table 2 showed that the organisms isolated from the CRBSI cases were 80, and the non-fermenters isolated were 30. The non-fermenters showed that Burkholderia cepacia complex 10.0% and Stenotrophomonas maltophilia (8.8%) were the most frequent non-fermenters, which revealed the transition to the opportunistic and resistant organisms among the catheter-related infections. Gram-positive cocci like the coagulase-negative staphylococci (15.0%) and Staphylococcus aureus (11.3%) showed their function as the common commensal for skin infection associated with the intravascular infections. Less frequent isolates were observed for Enterobacterales and other Gram-negative bacilli, while the most common isolate was the Klebsiella pneumoniae (10.0%). Candida species 5.0% caused fungal infection. Thus, the overall distribution of isolates showed the importance of the non-fermenting Gram-negative bacilli in CRBSI and showed the need for more catheter care for antimicrobial properties.

Table 2: Distribution of organism wise isolate for CRBSI as well as non-fermenters

Organism group / Species	Number (n)	Percentage (%)
Gram-negative non-fermenters (total) 30		
Burkholderia cepacia complex	8	26.66
Stenotrophomonas maltophilia	7	23.33
Pseudomonas species	4	13.33
Acinetobacter species	3	10
Elizabethkingia anophelis	3	10
Other Burkholderia species	2	6.66
Ralstonia species	2	6.66
Achromobacter denitrificans	1	3.33
Gram-positive cocci Total n=80		
Coagulase-negative Staphylococci (CONS)	12	15
Staphylococcus aureus	9	11.3
Enterococcus species	5	6.3
Enterobacterales		
─ Klebsiella pneumoniae	8	10
Acinetobacter baumannii complex	6	7.5
Escherichia coli	3	3.8
Fungal isolates		
Candida species	4	5
Others		
Bacillus species	2	2.5
Corynebacterium species	1	1.3
Total	80	100

Table 3 demonstrated the susceptibility test findings for the gram-negative isolates, showing that the third-generation cephalosporins showed less activity, with less than 30% of susceptibility, specifically for E. coli and K. pneumoniae. The combination of the β-lactam/β-lactamase inhibitor demonstrated moderate efficacy against the isolate for E. coli and P. aeruginosa. Variability was obtained for Carbapenem susceptibility and reduction in the K. pneumoniae and A. baumannii, which indicated the resistance. Organism-specific activity was obtained for Aminoglycosides, while the susceptibility for quinolones was low for Enterobacterales. The antimicrobial agents for tigecycline and colistin showed the highest activity for multidrug-resistant isolates, along with colistin, which consistently showed the susceptibility rates of more than 85%.

Table 3: The susceptibility test outcome for gram negative isolates

Antimicrobial Class	Antimicrobial Agent	Escherichia coli	Klebsiella pneumoniae	Acinetobacter baumannii	Pseudomonas aeruginosa
Cephalosporins	Ceftriaxone	(8.3%)	(5.3%)	(24.3%)	(75.6%)
	Ceftazidime	(16.7%)	(11.8%)	(29.7%)	(73.3%)
β-lactam combination agents	Piperacillin–Tazobactam	(62.5%)	(60.5%)	(36.5%)	(74.4%)
	Cefoperazone–Sulbactam	(66.7%)	(36.8%)	(31.1%)	(53.3%)
Monobactam	Aztreonam	(70.8%)	(38.2%)	(28.4%)	(80.0%)
Carbapenems	Meropenem	(75.0%)	(34.2%)	(33.8%)	(73.3%)
	Imipenem	(54.2%)	(32.9%)	(31.1%)	(50.0%)
Aminoglycosides	Gentamicin	(83.3%)	(39.5%)	(24.3%)	(77.8%)
	Amikacin	(12.5%)	(17.1%)	(25.7%)	(66.7%)
Quinolones	Ciprofloxacin	(4.2%)	(5.3%)	(40.5%)	(57.8%)
Folate antagonists	Cotrimoxazole	(29.2%)	(22.4%)	(55.4%)	—
Tetracyclines	Minocycline	(60.0%)	(55.3%)	(70.3%)	—
Glycylcyclines	Tigecycline	(95.8%)	(68.4%)	—	—
Polymyxins	Colistin	(95.8%)	(85.5%)	(91.9%)	(86.7%)

Table 4 demonstrated the susceptibility profile for the gram-positive isolate, which showed high susceptibility for oxacillin/cefoxitin, calculated to be 81.0% (68/84), while gentamicin showed 33.3% (28/84). The activity of Fluoroquinolones was effective, but the susceptibility for ciprofloxacin and levofloxacin showed 94.1% (80/85). All isolates for S. aureus showed consistent susceptibility for glycopeptides, oxazolidinones, tigecycline, daptomycin, and rifampicin. CoNS showed the lowest susceptibility against the β-lactams and fluoroquinolones, and the oxacillin/cefoxitin showed 12.5% (15/120), and ciprofloxacin showed 44.2% (38/86). Low susceptibility activity for the β-lactam was observed for Enterococcus faecium, while the resistance activity for ampicillin was (0/15). The highest susceptibility was observed for Enterococcus faecalis, against vancomycin and linezolid 100% (21/21), highlighting limited resistance.

Table 4: The susceptibility test outcome for gram positive isolates

Antimicrobial Class	Antimicrobial Agent	Staphylococcus aureus	CoNS	Enterococcus faecium	Enterococcus faecalis
Anti-Staph Penicillins	Oxacillin / Cefoxitin	(81.0%)	(12.5%)	(6.7%)	(66.7%)
Penicillins	Ampicillin	(72.3%)	(31.4%)	(0.0%)	(66.7%)
Macrolides	Erythromycin	(68.2%)	(34.7%)	(26.7%)	(57.1%)
Lincosamides	Clindamycin	(69.6%)	(50.0%)	(26.7%)	(57.1%)
Aminoglycosides	Gentamicin	(33.3%)	(32.9%)	(33.3%)	(57.1%)
	High-level Gentamicin	(47.7%)	(34.1%)	(26.7%)	(57.1%)
Quinolones	Ciprofloxacin	(94.1%)	(44.2%)	(100.0%)	(100.0%)
	Levofloxacin	(94.1%)	(61.0%)	(80.0%)	(95.2%)
Folate antagonists	Cotrimoxazole	(100.0%)	(97.1%)	(80.0%)	(95.2%)
Tetracyclines	Tetracycline	(100.0%)	(100.0%)	(80.0%)	(100.0%)
Glycylcyclines	Tigecycline	(100.0%)	(100.0%)	(80.0%)	(100.0%)
Glycopeptides	Vancomycin	(100.0%)	(100.0%)	(100.0%)	(100.0%)
	Teicoplanin	(100.0%)	(100.0%)	(80.0%)	(95.2%)
Oxazolidinones	Linezolid	(100.0%)	(100.0%)	(80.0%)	(100.0%)
Phenicols	Chloramphenicol	(100.0%)	(100.0%)	(80.0%)	(47.6%)
Lipopeptides	Daptomycin	(100.0%)	(100.0%)	(80.0%)	—
Rifamycins	Rifampicin	(100.0%)	(100.0%)	—	—

Discussion

A study was done to identify bacterial profile, a pattern of antimicrobial susceptibility, and related variables of the bloodstream infection (BSI) suspected patients. The general findings indicated that despite the relatively lower prevalence of BSI in Arba Minch (9.8%), the rates of multidrug resistance are alarmingly increasing, and this should be addressed using efficient surveillance and control plans [8].

Central venous catheter-related bloodstream infection (CRBSI) is a disease that is linked with elevated morbidity and mortality in critically ill patients. A study was done to establish the rate of central venous catheter-related infections (CRIs) and the factors that affect it. The general rates of CRI were 27.77% (15/54). The CABSI was 47.31 per 1000 catheter-days. The most common isolate was S. epidermidis, and low CRI was observed in the catheters placed by the more experienced venipuncturist, elective procedure, and CVC was retained for not more than 3 days [9].

A cross-sectional study was carried out to establish the prevalence and predictors of CRBSIs in haemodialysis patients. CRBSI was very prevalent amongst the patient's receiving haemodialysis. Coagulase negative Staphylococci was the most common causative agent but compared to Gram positive cocci there was a higher number of Gram-negative bacilli [10].

A retrospective epidemiologic study was done to determine the catheter-related bloodstream infections (CRBSI) in patients undergoing long-term home parenteral nutrition (HPN) between the period January 2002 and December 2005. We found that coagulase-negative staphylococci (CoNS) were the most common pathogen (44.7% of all CRBSI episodes), followed by Enterobacteriaceae. The prevalence of candidemia and Enterococcus bacteremia was rather high (14.4% and 10.8%, respectively). The prevalence of Cefuroxime resistance was 65.4% CoNS and 31.5% Enterobacteriaceae. Considering the findings of the study, it was proposed to use a new empiric antimicrobial treatment regimen [11].

The objective of the study was to identify the organisms that cause catheter-related nosocomial infections in the PICU and to research their antimicrobial susceptibility profile. The most prevalent organism to colonize the CVC/venous cutdown catheters was acinetobacter with the greatest susceptibility to ciprofloxacin. When all these sites of catheter-related infections were considered as one, E. coli and Klebsiella were the most prevalent nosocomial pathogens. The two were the most sensitive to amikacin. Only one culture contained Methicillin-resistant Staphylococcus aureus (MRSA). The susceptibility of all the organisms to cefazolin and amoxycillin was poor. An understanding of the resident microbial flora and antimicrobial susceptibility pattern is required to implement a reasonable antibiotic policy in an ICU [12].

The burden of catheter-related bloodstream infections, risk factors, and microbiological spectrum in a tertiary care facility in Ethiopia was studied. Finally, the rate of catheter-related bloodstream infection among hemodialysis patients was high with gram-negative predominance. Timely fistula has to be scheduled to shorten the period of temporary vascular access [13].

A study was conducted to identify the incidence of CRBI and the pattern of antimicrobial resistance of the bacteria that caused catheter related Nosocomial infections. The CRBSI rate in our hospital is at a normal rank, although the high rate of device use. However, the seclusion of multiresistant microorganisms is a dangerous issue. Interventions aimed at the minimization of the use and time of invasive equipment and monitoring antimicrobial resistance should take center stage in our hospital [14].

A meta-analysis and systematic review of antimicrobial-impregnated strategies, other than antimicrobial-impregnated catheters, which were thought to reduce the risk of catheter-related bloodstream infections and catheter colonization in the intensive care unit. The interventions that minimized the catheter colonization were the insertion of the central venous catheters in the subclavian vein instead of other locations, application of alternative skin disinfection agents before catheter insertion, and application of Vitacuff in combination with polymyxin, neomycin, and bacitracin ointment. The reduction strategies involved a multifaceted infection control programme and performance feedback in the form of education of staff [15].

Conclusion

The study concluded that the significant burden of the catheter-related bloodstream infections (CRBSIs), developed from the medical alliance, accounted for the 73.75% of cases, highlighting the effect of the long-term utilisation of the central line and the duration of catheter dwell. Microbiological findings revealed the divergent profile of pathogen, where the non-fermenting Gram-negative bacilli contributed the most significant one, specifically Burkholderia cepacia complex and Stenotrophomonas maltophilia. This indicated the transition towards more opportunistic and resistant organisms. The significant contributor for Gram-positive cocci was coagulase-negative staphylococci and Staphylococcus aureus. The outcome findings regarding the antimicrobial susceptibility patterns explained poor activity of the third-generation cephalosporins for the Enterobacterales, susceptibility against carbapenem with resistance activity for Klebsiella pneumoniae and Acinetobacter baumannii and low efficiency for quinolone. Resistance against β-lactam was observed for CoNS and Enterococcus faecium.

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