Infections liées aux cathéters centraux en réanimation pédiatrique: incidence et facteurs associées

Catheter-Related Bloodstream Infection in the Pediatric Intensive Care Unit: Incidence and Associated Factors

Harbi. A [1,2], Ajmi. H [1,2], Ben Saad. O [1], Mokni. H [1,2], Hannachi. S [1,2] Nouir. S [1,2], Mabrouk. S [1,2], Chemli. J [1,2]

[1] Université de Sousse, Faculté de Médecine de Sousse, 4002, Sousse, Tunisie
[2] Hôpital universitaire Sahloul, Service de pédiatrie, 4011, Sousse, Tunisie

RESUME

Introduction : Un accès veineux fiable est indispensable à la prise en charge des patients hospitalisés en unité de soins intensifs pédiatriques (USIP). Le recours aux cathéters veineux centraux (CVC), bien que fréquent, expose à des complications potentiellement graves, en particulier les infections liées aux cathéters centraux (ILC). L'objectif de cette étude était d'évaluer la survenue, l'incidence et les facteurs associés auxILC chez les enfants hospitalisés en USIP.

Patients et Méthodes : Il s'agit d'une étude prospective menée en USIP entre janvier 2022 et février 2024. Tous les enfants ayant bénéficié de la pose d'un CVC et dont la durée de maintien du cathéter dépassait 48 heures ont été inclus. Les cathéters veineux centraux comprenaient des cathéters tunnélisés (Broviac®) et des cathéters non tunnélisés insérés par les voies jugulaire interne, sous-clavière et fémorale. Les cathéters centraux insérés par voie périphérique (PICC lines) ainsi que les cathéters de type Jonathon ont été exclus de l'étude. Les données cliniques et évolutives ont été recueillies de manière systématique afin d'analyser les ILC.

Résultats : Au total, 85 cathéters veineux centraux ont été posés chez 70 enfants au cours de la période d'étude. Le taux d'incidence ILC était de 7.6 pour 1000 jours-CVC. Les analyses univariées ont identifié plusieurs facteurs significativement associés à la survenue des ILC, notamment la thrombose associée au cathéter.

Conclusion : Les infections liées aux cathéters veineux centraux représentent une complication fréquente et sévère en USIP. L'identification de facteurs associés aux ILC souligne la nécessité de renforcer les mesures de prévention, d'optimiser les protocoles de gestion des cathéters et d'assurer une détection précoce des complications.

Mots clés : infections liées aux cathéters centraux, cathéters veineux centraux, unités de soins intensifs pédiatriques, facteurs associés

ABSTRACT

Introduction : Reliable venous access is essential for patients hospitalized in pediatric intensive care units (PICUs). However, the use of central venous catheters (CVCs) is associated with a substantial risk of serious complications, particularly catheter-related bloodstream infections (CRBSIs). The objective of this study was to evaluate the occurrence, incidence, and factors associated with CRBSIs in children hospitalized in PICU.

Patients and Methods : We conducted a prospective study in a PICU between January 2022 and February 2024. All children who required CVC insertion with a catheter dwell time exceeding 48 hours were included. CVCs included tunneled catheters (Broviac®) and non-tunneled catheters inserted via the internal jugular, subclavian, or femoral veins. Peripherally inserted central catheters (PICC lines) and Jonathon catheters were excluded from the study. Clinical and catheter-related data were collected to assess the incidence of CRBSIs and identify associated factors.

Auteur Correspondant :
Doctor Azza Harbi
Email: azzaharbibi@gmail.com

Results: During the study period, 85 CVCs were inserted in 70 children. All included catheters remained in place for more than 48 hours. The incidence density of CRBSIs was 7.6 per 1000 CVC-days. Univariate analyses identified several factors significantly associated with the occurrence of CRBSIs, including catheter-associated thrombosis.

Conclusion : CVC-related complications, particularly CRBSIs, remain frequent in the PICU setting. Identifying factors associated with CRBSIs highlights the need for reinforced preventive measures, strict catheter management protocols, and early detection of catheter-related complications.

Keywords : catheter-related bloodstream infections, central venous catheters, pediatric intensive care units, associated factors

INTRODUCTION

The placement of central venous catheters (CVCs) has become a common procedure in pediatric intensive care. These catheters are used for various indications, but they are not without risk. Catheter-related bloodstream infections (CRBSI) are the leading cause of healthcare-associated infections in pediatric intensive care units (PICUs) and contribute to significant morbidity and mortality. This study aimed to describe the characteristics of CRBSIs in children hospitalized in the PICU and to identify associated factors.

PATIENTS ET MÉTHODES

Study Design and Setting:

We conducted a prospective observational study over a 26-month period (January 2022 to February 2024) in the PICU of the University Hospital of Sousse, Tunisia.

Study Population: All children hospitalized in the PICU who required placement of a CVC and whose catheter remained in situ for more than 48 hours were eligible for inclusion. CVCs inserted exclusively for hemodialysis, peripherally inserted central catheters (PICCs), and implantable venous ports were excluded. Although this approach may introduce clustering bias, the limited sample size precluded more complex modeling. Although multiple catheters could be inserted in the same patient.For patients who received more than one CVC during the study period, each catheter episode was analyzed separately.

Data Collection: For each catheter insertion, a standardized data collection form was completed, including:

- Demographic characteristics (age, sex),
- Primary diagnosis at PICU admission,
- Indications for CVC insertion,
- CVC characteristics (insertion site, side, type of catheter),
- Duration of catheterization,
- Use of vasoactive drugs and mechanical ventilation,
- Occurrence of infectious and thrombotic complications,
- Outcomes (catheter removal, death). Patients were monitored daily from the time of catheter insertion until 48 hours after catheter removal for clinical or biological signs of infection.

Definitions

Catheter-related bloodstream infection was defined according to the French Society of Intensive Care Medicine (SRLF) criteria as one of the following:

- Isolation of the same microorganism from a peripheral blood culture and from a catheter tip culture ?10^3 CFU/mL, or
- Positive peripheral and central blood cultures with:a quantitative central/peripheral blood culture ratio >5, or a differential time to positivity >2 hours in favor of the central blood culture.

Catheter-related local infection without bacteremia was defined by a catheter tip culture ? 10^3 CFU/mL associated with local signs of infection at the insertion site (purulence or tunnelitis) with resolution of clinical signs within 48 hours after catheter removal.

Outcome measures: The primary outcome was the occurrence of CRBSI. Incidence was expressed as: · **Cumulative incidence:** number of CRBSI episodes per 100 CVCs, and · Incidence density: number of CRBSI episodes per 1000 catheter-days. Total catheter-days were calculated as the sum of the duration of catheterization for all CVCs from insertion until removal or diagnosis of CRBSI [1].

Statistical Analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Qualitative variables are presented as numbers and percentages. Quantitative variables are reported as medians with interquartile ranges (IQR) due to non-normal distributions. Comparisons between CVCs with and without CRBSIs were performed using Fisher's exact test or ? ² test for categorical variables, and the Mann–Whitney U test for continuous variables.
Time-to-event analyses were used descriptively to illustrate the cumulative incidence of CRBSIs according to catheter dwell time and length of PICU stay. Kaplan–Meier curves were constructed with time from catheter insertion to CRBSI occurrence as the event of interest, and catheter removal without infection as a censored observation. No regression modeling was applied
to survival data. A two-sided p value < 0.05 was considered statistically significant.

RESULTS

A total of 85 CVCs were included in the analysis, inserted in 70 children. The median age of the patients was 11 months [3 -43 months]. Among these, 49 were male (57.6%) and 36 were female (42.4%), resulting in a male-to-female ratio of 1.36. The most common reason for admission was respiratory disease (43.5%), followed by neurological conditions (30.6%).

The primary indication for CVC placement was for drug administration (83.6%), followed by volume expansion (57.6%), vasoactive drugs (50.6%), elective surgery (18.8%), and plasmapheresis (3.5%). Twenty-two patients (25.9%) received noradrenaline, and 12 patients (14.1%) were administered both adrenaline and noradrenaline.

CVCs were placed at three main sites: the femoral vein was the most frequently used site (61 CVCs; 71.8%), followed by the internal jugular vein (22 CVCs; 25.8%), with 13 of these being surgically placed Broviac-type CVCs (15.3%). Only two CVCs (2.4%) were inserted into the subclavian vein. CVCs were predominantly placed on the right side in 66 cases (77.6%). The median dwell time of CVC placement was 11 days [6 - 16.5 days]. CVC removal was primarily due to the end of treatment in 31 cases (36.5%).

The study identified both infectious and thromboembolic complications, with particular emphasis on CRBSIs. Nine patients (10.6%) developed CRBSIs, yielding an incidence density of 7.6 per 1000 CVC-days. The femoral vein was the insertion site most frequently associated with CRBSIs, accounting for eight cases. The mean time from catheter insertion to the onset of infectious complications was 12.8 ± 18.9 days (range: 2–94 days). The median time to the onset of an infection from CVC insertion was 4 days [2 - 10 days], with a range of 48 hours to 21 days.

Among patients with suspected catheter-related infection, the most frequent clinical signs were alterations in hemodynamic status, such as tachycardia and hypotension, followed by temperature instability, including hypo- or hyperthermia.

Upon suspicion of a catheter-related infection, microbiological investigations were conducted. A total of 239 blood cultures were taken from 85 CVCs and 70 patients, averaging 2.9 blood cultures per CVC and 3.4 per patient. The most frequently isolated pathogens included Pseudomonas aeruginosa, Stenotrophomonas maltophilia, Klebsiella pneumoniae, and Candida parapsilosis. CVC tips were also cultured, with 65 CVCs (76.5%) showing no growth and 8 CVCs (9.4%) yielding polymorphic results. Pathogens responsible for CRBSIs included three cases each of Candida parapsilosis and Pseudomonas aeruginosa, and one case each of Burkholderia cepacia, Acinetobacter baumannii complex, and Candida tropicalis.

Of the 9 CRBSIs cases, 5 patients (5.9%) developed septic shock and died, while the remaining 4 patients (4.7%) had a favorable clinical outcome with antibiotic and/or antifungal treatment.

Descriptive Kaplan–Meier curves showed an increasing cumulative incidence of CRBSIs with longer catheter dwell time and prolonged PICU stay (Figures 1 and 2).

Figure 1 : Kaplan-Meier survival function estimating the percentage of patients who did not develop a CRBSI (Catheter-related bloodstream infection) based on the duration of CVC (Central Venous Catheter) placement.

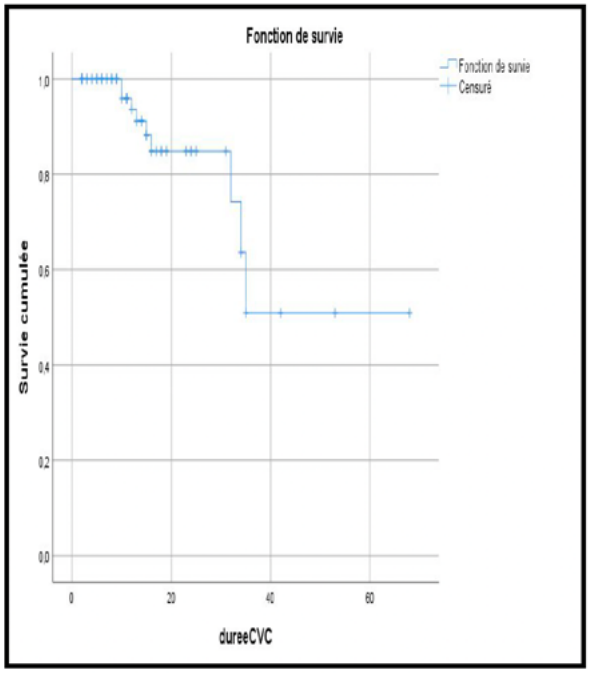
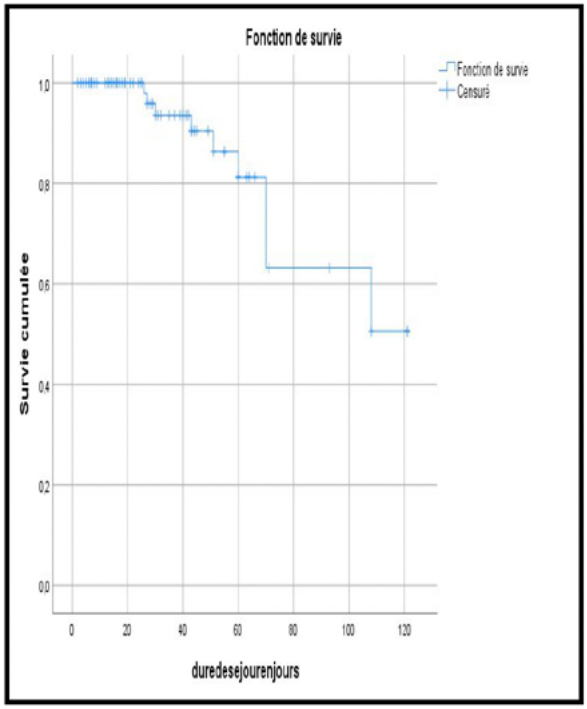


Figure 2 : Kaplan-Meier survival function estimating the percentage of patients who did not develop a CRBSI based on the duration of stay in the pediatric intensive care unit.



This study also investigated factors associated with CRBSIs occurrence. The univariate analysis identified several statistically significant associations with CRBSIs, including:
Plasmapheresis (p = 0.029)
Duration of mechanical ventilation (p = 0.002)
Dwell time of catheterization (p = 0.044)
Length of stay (p = 0.019)
CVC-associated thrombosis (p = 0.007)
Hyperglycemia (p = 0.037)

DISCUSSION

Late complications of CVCs are predominantly infectious and thrombotic. Infections are the principal complication associated with CVC placement and rank as the third most common cause of nosocomial infection in intensive care units (ICUs) [2]. CVC insertion often becomes necessary when peripheral venous lines fail, which can delay treatment and increase the risk of complications such as infiltration, extravasation, and infection. These complications are associated with increased morbidity,
mortality, length of hospital stay, and treatment costs [3], [4]. To our knowledge, this is one of the few prospective studies evaluating CRBSIs in a North African PICU. In our study, 85.9% of patients required CVCs due to difficulties with peripheral venous line insertion, a situation exacerbated by the limited venous access in the vulnerable age group of our population, with 55.3% being under one year of age.
In this section, CRBSIs represent a well-defined and clinically relevant complication of CVC use, as they represent a more precise outcome than overall CVC-related complications. Ferroni et al. (2001) found a 45% incidence of CRBSIs in a study conducted in pediatric wards at Necker Hospital [5]. Incidence density is a more precise measure than simple infection percentages, as it accounts for the catheter dwell time. Variations in incidence density are observed across departments, with higher rates often found in neonatology compared to other pediatric departments [6]. Our findings showed that the incidence density was 7.6 per 1,000 catheter-days. Upon suspicion of catheter-related infection, it is crucial to obtain multiple bacteriological samples, including central and peripheral blood cultures and skin swabs near the CVC insertion site [7].
The prevalence of CRBSIs is rising, with Gram-positive cocci being the predominant pathogens in adult ICUs [8]. Broudic et al. reported that coagulase-negative staphylococci were the most common pathogens in pediatric CVC infections [9].
Similarly, a Moroccan study by Mouaffak et al. found Gram-positive cocci to be the leading pathogens, with a significant increase in methicillin-resistant Staphylococcus aureus and extended-spectrum beta-lactamase-producing Enterobacteriaceae [10]. Our study identified Gram-negative bacilli in 55% of CRBSIs cases (e.g., Pseudomonas aeruginosa, Burkholderia cepacia, Acinetobacter baumannii) and Candida species in 45% (e.g., Candida parapsilosis, Candida tropicalis). Two critical aspects of managing CRBSIs are systemic antibiotic therapy and the decision regarding catheter retention. The treatment approach depends on the level of suspicion that the CVC is involved, the severity of the infection, patient risks, identified pathogens, and the necessity of maintaining the venous line. Persistently positive blood cultures beyond the third day should prompt investigations for thrombophlebitis or deep infections, particularly valvular infections, often requiring cardiac ultrasound [1].
Despite optimal management, mortality from infectious complications remains significant. A study published in 2015 reported a higher mortality rate among children with CRBSIs in PICUs compared with those without CRBSIs (15% vs. 7%) [11]. This study demonstrated, the mortality rate related to CRBSIs was lower at 5.9%. The high susceptibility to sepsis in our cohort may be explained by young patient age and the high incidence of infectious conditions at admission (67.1%). However, the direct impact of the CVC on overall mortality is challenging to isolate due to numerous confounding factors.
Prolonged ICU stays have both short- and long-term negative consequences. Several studies highlight a significant correlation between infectious risk and hospital length of stay. Chesshyre et al. found that CRBSIs were associated with prolonged hospital and ICU stays [11]. In our series, patients with infectious complications had a longer median hospital stay (55 days per patient-CVC) compared to those without (30 days per patient-CVC). The univariate analysis showed a significant correlation between CRBSIs and the median duration of catheterization (p = 0.019).
CVC-related thrombosis is a well-known complication, accounting for 10% of deep vein thromboses in adults and 50-80% in children [12]. In our cohort, CVC-related thrombosis was frequently associated with septic thrombosis. The small caliber of pediatric veins exacerbates the risk. Krafte-Jacobs et al. observed a higher incidence of CRBSIs in children with thrombosis compared to those without [13].
Mechanical ventilation has been linked to an increased risk of CRBSIs. DiPietro et al. found a significant association between MV and CRBSIs [14], Similarly Perlman et al. confirmed that MV increased the risk of CRBSIs by 3.7 times [15]. Our study supports this finding, showing a significant correlation with the median duration of MV (p = 0.002), likely due to prolonged hospital stays, multiple pathologies, and high manipulation risks. Martinez et al. reported that a catheter dwell time of more than 16 days was a risk factor for CRBSIs [16]. In our cohort, catheter dwell time was significantly associated with infections (p = 0.044). Plasmapheresis, associated with high infection risk, was also identified as a factor significantly associated with CRBSIs (p = 0.029). Overall, the risk of CRBSIs increases with the dwell time of CVC placement due to increased colonization over time. Continued research and improvement in management strategies are essential to mitigate these risks.

Limitations:
Our study has several limitations:
Single-Center Design: This study was conducted at a single pediatric intensive care unit with a limited capacity of six beds.
Consequently, the sample size is relatively small compared to other studies in the literature, which may limit the validity of our findings. The relatively small number of CRBSI events may limit statistical power and should be considered when interpreting these findings.
Lack of Resistance Profiling: The resistance profile of the pathogens involved in CRBSIs was not analyzed. This omission limits our understanding of the antibiotic resistance patterns and may affect the interpretation of treatment strategies.
Associated factors: Given the limited number of CRBSIs events, multivariate analysis was not performed to avoid unreliable results. The associations identified in our population are based on univariate analyses alone and are not independent predictors. The inability to adjust for potential confounding factors represents an important limitation. Our results require confirmation in larger, multicenter studies.

CONCLUSION

Central venous catheters are indispensable in pediatric intensive care but remain associated with significant infectious complications. Catheter-related bloodstream infections contribute to increased morbidity, mortality, and healthcare utilization.
Early identification of risk factors, strict adherence to insertion and maintenance bundles, and continuous staff training are essential to reduce CRBSIs incidence. Larger multicenter studies are needed to confirm these findings and optimize prevention strategies. Catheter dwell time, mechanical ventilation, and catheter-associated thrombosis should be key targets for preventive strategies.

No conflicts of interest to declare.

Ethical Approval: The medical ethics committee of the Faculty of Medicine, Sousse, Tunisia, approved this study (reference number CEFMS 232/2024).

REFERENCES :

[1] Timsit J, Wolff M, Mourvillier B, Schortgen F, Régnier B. Réactualisation de la douzième conférence de consensus de la Société de réanimation de langue française (SRLF): infections liées aux cathéters veineux centraux en réanimation. Reanimation. 2003;12(3): 258-65. doi: 10.1016/S1624-0693(03)00051-3.

[2] Er-Rahmany M, Boughalem M. Les infections liées aux cathéters veineux centraux en réanimation [thèse]. Marrakech: Faculté de Médecine et Pharmacie; 2010.

[3] Rauch D, Dowd D, Eldridge D, Mace S, Schears G, Yen K. Peripheral difficult venous access in children. Clin Pediatr (Phila). 2009;48(9): 895-901. doi: 10.1177/0009922809335737.

[4] Messika J, Roux D, Dreyfuss D, Ricard JD. Voies veineuses périphériques et risque d'infections acquises en réanimation. Reanimation. 2015;24(3):310-17. doi: 10.1007/s13546-015-1063-5.

[5] Ferroni A, Gaudin F, Guiffant G, Flaud P, Durussel J, Descamps P, et al. Pulsative flushing as a strategy to prevent bacterial colonization of vascular access devices. Med Devices (Auckl). 2014;7: 379-85. doi: 10.2147/MDER.S71217.

[6] Quinet B. Abord veineux de longue durée: épidémiologie, diagnostic, prévention et traitement des complications infectieuses. Arch Pediatr. 2006;13(6): 718-720. doi: 10.1016/j.arcped.2006.03.104.

[7] Moreau E, Bresson V, Bosdure E, Sarles J, Coste ME. Infections des voies veineuses centrales en nutrition parentérale à domicile: étude rétrospective monocentrique sur 2 ans. Arch Pediatr. 2014;21(6): 571-78. doi: 10.1016/j.arcped.2014.03.011.

[8] Kallel H, Damak H, Mahjoubi F, et al. Microbiological characteristics of catheter-related bacteremia in a Tunisian intensive care unit. Tunis Med. 2010;88(10): 724-28.

[9] Broudic M, Bodet L-M, Dumont R, et al. A 1-year survey of catheter-related infections in a pediatric university hospital: a prospective study. Arch Pediatr. 2020;27(2): 79-86. doi: 10.1016/j.arcped.2019.11.004.

[10] Mouaffak Y, Taoufiki R, Rebahi H, Arib S, Jlaïdi A, Soraa N, et al. Bactériémies en réanimation pédiatrique. Reanimation. 2013;22(S1): 104-7. doi: 10.1007/s13546-012-0572-8.

[11] Chesshyre E, Goff Z, Bowen A, Carapetis J. The prevention, diagnosis and management of central venous line infections in children. J Infect. 2015;71: S59-S75. doi: 10.1016/j.jinf.2015.04.029.

[12] Citla Sridhar D, Abou-Ismail MY, Ahuja SP. Central venous catheter-related thrombosis in children and adults. Thromb Res. 2020;187: 103-12. doi:10.1016/j.thromres.2020.01.017.

[13] Krafte-Jacobs B, Sivit CJ, Mejia R, Pollack MM. Catheter-related thrombosis in critically ill children: comparison of catheters with and without heparin bonding. J Pediatr. 1995;126(1): 50-4. doi:10.1016/S0022-3476(95)70499-X.

[14] DiPietro LM, Gaies M, Banerjee M, et al. Central venous catheter utilization and complications in the pediatric cardiac ICU: a re-

port from the Pediatric Cardiac Critical Care Consortium (PC4). Pediatr Crit Care Med. 2020;21(8): 729-37. doi: 10.1097/PCC.0000000000002306.

[15] Perlman SE, Saiman L, Larson EL. Risk factors for late-onset health care–associated bloodstream infections in patients in neonatal intensive care units. Am J Infect Control. 2007;35(3): 177-82. doi: 10.1016/j.ajic.2006.01.002.

[16] Martinez T, Baugnon T, Vergnaud E, et al. Central-line-associated bloodstream infections in a surgical paediatric intensive care unit: risk factors and prevention with chlorhexidine bathing. J Paediatr Child Health. 2020;56(6): 936-42. doi: 10.1111/jpc.14780.