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A comparison of Broviac® and peripherally inserted central catheters in children with intestinal failure☆,☆☆

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ABSTRACT

Purpose: Central venous catheters (CVCs) are a source of morbidity for children with intestinal failure (IF). Complications include infection, breakage, occlusion, and venous thrombosis. Broviacs® have traditionally been preferred, but peripherally inserted central catheters (PICCs) are gaining popularity. This study compares complications between Broviacs® and PICCs in children with IF.
Methods: After IRB approval, children with IF receiving parenteral nutrition (2012–2016) were reviewed. Complications were compared between Broviacs® and PICCs using the generalized estimation equation population-averaged Poisson regression model. P values <0.05 were considered significant.
Results: 36 children (0.1–16 years) with IF were reviewed, accounting for 27,331 catheter days, 108 Broviacs® (3F–9F), and 54 PICCs (2-11F). Broviacs® had a significantly higher infection rate (4.2 vs. 2.6/1000 catheter days, $p = 0.011$), but PICCs were more likely to break (1.56 vs. 0.26/1000 catheter days, $p = 0.002$). When comparing same size catheters (3F), there were no significant differences in infection, breakage, or occlusion. Twelve children (33%) had central venous thrombosis, all after Broviac® placement. Three children (8%) had basilic vein thrombosis after PICC placement.
Conclusion: Although Broviacs® and PICCs had similar complication rates, there were fewer central venous thromboses associated with PICCs. This should be considered when choosing catheters for children with IF.
Level of evidence: 11b (Prognosis Study).

Children with intestinal failure (IF) who are dependent on parenteral nutrition (PN) rely on a functional central venous catheter (CVC) for the delivery of fluids and nutrition. As the management of these children continues to evolve and outcomes improve, patients are able to be maintained on PN support for extended periods of time, often for years. Unfortunately, catheter-related complications occur frequently because of their chronic use, resulting in increased morbidity. The most common complications related to CVCs include infection, catheter breakage or occlusion, and central venous thrombosis. Children with IF are at particularly high risk for both catheter-related infections, with published rates anywhere from 0.9 to 11 infections per 1000 catheter days [1–6], and central venous thrombosis with an incidence of 35–57% reported in small series [7,8]. Preventing CVC-related complications could significantly improve the quality of life for these patients.

Traditionally, children with IF requiring prolonged PN support received a long-term, tunneled CVC (Broviac®). These catheters require general anesthesia for placement, and are placed by directly accessing one of the central veins, either percutaneously or via cut-down. More recently peripherally inserted central catheters (PICCs) have also been used for long-term PN. Although they often require sedation for placement, a general anesthetic is not always needed, and the central veins are not directly accessed during placement. Because PICCs are still not

Abbreviation: IF, intestinal failure; PN, parenteral nutrition; CVC, central venous catheter; PICC, peripherally inserted central catheter; CLABSI, central line-associated bloodstream infection; CVT, central venous thrombosis.

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☆☆ Author's RoleCarolina Blotte BA made substantial contributions to the conception and design of the work, the acquisition and analysis of the data, and is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.Jennifer Styers CPNP made substantial contributions to data collection for the work, and is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.Hong Zhu PhD made significant contributions to the interpretation of data for the work; gave final approval of the version to be published; and is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.Nandini Channabasappa MD made substantial contribution to the conception and design of the work, gave final approval of the version to be published, and is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.Hannah G. Piper MD made substantial contributions to the conception and design of the work, the acquisition, analysis, and interpretation of data for the work; drafted the work and revised it critically for important intellectual content; gave final approval of the version to be published; and is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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widely used for children with IF, the complication rates compared to Broviac® catheters are not well known. The purpose of this study is to compare complication rates between Broviacs® and PICCs used for long-term PN delivery in children with IF.

1. Methods

1.1. Study population

After obtaining approval from the University of Texas Southwestern Investigational Review Board, a retrospective review of children with IF managed by the multidisciplinary Center for Intestinal Rehabilitation at Children's Health from January 2012 through January 2016 was performed. This date range was selected because PICCs were introduced in our Intestinal Rehabilitation program in 2012. Only children (<18 years) receiving PN support for >3 months through either a Broviac® catheter or PICC were included in the study. At our center Broviac® catheters are placed in the operating room by a surgeon and PICCs are placed in the radiology suite by an interventional radiologist. In both cases the catheters are placed under sterile conditions. Subsequently catheter care is performed by skilled nurses or parents who have demonstrated competency after formal training in line care and dressing changes.

1.2. Data collection

Patient data were collected including: age, gender, diagnosis, intestinal anatomy, surgical intervention, nutritional requirements, duration of PN therapy, number of CVCs per patient, and any history of venous thrombosis. Additionally, catheter-specific information was collected including: type, size, number of days each catheter was in place, reason for removal and complications associated with the catheter (bloodstream infections, breakage, occlusion). A central line-associated bloodstream infection (CLABSI) was defined using the Center for Disease Control guideline: "A confirmed bloodstream infection where a central line was in place for >2 calendar days on the date of the event" (www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABScurrent.pdf). A catheter was considered occluded if it would no longer flush and/or withdraw, requiring treatment with tPA, and a catheter-related venous thrombosis was documented when thrombus was seen on ultrasound or with magnetic resonance venography in the same extremity as the catheter.

1.3. Statistical analysis

Data were analyzed and reported as medians or means with range or standard deviation for continuous variables and with frequency and percentages for categorical data. The rates of catheter complications were calculated as events per 1000 catheter days [9]. The generalized estimation equation population-averaged Poisson regression model was used to compare rates of complications between Broviacs® and PICCs. A p value <0.05 was considered statistically significant. The analysis was performed using STATA 12 (StataCorp. 2011 Stata Statistical Software: Release 12. College Station, TX: StataCorp. LP).

2. Results

A total of 36 children were included in the study (2–12 years), 25 of whom where younger than one. The median gestational age was 34 weeks (range 24–40 weeks), and the median time on PN support was 516 days (range 185–750 days) with 16 (44%) of the children remaining on PN at the end of the study period. Patient characteristics can be seen in Table 1.

There were 162 CVCs in the analysis including 108 Broviacs® (3F to 9F) and 54 PICCs (2F to 11F), accounting for 27, 331 catheter days. Almost all of the catheters were single lumen (99%), and placed in the upper extremities/chest (90%). The overall CLABSI rate for all CVCs was 3.99 per 1000 catheter days, and the overall occlusion and breakage rates were 5.67 and 0.44 per 1000 catheter days respectively. When comparing all Broviacs® to all PICCs, PICCs were significantly less likely to become infected than Broviacs® (2.6 vs. 4.2 per 1000 catheter days) with an incidence ratio of 0.45 ($p = 0.011$, 95% CI: 0.24–0.83). However, PICCs were six times as likely to break (1.56 vs. 0.26 per 1000 catheter days) with an incidence ratio of 6.23 ($p = 0.002$, 95% CI: 2.00–19.4). There was no significant difference in catheter occlusion rates or the mean time to catheter replacement although there was a trend toward Broviacs® requiring fewer replacements (125 days vs. 85 days, $p = 0.32$). Two patients received ethanol lock therapy (4 h dwell time, three days per week) during the study period accounting for three episodes of occlusion (one with a PICC and two with a Broviac®). On each occasion the occlusion was resolved with tPA. All other patients received standard heparin lock during time off PN support. When a subset analysis of single lumen catheters of the same diameter (3F, all with cuffs) was performed, there was no significant difference in the rates of infection, occlusion or breakage between Broviacs® and PICCs (Table 2). There was also no significant difference in the mean time to catheter replacement between 3F Broviacs® and 3F PICCs (50 days vs. 42 days, $p = 0.63$).

Fifteen patients (42%) developed at least one venous thrombosis directly related to a CVC, and 9 children had two or more thrombosed veins. None of the patients were symptomatic. Venous thrombosis was determined by ultrasound or magnetic resonance venography performed for operative planning. Twelve patients had thrombosis of a central vein, directly related to Broviac® placement, and three patients had thrombosis of the basilic vein after PICC placement. There were no central venous thromboses associated with PICCs in this series (Table 3).

Table 1
Patient Characteristics.

Total # of patients	36
Median gestational age at birth (weeks), range	34 weeks (24–40)
Median age when PN started, range	1 day (1 day–12 years)
Etiology of intestinal failure, n (%)	
Intestinal atresia	14 (39)
Necrotizing enterocolitis	9 (25)
Midgut Volvulus	7 (19)
Gastroschisis	1 (3)
Other	5 (14)
Median duration of PN support (days), range	516 days (185–750)
Median # of CVCs per patient, range	3 (1–8)`
Type of CVC, n (%)	
# of patients with only Broviacs	15 (42)
# of patients with only PICCs	2 (6)
# of patients with both Broviacs and PICCs	19 (53)

3. Discussion

This objective of this study was to determine if the type of central venous catheter impacts the complication rate in children with intestinal failure receiving PN. Traditionally, tunneled Broviac® catheters, placed under general anesthesia, have been the preferred catheter for delivering long-term PN, and they continue to be the most common choice for children with IF in most centers. However, PICCs have gained popularity because they can sometimes be placed without a general anesthetic, and they do not require direct manipulation of a central vein. Despite these potential benefits there are some concerns with the use of PICCs in patients who require long-term central access. Because PICCs start at the peripheral vein they are, by necessity, longer than Broviacs®, possibly predisposing them to blockage, breakage and/or malfunction. Additionally, depending on the type of PICC, they may not be tunneled or have a cuff, potentially increasing the likelihood of infection or malposition with prolonged use.