

A Study on Etiological and Microbiological Profile of Catheter Related Bloodstream Infection in Paediatric Intensive Care Unit of a Tertiary Care Hospital in Eastern India

Nagesh Nayak M¹, B Vamshi Krishna², Suneel Kumar G³

¹Assistant Professor, Dept. of Paediatrics, Govt. Medical College, Mahabubnagar

²Assistant Professor, Dept. of Paediatrics, Rajiv Gandhi institute of Medical Sciences, Adilabad

³Senior Resident, Dept. of Paediatrics, Calcutta National Medical College and Hospital, Kolkata

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Corresponding author: Dr. B Vamshi Krishna

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Abstract

Background: Central venous catheters are used commonly in Pediatric ICU settings now a days, but their potential complications are also well known. One of the main complications is catheter-related bloodstream infection (CRBSI). The present study (pediatric ICU-based study) aimed at diagnosing such infections and identifying the potential pathogens implicated, in order to provide better patient care and to prevent such infections from occurring in the future.

Methods: This study included a group of 350 consecutive patients between age 1-12 years with indwelling central venous catheter, admitted in PICU of Dr B.C. Roy Postgraduate Institute of Paediatric Sciences, Kolkata who had developed clinical manifestations suggesting CRBSI such as fever or chills, unexplained hypotension, and no other localizing sign. after 48hours of catheterization.

Results: Among the 350 catheter tips paired with blood cultures, there was no evidence of any bacterial growth among the 106(30.3%) subjects. The remaining 244 (69.7%) catheter tips paired with blood culture showed bacterial growth, of which 223 catheters (63.7%) had only tip colonization with negative blood culture and 21 (6%) catheters were positive for both tip and blood culture with same micro-organism. triple lumen catheters accounted for 47.6% (10/21) of CRBSI while double lumen and single lumen catheters accounted for 33.3% (7/21) and 19% (4/21) respectively. Femoral site catheterization accounted for majority of CRBSI's (15 out of 21), while jugular and subclavian site accounted for 5 and 1case of CRBSI's respectively, among the CRBSI patients a total of 9 organisms were isolated, of which most common were Gram positive cocci (GPC) with 57.1% (12 out of 21) followed by Gram-negative organisms with 42.9% (9 out of 21).

Conclusion: This study concluded that CRBSI are more common with femoral site insertion and gram positive cocci are common in CRBSI.

Keywords: CRBSI, Pediatric ICU.

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Introduction

Central venous catheters are used commonly now a days in modern pediatric ICU care, but their potential complications are also well known, they may be inserted for administration of fluids, blood products, medications, nutritional solutions and for hemodynamic monitoring.[3] Although these types of catheter provide necessary vascular access, they can put the patients at risk for local and systemic infectious complications including local site infection, catheter-related blood stream infections (CRBSI), septic thrombophlebitis, and endocarditis and other metastatic infections.[4] Occurrence of these infections in a hospital set up leads to decrease in the quality of health care provided to the patients. These infections often result in prolonged hospital stay, thereby exposing the patients to the risks of

acquiring multiple infections which in turn leads to increase in morbidity as well as mortality.

Catheter-related bloodstream infection (CRBSI) is defined as the presence of bacteremia originating from an intravenous catheter.[5] Biofilm formation on the surfaces of indwelling catheters is central to the pathogenesis of CRBSI. Catheter related blood stream infections (CRBSI) contributes significantly to increased morbidity, mortality and medical costs to hospitalized patients.[6,7] The incidence of CRBSI, in paediatric intensive care units (PICUs) ranges between 5.3 and 8.64 episodes/1000 catheter days.[8,9] Along with the illness and immune status of the patient, catheter insertion and maintenance practices followed by the health care providers also contribute to the causation of CRBSI.

In the Indian literature, studies regarding the incidence and risk factors of CRBSI exist in the adult literature, but few such studies in the paediatric population exist. We conducted this study to determine etiological and microbiological profile (gram positive or negative) of organisms causing Catheter Related Blood Stream infections.

Methods:

We conducted the study at Dr BC Roy Post Graduate Institute of Pediatric Sciences, Kolkata, after institutional ethics committee approval, This study included a group of 350 consecutive patients admitted in PICU between age 1-12years with indwelling central venous catheter who had developed clinical manifestations suggesting CRBSI such as fever or chills, unexplained hypotension, and no other localizing sign.[1,2] after 48hours of catheterization (Consecutive sampling technique), informed consent had been taken from gaurdians, patients with previously diagnosed bacteraemia and septicemia or Patients with blood stream infections due to indwelling urinary catheters or central venous catheters inserted outside our hospital or having prosthetic heart valves or Pulmonary or arterial catheters or totally implanted intravascular access devices (ports) are excluded from the study

Semiquantitative (roll-plate) method was used in which distal 5cm of catheter was cut with sterile blade and was kept in a sterile container. Using sterile forceps, catheter tip was removed from transport tube and was laid on Blood agar plate and MacConkey agar plate. Plates were incubated at 37°C under aerobic conditions and read at 24 and 48hours. Count was done of each type of colony isolated, comparing growth on each medium. Each organism which was present from vascular catheter tips with colony counts of ≥ 15 CFU, including Gram-positive rods were identified. For counts of ≤ 15 CFU, only significant pathogens (e.g. group-A Streptococci and Gram-negative rods) were identified. Plates were saved for 1 week to compare with growth in Blood culture.

A set of paired blood culture were collected from peripheral sites. Blood culture bottles were placed in

Bact Automated Blood Culture system (BACT/ALERT 3D/60). From positive blood culture bottles, few drops of media were taken after gentle agitation and was sub cultured on Nutrient agar, blood agar and Mac Conkey agar plates and were incubated overnight at 37°C. Culture isolates were identified by standard microbiological methods and antimicrobial susceptibility testing of all the isolates was performed by automated method VITEK2-AST panel, AST-P628 was used for gram positive organisms and AST-N280 for gram negative organisms, For reporting of the laboratory results following definitions were followed:

Catheter related blood stream infection: A positive blood culture with same organism isolated from catheter tip culture was considered to indicate CRBSI. It is reported as rate or Incidence Density (ID).[10]

Catheter tip Colonization: A positive quantitative catheter culture with >1000 cfu/ml was considered as catheter tip colonization.

Blood stream infection: Positive blood culture with negative Catheter tip culture or different organism isolated from Catheter tip was presumed to be blood stream infection (cause may be other than catheter).

For statistical analysis data were entered into a Microsoft Excel spreadsheet and then analysed by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Unpaired *t*-test (continuous variables) and Chi-square test (discrete variables) were used to test the significance of observed differences. *P* value of less than 0.05 was considered significant.

Results

In the present study, children in the age groups 1-4 years, 5-8 years and 9-12 years constituted 65.7%, 28% and 6.3% of the study population respectively with mean age \pm SD 3.5 ± 2.4 years (range of 1 to 12 years) and median was 3 years. Among the study children, 54.9 % were boys and 45.1% girls with male: female ratio 1.2:1 [Table 1]

Table 1: Age and Sex distribution of subjects

Age group	Male	Female	Total (%)
1-4 yrs.	111	119	230(65.7)
5-8 yrs.	65	33	98(28)
9-12 yrs.	16	6	22(6.3)
Total (%)	192(54.9)	158(45.1)	n=350

We found that among the suspected cases 63.7% (223/350) had tip colonization of which 41% (144) were males and 22.7% (79) were female patients and 6% (21/350) had CRBSI, of which 4% (14) were males and 2% (7) were females [Table 2]

Table 2: Sex distribution of Tip colonization and CRBSI (n=350)

Sex %	Tip colonisation	CRBSI %	Total
Male	41% (144)	4% (14)	45% (158)
Female	22.7% (79)	2% (7)	24.7% (86)
Total	63.7% (223)	6% (21)	69.7% (244)

The common age group with tip colonization was between 1-4 years (41.5%, 145/350 cases), while most common age group having CRBSI was also 1-4 years (3.7%, 13/350 cases) [Table 3]

Table 3: Age distribution of Tip colonization and CRBSI

Age group	Tip colonisation	CRBSI	Total (n=350)
1-4 yrs.	41.5% (145)	3.7% (13)	45.2%
5-8 yrs.	18% (63)	1.7% (6)	19.7%
9-12 yrs.	4.2% (15)	0.6% (2)	4.8%
Total	63.7% (223)	6% (21)	69.7% (244)

Most common type of catheter used was the triple lumen (40 %), followed by double lumen (36%) and single lumen (24%), of these, triple lumen catheters accounted for 47.6% (10/21) of CRBSI while double lumen and single lumen catheters accounted for 33.3% (7/21) and 19% (4/21) respectively.[Table 4]

Table 4: Distribution of Type of catheter

Type of Catheter	Frequency	Percent
Double lumen	126	36.0%
Single lumen	84	24.0%
Triple lumen	140	40.0%
Total	350	100.0%

The most common site of catheterization was the jugular vein (40.9% overall) followed by subclavian vein and femoral vein with 30.3% and 28.9% are the overall site of insertion respectively. Femoral site catheterization accounted for majority of CRBSIs (15 out of 21), while jugular and subclavian site accounted for 5 and 1 case of CRBSIs respectively [Table 5]

Table 5: Distribution of site of insertion

Site of insertion	Frequency	CRBSI (n=21)
FEMORAL VEIN	28.9% (101)	71.4% (15)
JUGULAR VEIN	40.9% (143)	23.8% (5)
SUBCLAVIAN VEIN	30.3% (106)	4.8% (1)
Total	350	21

Among the 350 catheter tips paired with blood cultures, there was no evidence of any bacterial growth among the 106(30.3%) subjects. The remaining 244 (69.7%) catheter tips paired with blood culture showed bacterial growth, of which 223 catheters (63.7%) had only tip colonization with negative blood culture and 21 (6%) catheters were

positive for both tip and blood culture with same microorganism. [Table 6]. Thus, 21 patients developed CRBSI with rate of CRBSI was 6% or Incidence density of CRBSI was 6.6 per 1000 catheter days.

Table 6: Culture profile of catheter tips and blood samples

	Blood culture Positive	Blood culture Negative	Total
Tip culture Positive	21	223	244
Tip culture Negative	0	106	106
Total	21	239	350

Among the CRBSI patients a total of 9 organisms were isolated, of which most common were Gram positive cocci (GPC) with 57.1% (12 out of 21) followed by Gram-negative organisms with 42.9% (9 out of 21) [Table 7]

Table 7: Distribution of gram stain

Gram Stain	Frequency	Percent
Gram-positive	12	57.1%
Gram-negative	9	42.9%
Total	21	100.0%

Among the Gram-positive organisms, CONS were the most common (33.3%) which constitutes *S. hominis* (19%), *S. hemolyticus*, *S. capitis* and *S. sciuri* (4.8% each). *S. aureus* was the second most common isolate (23.8%). Among the Gram-negative organisms, Nonfermenters constitute the major part (23.8%) which constitutes *P. aeruginosa* (14.3%) and *A. baumannii* (9.5%), followed by Enterobacteriaceae (19%) which constitutes *E. coli* and *K. pneumoniae* (9.5% each). [Table 8]

Table 8: Distribution of isolated organisms

Organism	Frequency	Percent
<i>Acinetobacter baumannii</i>	2	9.5%
<i>Escherichia coli</i>	2	9.5%
<i>Klebsiella pneumoniae</i>	2	9.5%
<i>Pseudomonas aeruginosa</i>	3	14.3%
<i>Staphylococcus aureus</i>	5	23.8%
<i>Staphylococcus capitis</i>	1	4.8%
<i>Staphylococcus hemolyticus</i>	1	4.8%
<i>Staphylococcus hominis</i>	4	19.0%
<i>Staphylococcus sciuri</i>	1	4.8%
Total	21	100.0%

Discussion

Out of 350 study population, the most common age group was 1-4 years with 65.7% followed by 5-8

years of age and 9-12 years age group with 28% and 6.3% of total subjects, with mean age \pm SD 3.5 \pm 2.4 years with an age range of 1 to 12 years and median

3 years, which is similar to a study done by Lakshmi KS et al.[11] La Torre FP et al.[12] M.A. Almuneef et al.[13] and Haldar et al.[14] They found that the mean age of the patients with BSI was 3.7 ± 3.5 years, median age of 2.7 years, mean age of 2.6 years and median age of 2 years respectively in their studies and also in a study done by Deep A et al.[15] showed the mean age of patients in the study group was 3.83 years.

In our study we found males were predominant with 54.9% (192) with male to female ratio of 1.2:1, which is similar to a study done by La Torre FP et al.[12] Deep A et al.[15] M.A. Almuneef et al.[13] and Haldar et al.[14] where male: female ratio was 1.3:1, 3:2, 1.2:1 and 1.7:1 in their respective studies. In our study we found, males having local catheter infection and CRBSI were 64.5% and 66.6% respectively, this finding is almost similar to a study done by Khanna et al.[16] they showed that males were more predominant as 66.7% males having local catheter infection and 72.7% males having CRBSI.

In the present study, Catheter type did not appear to have direct bearing on blood stream infection (P-value 0.74) and the most common type of catheter used was the triple lumen (40%), followed by double lumen (36%) and single lumen catheters (24%). This is in concordance with a study done by Khanna et al.[16] Thomas D et al. [17](2013) and M.A. Almuneef et al.[13](2006) where triple lumen catheters were the most common type in their studies. In our study, femoral vein was the most common site of insertion among CRBSI (71.4%) followed by jugular and subclavian site of insertion accounted for 23.8% and 4.8% of CRBSI respectively which is in concordance with study done by Khanna et al.[16] Thomas D et al.[17](2013), M.A. Almuneef et al.[13](2006) and Haldar et al.[14](2021) where the most common site of catheter insertion among CRBSI was femoral site in their respective studies. Our study findings were again comparable with study done by Parameswaran et al.[18] where femoral catheters accounted for 33.3% of infections followed by jugular and subclavian site accounted for 22.2% and 21.3% of infections respectively and Lorente et al.[19] showed CRBSI incidence density was statistically higher for femoral than for jugular and subclavian accesses, and higher for jugular than for subclavian access, which is similar to our study finding.

In our study, out of 350 catheter tips cultured, 244 (69.7%) tips showed significant growth. Of these 244 catheter tips, 21 (6%) tips accounted for CRBSI and remaining 223 (63.7%) had only tip colonization. The rate or incidence density of CRBSI was 6% or 6.6/ 1000 catheter days respectively. Thomas D et al.[17] showed in their study that tip colonization and CRBSI rate was 51% and 6.3/1000 catheter days, which is almost similar

to our study findings. In a study done by Pandit P et al.[20](2019) found the prevalence of CRBSI due to CVC to be 39.25% and The International Nosocomial Infection Control Consortium (INICC) study conducted in 12 ICUs in seven Indian cities quoted similar result of 7.92 per 1000 catheter days.[21] which is higher in comparison to our study.

Similar to our findings in a study done by Chopdekar et al.[8] and Abirami et al.[22] found 57.6%, 58.8% of catheter tip colonization rate respectively and 7.05%, 6.5/1000 CVC days of CRBSI reported in their respective studies. In a recent study done by Haldar et al.[14](2021) showed 19.6% of Tip colonization rate and 10.4% CRBSI rate. But study done by Khanna et al.[16] showed higher rates of catheter tips accounting for colonization and CRBSI (78% and 22% respectively), while study done by Lorente et al.[19] showed lower rates of tip colonization and CRBSI (4.43% and 2.04% respectively) with lower ID of CRBSI of 2.79 per 1000 catheter days. This variability of incidences in various studies could be due to various factors like insertion techniques, site of catheterization, type of catheter used, catheter care and diagnostic criteria used for diagnosing catheter related infection (CRI).

In our study a total of 9 organisms were isolated, of which most common were Gram-positive organisms accounted for 57.1% (12/21) followed by Gram-negative organisms with 42.9% (9/21) of the isolates, which is in concordance with study done by Khanna et al.[16] Parameswaran et al.[18] and Haldar et al.[14] where major microorganisms of isolates causing CRBSI were Gram positive cocci with 64%, 64% and 74.1% respectively. In a study by Lorente et al.[19] showed higher rates of Gram positive (71.70%) isolates implicated in CRBSI while rest 22.64% isolates being Gram negative. And in a review study by Gahlot et al.[23] found that both gram positive and gram-negative microorganisms were major causes of CRBSI in studies by different Indian authors. Predominant isolate among Gram positive cocci in present study was coagulase negative staphylococci (33.3%). Similar findings were reported by Chopdekar et al.[8](2011), HV Patil et al.[24](2011), Subba Rao et al.[25] and Haldar et al.[14](2021) as commonest pathogen causing CRBSI was CONS with 50%, 65%, 32.4% and 66.7% respectively. In our study we found that among 57.2% of gram positive cocci, 33.3% were coagulase negative staphylococci (CONS), and 23.8% were *S. aureus* and among gram negative bacilli we found 9.5% each of *E. coli*, *A. baumannii* and 14% of *K. pneumoniae*, which is almost similar to a study done by Bhatawadekar S M et al.[26] showed Gram-positive cocci were 63.15% of which 26.3% were CONS followed by *S. aureus* with 21.05% and among gram negative bacilli two were *E. coli* (10.5%), two

were *Acinetobacter baumannii* (10.5%) and one was *K. pneumoniae* (5.26%). In this study *P. aeruginosa* is most commonly isolated Gram negative bacilli (GNB) followed by *K. pneumoniae* with 14.3% and 4.8% each, which is similar to study done by Khanna et al.[16] where *Pseudomonas* and *K. pneumoniae* accounted for 16.87% and 9.64% cases. In all the above-mentioned studies Gram-positive organisms, especially *Staphylococcal* spp were the most common isolates. And also, in a study done by Singhal et al.[27] and by Thacker et al.[28] showed 80% and 70.9% of isolates were GNB which is again in contrast to our study findings.

In this study, patients aged between 1-4 years, and males were more prone for either CRBSI or local catheter infections due to tip colonization with male to female ratio of 1.2:1. The study also showed that majority of CRBSI cases were seen with triple lumen catheters (47.6%) and femoral vein insertion (71%), suggesting easy access for the pathogens. The CRBSI rate (6%) or incidence density (6.6/1000 catheter days) in our study is nearly similar when compared to other Indian studies however the incidence density is significantly on the higher side when compared with foreign studies, indicating the need for more stringent catheter care protocol. In this study, gram positive organisms are implicated more (57.1%) in the causation of CRBSI than gram negative organisms (42.9%). The study showed the predominance of common nosocomial pathogens, *Staphylococcal* and *P. aeruginosa* in the causation of these infections, thereby indicating that occurrence of such infections could be controlled by active surveillance strategies

Conclusions:

1. We found that the femoral venous access was associated with a significantly higher incidence of CRBSI than the jugular and subclavian venous accesses.
2. Gram positive organisms are implicated more in the causation of CRBSI than gram negative organisms.

What this study adds: The knowledge of incidence of CRBSI and the microbiological spectra will be useful in formulating bundles of care and effective prevention programs of hospital acquired infections.

Limitations:

1. The study has been done in a single centre and covered a limited area of population.
2. Fungal culture studies have not been done in this study due to laboratory limitations.

Contributors: BVK: Conceptualized the study; NNM: Collected data; SKG: Drafted the manuscript. All authors approved the final manuscript.

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