Incidence of Infection in Central Venous Catheters in Children Hospitalized at the Children‘s Medical Center in Tehran from 2011 to 2020

Ashjaei B[1*], Sharifzadeh M[2], Hamzelouei H[3], Amiri Sh[4] Movahedi Jadid M[5]

Abstract:

Background and Objective: Central venous access is an essential component of pediatric clinical care and is widely used for supportive and therapeutic interventions in acute and chronic conditions. Despite its clinical benefits, central venous catheter (CVC) insertion may be associated with several complications, including catheter-related infections, thrombosis, and phlebitis, which adversely affect patient treatment outcomes. This study aimed to investigate the incidence of catheter-related infections and associated risk factors in children undergoing central venous catheter insertion at the Children‘s Medical Center in Tehran from 2011 to 2020.

Materials & Methods: In this retrospective cross-sectional study, the medical records of 254 children who underwent central venous catheter insertion from spring 2011 to winter 2020 were reviewed. Demographic and clinical variables, as well as potential risk factors associated with infection, were extracted and analyzed. Univariate and multivariate logistic regression analyses were performed to investigate factors associated with infection, with odds ratios (ORs) reported. Statistical analyses were conducted using 95% confidence intervals (CIs), and a P-value of less than 0.05 was considered statistically significant.

Results: The mean patient age was 280.35 months, and the mean catheter dwell time was 500.12 days; 131 patients (600.51%) were male, and 230 patients (600.90%) had underlying diseases. The most common insertion site was the femoral vein (147 patients; 900.57%), and the most common indication was antibiotic administration (182 patients; 700.71%). Infection was observed in 35 patients (800.13%). Antibiotic use (OR = 826.9; 95% CI: 812.3–331.25; $P < 0.001$) and catheter dwell time (OR = 1.055; 95% CI: 1.006–1.107; $P = 0.027$) were identified as independent predictors of infection. The other variables were not significantly associated with infection ($P > 0.05$).

Conclusion: The findings of this study showed that catheter-related infection occurred in 800.13% of patients, and antibiotic use and catheter dwell time were identified as the most important independent predictors of infection. Therefore, considering the history of antibiotic use and reducing catheter dwell time may be effective in preventing catheter-related infections.

Keywords: Central Venous Catheter, Catheter-Related Infection, Children, Bloodstream Infection, Phlebitis, Catheter Complications

[1] Associate Professor of Pediatric Surgery, Tehran University of Medical Sciences, Markaz Tebi Hospital, Tehran, Iran
[2] Associate Professor of Pediatric Intensive Care, Markaz Tebi Hospital, Tehran, Iran
3 General Practitioner, Tehran University of Medical Sciences, Tehran, Iran
4 Operating Room Technician, Tehran University of Medical Sciences, Tehran, Iran
5 Medical Student, Yeditepe University, Istanbul, Turkey
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Corresponding Author: Dr. Bahar Ashjaei
Tel: 021-44806668

E-mail: ashjaei@tums.ac.ir

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Background and Objective

Central venous access is a major challenge in pediatric healthcare worldwide and has become an integral component of modern medicine. Millions of central venous access devices are used annually in healthcare facilities to provide supportive therapies and therapeutic interventions for acute and chronic diseases. In children, these devices are indicated for long-term parenteral nutrition, chemotherapy, blood product transfusion, hemodialysis, frequent blood sampling, plasmapheresis, and the administration of medications that may cause severe irritation or phlebitis when infused through peripheral veins.[1-3]

Despite their undeniable clinical benefits, central venous access devices are associated with several complications that may compromise treatment success. Catheter-related bloodstream infection, thrombosis, catheter occlusion, mechanical failure, and catheter displacement are among the most commonly reported complications. Younger children, particularly infants under one year of age, are at greater risk of catheter-related treatment failure because of their smaller vessel diameter and physiological vulnerability.

The most common indications for central venous catheter insertion include long-term intravenous antibiotic therapy, total parenteral nutrition, chemotherapy, hemodialysis, frequent blood sampling, plasmapheresis, and the administration of medications with a high risk of damaging peripheral veins. Although these catheters provide reliable vascular access, preventing catheter-related complications remains a major concern in pediatric surgery and intensive care.

In the present study, the incidence of infection and phlebitis associated with venous catheters was investigated in pediatric patients who underwent central venous catheter insertion at the Children‘s Medical Center. The associations between these complications and demographic characteristics, underlying diseases, catheter type, insertion site, insertion technique, and concomitant medications were also evaluated to identify potential risk factors.

Jumani et al. reported that 20.8% of central venous catheters were removed because of complications, of which 4.4% were attributable to infectious complications and 16.4% to non-infectious causes.1 A wide range of central venous access devices is available. Specialists select the appropriate device based on the anticipated duration of clinical use (short-term, intermediate-term, or long-term), the risk of complications, therapeutic requirements (such as hemodialysis), frequency of use, and vascular access status. Traditionally, non-tunneled and umbilical catheters are recommended for short-term use (7–10 days), peripherally inserted central catheters (PICCs) for short- to intermediate-term use (4 weeks to 6 months), and tunneled catheters and totally implantable ports for long-term use (months to years). All central venous access devices are intended to provide safe and reliable vascular access to facilitate treatment without complications associated with catheter insertion, maintenance, or removal.[1,3]

Ruebner et al. investigated complications associated with central venous catheters and their related risk factors. More than 30% of the inserted catheters were associated with complications. Other studies have also reported complication rates ranging from 29% to 41%, varying according to the indication, insertion method, catheter type, and study population.[2–4]

According to various studies, infectious and mechanical complications are among the leading causes of failure of peripherally inserted central catheters. Reliable, long-term intravenous access is essential for treating children with malignancies and ensuring the safe administration of chemotherapy, as the extravasation of certain medications, such as vinca alkaloids and anthracyclines, can lead to tissue necrosis and ulceration. Although peripheral venous catheters are easy to insert, displacement and accidental dislodgement are common, and the catheters must be replaced when these complications occur. Recently, various

types of central venous catheters have been developed to provide long-term vascular access. Reducing the frequency of catheter replacement during treatment may help decrease patient pain and stress.

Central venous catheter-related thrombosis in children is a clinically significant event and accounts for approximately two-thirds of venous thrombosis cases in this population.[5,6] Male et al. reported that 34% of patients developed venous thromboembolism, of whom 14% were symptomatic. Of these thromboembolic events, 97% occurred in the upper venous system, and 72% were on the left side.[7] Menendez et al. demonstrated that although thrombosis associated with peripherally inserted central venous catheters is almost always asymptomatic, it is a significant and common complication that requires greater attention, particularly in the superficial venous system. Up to 33.2% of patients in their study developed thrombosis, with isolated superficial thrombosis being the most common type (24.9%).[8]

Other studies in adults have reported thrombosis rates ranging from 23.3% to 38.5%.[9–13] Other studies have reported that 73.8% of catheters were removed without complications after completion of treatment.1 Levy et al. also reported that 63% of all catheters were free of complications, with mechanical complications and infections being the most common adverse events.[14]

In 2018, Tolunay et al. reported that central venous catheter insertion and its associated complications in children require careful evaluation to reduce treatment costs and patient mortality.[15] In a study conducted by Shenep et al. in 2017, catheter-related complications were evaluated in children receiving parenteral nutrition.[16] A study by Johnson et al. in 1998 described the complications and risks associated with central venous catheter insertion in children.[17] Furthermore, Haldar et al. evaluated catheter-related infectious complications in pediatric surgical patients in 2022.[18]

According to a study by Östlund et al. in 2019, complications associated with non-tunneled central venous catheters included both infectious and non-infectious complications, with non-infectious complications being more prevalent.[19] Although the likelihood of non-infectious complications, such as displacement and swelling, was lower with catheters inserted at certain anatomical sites, the risk of infection at these sites did not differ significantly from that at other vascular access sites. One of the most important risk factors for catheter-related bloodstream infections is the normal skin flora; therefore, the use of antiseptic solutions before catheter insertion is particularly important. This study also demonstrated that central venous catheter insertion is a major risk factor for deep vein thrombosis in hospitalized children.[19] Accordingly, the present study was conducted to investigate the incidence of catheter-related infections and identify associated risk factors in children undergoing central venous catheter insertion at the Children‘s Medical Center from 2011 to 2020.

Materials and Methods

Study Design: This retrospective cross-sectional study was conducted at the Children‘s Medical Center Hospital, Tehran University of Medical Sciences. The medical records of children under 18 years of age who underwent central venous catheter insertion for any clinical indication between 2011 and 2020 were reviewed. The study included patients of both sexes, with no restrictions regarding the type of underlying disease. The catheter types evaluated included peripherally inserted central catheters (PICCs), central venous catheters (CVCs), long-term central venous access devices or implanted port catheters, peripheral venous cutdown catheters, and central venous cutdown catheters.

Data Collection: Following approval from the Research Ethics Committee (approval code: IR.TUMS.CHMC.REC.1399.123) and authorization from the hospital administration, patient information was extracted using a standardized checklist. The checklist included demographic variables, underlying diseases, catheter type, insertion technique, anatomical insertion site, indication for insertion, catheter dwell time, anticoagulant use,

antibiotic use, and catheter-related infectious complications. Given the risk of thrombophlebitis in some patients, follow-up assessments were performed at 3, 6, and 12 months after the intervention using color Doppler ultrasonography. During follow-up visits, patients were also evaluated for clinical signs of infection and the condition of the insertion site. Repeat cultures were not performed because the source of infection had resolved.

Study Variables: The primary outcome was the occurrence of catheter-related infection or phlebitis. The independent variables included age, sex, weight, underlying disease, catheter type, insertion technique, anatomical insertion site, indication for insertion, catheter dwell time, anticoagulant use, and antibiotic therapy. Patients were also followed up at 3, 6, and 12 months after catheter insertion using color Doppler ultrasonography and were assessed for the occurrence of thrombophlebitis, clinical signs of infection, and the condition of the catheter insertion site.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics, version 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The normality of variable distributions was assessed. The independent-samples t-test or Mann–Whitney U test was used for continuous variables, and the chi-square test was used for categorical variables. A *P*-value of less than 0.05 was considered statistically significant.

Univariate logistic regression analysis was performed to assess the associations between the variables and the study outcome, and variables with $P < 0.20$ were entered into the final analysis. Age and sex were not statistically significant in this analysis; however, they were included in the multivariate analysis because they were considered potential confounders. Multivariate logistic regression analysis was performed to control for confounding effects and to assess the associations between the variables and the primary outcome (infection).

Ethical Considerations: Patient confidentiality was maintained throughout all stages of the study. Approval from the Research Ethics Committee (approval code: IR.TUMS.CHMC.REC.1399.123) and institutional authorization were obtained before data collection, and no direct interventions were performed on patients. Data were extracted from medical records, and a questionnaire/checklist specifically developed for this study was completed for each patient.

Table 1. Frequency distribution of qualitative variables

Variable	*Category*	*Percentage*	*Count*
Sex (Gender)	*(Female)*	*51.600*	*131*
	Male	*48.400*	*123*
Underlying Disease	*Absence*	*9.400*	*24*
	Presence	*90.600*	*230*
Catheter Insertion Method	*Surgical*	*90.200*	*229*
	Interventional	*9.800*	*25*
Catheter Insertion Site	*Femoral*	*57.900*	*147*
	Jugular	*12.600*	*32*
	Subclavicular	*12.600*	*32*
	Cephalic	*10.600*	*27*
	Basilic	*6.300*	*16*
Catheter Type	*Central Venous Access Device*	*51.600*	*131*

	Central Venous Line	*31.500*	*80*
	Peripheral Venous Access Device	*4.300*	*11*
	Peripherally Inserted Central Catheter	*12.600*	*32*
Indication for Catheter Insertion	*Antibiotics*	*71.700*	*182*
	Dialysis	*16.500*	*42*
	Phlebitis	*5.100*	*13*
	Frequent Blood Sampling	*3.900*	*10*
	Others	*2.800*	*7*
Anticoagulant Use	*No*	*41.300*	*105*
	Yes	*58.700*	*149*
Antibiotic Use	*No*	*11.800*	*30*
	Yes	*88.200*	*224*
Infection	*No*	*86.200*	*219*
	Yes	*13.800*	*35*

Table 2. Distribution of quantitative variables

Variable	*Median*	*Mean*	*Minimum*	*Maximom*
Age	*26.500*	*35.280*	*1.000*	*191.000*
Weight	*12.400*	*13.766*	*3.000*	*57.000*
Catheter Dwell Time	*11.000*	*12.500*	*1.000*	*45.000*

Findings

A total of 254 patients were evaluated in this study, including 131 males (51.6%) and 123 females (48.4%). The mean age of the patients was 35.28 months (median: 26.5), and the mean weight was 13.77 kg (median: 12.4 kg). Most patients had an underlying medical condition (230 patients; 90.6%), and the catheter placement method was surgical in the majority of cases (229 patients; 90.2%). The most common site of catheter insertion was femoral (147 patients; 57.9%), and the most frequent catheter type was central venous access device (131 patients; 51.6%). The primary indication for catheter placement was antibiotic administration (182 patients; 71.7%), followed by dialysis (42 patients; 16.5%). A history of anticoagulant use was positive in 149 patients (58.7%), and antibiotic use in 224 patients (88.2%). The mean duration of catheterization was 12.5 days (median: 11.0 days, range: 1 to 45 days), and ultimately, infection was reported in 35 patients (13.8%). Univariate analysis showed that catheterization duration, anticoagulant use, and antibiotic use were significantly associated with the studied outcome individually (*P* = 0.039, 0.044, and < 0.001, respectively) and were entered into the multivariate analysis.

Table 3. Results of univariate logistic regression analysis

Variable	*Category*	*Odds Ratio (OR)*	*CI: 95% CI*	*P-value*
Age	*Per unit increase*	*0.995*	*0.982 – 1.007*	*0.401*
Sex	*1*	*1.007*	*0.493 – 2.056*	*0.985*
Weight	*Per unit increase*	*0.974*	*0.924 – 1.027*	*0.328*
Underlying Disease	*1*	*0.543*	*0.122 – 2.417*	*0.423*
Catheter Insertion Method	*1*	*1.191*	*0.337 – 4.211*	*0.786*
Catheter Insertion Site	*1*	*0.763*	*0.201 – 2.897*	*0.691*
Catheter Insertion Site	*2*	*0.448*	*0.080 – 2.526*	*0.363*
Catheter Insertion Site	*3*	*0.448*	*0.080 – 2.526*	*0.363*
Catheter Insertion Site	*4*	*0.754*	*0.146 – 3.901*	*0.736*
Catheter Type	*1*	*0.805*	*0.273 – 2.375*	*0.695*
Catheter Type	*2*	*0.861*	*0.273 – 2.710*	*0.798*
Catheter Type	*3*	*1.200*	*0.197 – 7.296*	*0.843*
Indication for Catheter Insertion	*1*	*269244816.233*	*0.000 – —*	*0.999*
Indication for Catheter Insertion	*2*	*269244816.233*	*0.000 – —*	*0.999*
Indication for Catheter Insertion	*3*	*134622408.117*	*0.000 – —*	*0.999*
Indication for Catheter Insertion	*4*	*403867224.350*	*0.000 – —*	*0.999*
Catheter Dwell Time	*Per unit increase*	*1.049*	*1.002 – 1.097*	*0.039*
Anticoagulant Use	*1*	*2.102*	*1.021 – 4.329*	*0.044*
Antibiotic Use	*1*	*7.021*	*3.014 – 16.356*	*<0.001*

**In all analyses, the first group was considered as the reference*

Table 4. Results of multivariate logistic regression analysis

Variable	*Adjusted Odds Ratio (aOR)*	*95% CI*	*P-value*
Age	*0.991*	*0.977 – 1.004*	*0.177*
Sex	*0.959*	*0.437 – 2.106*	*0.918*
Indication for Catheter Insertion (Overall)	—	—	*0.914*
Indication for Catheter Insertion (1)	*207648102.678*	*0.000 – —*	*0.999*
Indication for Catheter Insertion (2)	*168865147.399*	*0.000 – —*	*0.999*
Indication for Catheter Insertion (3)	*104320507.516*	*0.000 – —*	*0.999*
Indication for Catheter Insertion (4)	*394927075.088*	*0.000 – —*	*0.999*
Antibiotic Use (1)	*9.826*	*3.812 – 25.331*	*0.000*
Anticoagulant Use (1)	*2.032*	*0.892 – 4.628*	*0.091*
Catheter Dwell Time	*1.055*	*1.006 – 1.107*	*0.027*

In the multivariate logistic regression analysis, after adjusting for the effects of the evaluated variables, no statistically significant association was observed between age and the studied outcome (OR = 0.991, 95% confidence interval: 0.997 - 1.004, and *P* = 0.177). Similarly, gender was not significantly associated with the outcome (OR = 0.959, 95% confidence interval: 0.437 - 2.106, *P* = 0.918). Furthermore, catheter placement indication showed no overall significant association with the studied outcome (*P* = 0.914). Antibiotic use was significantly associated with the odds of the outcome; the odds of the outcome in individuals receiving antibiotics were approximately 8.9 times higher than those in the reference group (OR = 9.826, 95% confidence interval: 3.812 - 25.331, *P* < 0.001). Anticoagulant use was also associated with increased odds of the outcome, but this association was not statistically significant (OR = 2.032, 95% confidence interval: 0.892 - 4.628, *P* = 0.091). Additionally, a statistically significant association was observed between the duration of catheterization and the occurrence of the outcome, such that for each unit increase in catheterization duration, the odds of the outcome increased by 5.5% (OR = 1.055, 95% confidence interval: 1.006 - 1.107, *P* = 0.027).

Discussion and Conclusion

In this study, catheter-related infection was observed as one of the important complications in patients undergoing catheter insertion, and the associated factors were investigated. The results showed that antibiotic use and catheter dwell time were among the most important predictors of infection occurrence. Based on the findings of this study, consideration of a history of antibiotic use and reduction of catheter dwell time are highly important in preventing infection. These findings highlight the need for closer patient monitoring and adherence to hygiene principles during catheter insertion and maintenance.

Consistent with our findings, the study by Tolunay et al. (2018) found no significant association between the occurrence of venous catheter-related infection and patient age.[15] Similarly, in the study by Shenep et al. (2017), the risk of catheter-associated bloodstream infection (CLABSI) was not associated with patient age (P = 0.38).[16] Overall, these findings do not demonstrate a measurable association between age and catheter-related infection in the pediatric populations studied.

Similarly, the studies by Johnson et al. (1998) and Haldar et al. (2022) reported no association between central venous catheter infection and sex[17,18] which is consistent with the findings of the present study. No statistically significant association was observed between patient weight and the occurrence of infection ($P = 0.635$). Östlund et al. (2019) also reported no significant association between patient weight and catheter-related infection ($P = 0.781$).[19]

Regarding catheter insertion site, no statistically significant association was found between the anatomical site of catheter insertion and the occurrence of infection. Advani et al. (2011) and Jumani et al. (2013) likewise reported no statistically significant association between catheter insertion site and infection ($P = 0.64$).[1,20] Accordingly, no specific insertion site was identified as being associated with a significantly higher risk of infection in the present study.

Regarding catheter type, no significant association was observed between catheter type and the occurrence of infection. Similarly, the studies by Yau et al. (2019) and Beck et al. (2019) found no significant association between catheter type and bloodstream infections.[21,22]

With regard to the mean catheter dwell time, no significant association was found between catheter dwell time and infection. Similar findings were reported by Tolunay et al. (2018) and Fratino et al (2005).[15,23] In contrast, Napalkov et al. (2013) reported a statistically significant association ($P < 0.05$).[24]

Anticoagulant therapy was significantly associated with a lower rate of infection. Shah et al. (2014) reported that heparin-coated catheters were associated with a lower risk of bloodstream infection.[25] Huang et al. (2020) also reported that low-molecular-weight heparin reduces thrombosis associated with peripheral venous access devices.[26] However; the latter finding relates to thrombosis and does not directly establish a preventive effect on infection.

No significant association was found between the insertion method and infection. Although McBride et al. (1997) reported a lower risk of infection with radiologically guided insertion,[27] Lund et al. (1996) found no significant difference.[28] Differences in insertion techniques and the small number of interventional cases in our study may have contributed to these findings.

Antibiotic therapy was significantly associated with a lower rate of infection. Sahli et al. (2017) and Bell et al. (2017) also investigated antibiotic use and evidence-based strategies for preventing catheter-related bloodstream infections.[29,30] Given the observational design of the present study, this association should not be interpreted as evidence of a causal protective effect.

No significant association was found between underlying disease and catheter-related infection, which is consistent with the findings of Tolunay et al (2018).[15]

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