Peripherally inserted central catheter-related complications in infants with intestinal failure

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ABSTRACT

Background and Objectives: For delivery of parenteral nutrition (PN), long-term central access is often required in infants with intestinal failure (IF). Compared to central venous catheters (CVCs), peripherally inserted central catheters (PICCs) are less invasive, as they are smaller, and they can even be placed without general anesthesia. In this study, we report the complications of long-term use of PICCs, and compare our results with previously published research. **Methods and Study Design:** We reviewed the infants in the Xin Hua Hospital to determine the incidence of catheter-related bloodstream infections (CRBSIs) as well as other complication rates. **Results:** A total of 43 infants diagnosed with intestinal failure and receiving PN through a PICC met the inclusion criteria. There were 66 PICCs accounting for 2563 catheter days, and a total of 29 complications were been recorded. The overall incidence of complications was 11.31 per 1000 catheter days, and the incidence of CRBSI was 5.85 per 1000 catheter days. Gram-positive bacterial species were the most common organisms growing in blood cultures. As for the risk factors, we find that low weight when PICC was inserted was associated with an increased risk of complications as well as low mean weight during the PICC dwelling time. **Conclusions:** We did not find an increased incidence rate of CRBSI in using PICC as an alternative to CVC. Also, as PICCs offer an advantage over CVCs in placing and nursing, we recommended PICCs as the first choice in patients with IF.

Key Words: intestinal failure, PN, PICC, catheter-related complications, CRBSI

INTRODUCTION

Intestinal failure (IF) is a severe disease for infants. It is usually considered to consist of four major pathophysiological conditions: short bowel syndrome (SBS), chronic intestinal pseudo-obstruction (CIPO), small bowel parenchymal disease, and intestinal fistula.[1] Regardless of the original disease, the patient often suffers from weight loss and electrolyte and/or micronutrient unbalance due to the malabsorption of the intestine. For adequate intestinal adaptation, most of these patients generally require long-term parenteral nutrition (PN). In this case, the catheters that deliver the nutrition are vital to the infants. However, the complications of catheters are sometimes life-threatening to the patients. According to our observation, catheter-related bloodstream infections (CRBSI) are one of the most serious complications, including mechanical factors, such as breakage or translocation.

Traditionally, a surgically placed central venous catheter (CVC) under general anesthesia was the first choice for patients. However, CRBSI represents a large portion of the morbidity and mortality for children with IF. Many children with indwelling CVCs still suffer from line sepsis. Moreover, CRBSI can even lead to line removal, loss of access sites, accelerated hepatic damage, hospitalization, which will observably increase the mortality.[2]

With the development of clinical nursing technology, more and more surgeons have realized that peripherally inserted central catheters (PICCs) are a good alternative to tunneled CVC. Generally, PICCs are smaller, so they cause less trauma to the blood vessel. Another theoretical advantage is that PICCs can usually be placed under local anesthesia, which most parents prefer. In addition, as PICCs are more stable, their replacement cycle tends to be longer, which means less pain to the patients. To date, more and more PICCs are being used routinely in infants with intestinal failure.

As some of the complications, such as CRBSI, are fatal to the patients, the purpose of our study was to assess whether PICCs did indeed work better in decreasing the rate of catheter-related infections than CVCs in PN-dependent children with IF.

MATERIALS AND METHODS

Patients and setting

A retrospective review was performed for all the infants diagnosed as IF, receiving PN through a PICC at Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, between June 2004 and September 2016. The patients were diagnosed as IF if he or she had <25% of expected length of small bowel for gestational age and/or were receiving PN for >42 days because of intestinal dysmotility or bowel resection.[3]

In our study, the inclusion criteria included the presence of a silicone PICC for administration of PN to treat IF, and the age of the patients ranged from one day to 5 years old. Any patient who was in the different age bracket or using PICC without PN was not included in our study. All the patients received PICC implantation at Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, by the nurses in the Department of Pediatric Surgery, and strict disinfection was managed before the operation. All the nursing interventions in our study were performed at Xin Hua Hospital. Any patient with PICC placed in another center or was treated in another hospital was excluded. In all the cases, we used heparin to lock the catheters when they were not in use.

All the PICCs were defined as peripherally inserted CVCs, as they were inserted peripherally and terminated at or close to the heart or in one of the great vessels. In all cases, chest radiography was performed to confirm whether the PICC had been placed in the specific location. This study was approved by Ethics Committee of Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine.

Data collection

We followed up the infants' hospital stay, especially the time with PICCs, to acquire detailed knowledge of the influence that PICCs had on the infants with intestinal failure. We collected the data of the study objects until the PICC was removed, no matter what the reason for the removal. The following data of patients were collected for further analysis: gender, gestational age, primary diagnosis leading to intestinal failure, age at which PICC was inserted. Additionally, specific information relating to the PICCs, such as the size and number of lumens, date each PICC was changed (removed or replaced), reason for changing, and other catheter-related complications, such as occlusion, infection, breakage, or malposition, was also collected. As we focused more on the CRBSI, we also recorded the results of catheter culture and the antibiotics that were used to treat the infection.

A positive blood culture taken from the PICC was essential to diagnose catheter-related bloodstream infection. When a PICC would no longer flush or withdraw blood, it was defined as occluded. This study was approved by Ethics Committee of Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, and the approval number is XHEC-D-2016-058.

Statistical analysis

IBM SPSS Statistics (ver.22) for Windows was available for statistical analysis. Descriptive analyses were performed to catalog the characteristics of the patients and catheters. All the results were reported as medians or means, with ranges and categorical data reported as frequency and percentages. The data of the patient was not included in the analysis if he/she was transferred to another center before PICC removal. Following the recommendation by the Centers for Disease Control and Prevention, CRBSI rates were expressed as the number of infections per 1000 catheter days.[4] Chi-squared tests were used to determine the association between independent predictors and complication necessitating PICC removal. We set the p value <0.05 to indicate significant difference.

RESULTS

In our study, a total of 43 infants met the inclusion criteria, (24 boys and 19 girls). The mean gestational age was 37.3 weeks (31 to 40 weeks). Among all the patients, intestinal atresia accounts for 14 newborns to be born with IF, which takes the highest percentage. As all the patients were considered to be in IF, they all had a need of PN for a portion of their energy. For all the infants in our study, the average length of the remaining small intestine (in the latest surgery as measured from the ligament of Treitz) was 0.652 m (0.15-1.65 m), and they required PN for a mean of 105.2 days (34 to 280 days) while PICC was placed for a mean of 59.7 days (7 to 260 days). The median age when PICC was inserted was nearly 4 months, and the median weight was 3.3 Kg (1.55 to 13.6 Kg). Table 1 shows the summary of patient characteristics. The mean weight growth during the PICC dwelling time was 0.0173 Kg (-0.0556 to 0.0763 Kg), most patients had a good weight growth.

At least 1, but no more than 4, PICCs were used in each patient, with an average of 1.6 PICCs. Sixty-six PICCs accounted for 2563 catheter days, among which 60 were 1.9F, cuffed, single-lumen catheters, while the other 6 were 3F. No longer required was the most common reason for PICC removal. With this exception, a total of 29 complications has been recorded, among which CRSBI accounted for 15 PICC removals.

The overall incidence of complication was 11.31 per 1000 catheter days, and the incidence of CRBSI was 5.85 per 1000 catheter days (15 infections in 2563 catheter days). Among the 13 patients who had blood stream infections, 2 patients went through 2 infections as they used PICCs for more than half year. (Table 2)

A total of 15 organisms grew in the harvested blood cultures, including 10 gram-positive bacterial species, 3 gram-negative bacterial species, and 2 fungal species. The most common organism cultured was staphylococcus epidermidis. Table 3 shows the details of infectious organism types.

Outcomes were also assessed based on having other catheter-related complications, among which occlusion and malposition respectively accounted for 5 line removals, which takes up the highest percentage apart from the infection.

We tried to study some risk factors for complications in infants with PICCs, such as PICU exposure, weight when PICC was inserted, age when PICC was inserted, and catheter dwell time. Some factors of the PICC were included as well. We found that weight when PICC was inserted was associated with an increased risk of complications ($p<0.05$). Catheter dwell time was also a risk factor for non-infectious complications ($p<0.05$). The details are shown in Table 4.

DISCUSSION

Infants with intestinal failure often experience involuntary weight loss because of the malabsorption of the intestine. In order to achieve nutrition goals, parental nutrition is one of the most important parts of. In this way, all of them require central access for nutrition support for quite a long period. Compared with other groups of children with long-time CVCs, these patients seem to have a greater risk of suffering from complications of catheters, as they usually require daily line access for years. Providing adequate nutrition, as well as minimizing complications, are of the utmost importance for these patients, as it permits time for intestinal adaptation to occur.

In most hospitals, CVCs are still the first choice when venous access is needed, because they are easier to properly position and less likely to become infected than other catheters, such as PICCs. However, in many centers, the placement and removal of CVCs requires general anesthesia, and direct dissection of the vein is required for insertion as well. PICC lines are a good alternative to the disadvantages of CVCs, not only because the patient can be placed under local anesthesia, but also because they can be used for longer periods of time.

As several studies have reported, in the pediatric IF population, the CRBSI rate for long-term central catheters ranges from 6.99 to 26.5/1000 catheter days.[5-7] In the other studies involving neonates and children with central lines for a variety of other reasons, the CRBSI rates range from 7.3 to 18.2/1000 catheter days.[8,9] The reason why the rate has such a wide range may be because the patient population is diverse, as the rate in neonates with serious illness as well as low birth weight is much higher than that in older children who require short-term intravenous therapy.

As for our study, the overall incidence of CRBSI was 5.83/1000 catheter days. We did not find an increased incidence rate of CRBSI, although over 30% of the patients in our study had a lower gestational age, and the majority the patients used PICCs for over 42 days. With no higher CRBSI rates, PICC offers an advantage of more stability to be used for a longer time theoretically, which reduces patients' pain. With the recent developments in clinical nursing, most PICCs can be placed without anesthesia. Also, the incidence of other events is low according to our observation. We attribute this to the standard of care in large centers.

To study the underlying risk factors of PICC-related complications, we find that low weight when PICC was inserted is associated with an increased risk of complications as well as low mean weight during the PICC dwelling time. However, we failed to find any significant statistical difference in other risk factors, and the small sample size is probably responsible for this. Although the incidence of complications is almost the same in the group of indwelling PICC for more than 2 weeks and within 2 weeks, we found that in the former group, the CRBSI took the majority while in the latter the non-infectious complications took place more often. Therefore, we speculate that with the time going on, the incidence of infectious complications increase while non-infectious complications decrease.

It should be noted that the strict criteria we defined for CRBSIs may be one reason for the low incidence. Also, for infants, invisible infections with few symptoms may be ignored. Our study is retrospective in design and lacks a true control group, and we do not think the historical control group of infants who received a primary tunneled CVC for long-term PN support is comparable as the nursing and management between different centers differs so much.

An increasing number of studies have focused on methods to reduce the incidence of CRBSI. As reported, ethanol lock seems to be sufficient in lowering; however, further study is required to determining whether it lead to some severe side effects.[10,11] In conclusion, we recommend that clinicians could choose PICCs in patients who require long-term PN in the first place, and antimicrobial agents for gram-positive cocci should be the first choice when infection is suspected according to organism culture results. We believe that with the continuing developments in daily nursing of the catheters, the prognosis will be much better.

Limitation

The limitation of the article was that the current number of patients was small. This may because intestinal failure was a rare disease, and the design was limited by being retrospective and at a single center. Therefore, a multicenter prospective study on prognosis-related factors will be required.

Conclusion

As a good alternative to tunneled CVC, we did not find an increased incidence rate of CRBSI in using PICC as an access of long-term PN. Also, as PICCs offer an advantage over CVCs in placing and nursing, we recommended PICCs as the first choice in patients with IF who need long-term PN. Though national efforts have reduced the risk of complication a lot, but further efforts are needed to improve the patient prognosis, as well as the healthcare costs.

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AUTHOR DISCLOSURE

The authors declare no conflict of interest.

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REFERENCES

1. O'Keefe SJ, Buchman AL, Fishbein TM, Jeejeebhoy KN, Jeppesen PB, Shaffer J. Short bowel syndrome and intestinal failure: consensus definitions and overview. Clin Gastroenterol Hepatol. 2006; 4:6-10.
2. Jones BA, Hull MA, Richardson DS, Zurakowski D, Gura K, Fitzgibbons SC et al. Efficacy of ethanol locks in reducing central venous catheter infections in pediatric patients with intestinal failure. J Pediatr Surg. 2010;45:1287-93.
3. Wales PW. Surgical therapy for short bowel syndrome. Pediatr Surg Int. 2004;20:647-57.
4. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO et al. Guidelines for the prevention of intravascular catheter-related infections. Am J Infect Control. 2011;39(4 Suppl 1):S1-34.
5. Onder AM, Kato T, Simon N, Rivera-Hernandez M, Chandar J, Montane B et al. Prevention of catheter-related bacteremia in pediatric intestinal transplantation/short gut syndrome children with long-term central venous catheters. Pediatr Transplant. 2007;11:87-93.
6. Mouw E, Chessmana K, Lesherb A, Taggeb E. Use of an ethanol lock to prevent catheter-related infections in children with short bowel syndrome. J Pediatr Surg. 2008;43:1025-9.
7. Ardura MI, Lewis J, Tansmore JL, Harp PL, Dienhart MC, Balint JP. Central catheter-associated bloodstream infection reduction with ethanol lock prophylaxis in pediatric intestinal failure: broadening quality improvement initiatives from hospital to home. JAMA Pediatr. 2015;169:324-31.
8. Randolph AG, Brun-Buisson C, Goldmann D. Identification of central venous catheter-related infections in infants and children. Pediatr Crit Care Med. 2005;6(3 Suppl):S19-24.
9. Süner A, Karaoğlan I, Mete AO, Namiduru M, Boşnak V, Baydar I. Assessment of bloodstream infections and risk factors in an intensive care unit. Turk J Med Sci. 2015;45:1243-50.
10. Abu-El-Haija M, Schultz J, Rahhal RM. Effects of 70% ethanol locks on rates of central line infection, thrombosis, breakage and replacement in pediatric intestinal failure. J Pediatr Gastroenterol Nutr. 2014; 58:703-8.
11. Wales PW, Kosar C, Carricato M, de Silva N, Lang K, Avitzur Y. Ethanol lock therapy to reduce the incidence of catheter-related bloodstream infections in home parenteral nutrition patients with intestinal failure: preliminary experience. J Pediatr Surg. 2011;46:951-6.

Table 1. Patient characteristics

Total no.	43
Etiology of intestinal failure (%)	
Intestinal Atresia	14 (32.6)
NEC	11 (25.6)
Volvulus	6 (14.0)
Intestinal neuronal dysplasia	4 (9.3)
Postoperative intestinal necrosis	4 (9.3)
Hirschsprung disease	2 (4.7)
Intestinal malrotation	1 (2.3)
Congenital short bowel syndrome	1 (2.3)
Median gestational age at birth, wk	37.3 (31-40)
Males (%)	24 (55.8)
Median length of remaining small bowel, m	0.652 (0.15-1.65)
Median weight insert PICC, kg	4.210 (1.55-13.6)
Median duration of PN, days	105.2 (34-280)

Table 2. PICC characteristics

Total no. PICCs	66
Total catheter days	2563
Median no. PICCs per patient	1.6 (1-4)
Mean no. days with PICC per patient	59.7 (7-260)
PICC size (%)	
1.9-F single lumen	60 (90.9)
3-F single lumen	6 (9.0)
Reason for removal (%)	
Discharged	37 (56.1)
Infected	15 (22.7)
Occluded	5 (7.6)
Malposition	5 (7.6)
Swelling	2 (3.0)
Leakage	1 (1.5)
Broken	1 (1.5)

Table 3. Organisms cultured from catheters

Total no. infections	15
Organism	No. infection (%)
Gram-positive bacterial species	10 (73.3)
Staphylococcus epidermidis	5 (33.3)
Staphylococcus aureus	2 (13.1)
Staphylococcus saprophyticus	1 (6.7)
Staphylococcus capitis	1 (6.7)
Enterococcus faecalis	1 (6.7)
Gram-negative bacterial species	3 (20.0)
Escherichia coli	2 (13.1)
Acinetobacter baumannii	1 (6.7)
Fungal species	2 (13.1)
Candida tropicalis	2 (13.1)

Table 4. Risk factors for complications in infants with PICCs

Variable	Complication Number (%)	*p* value	CRBSI (%)	*p* value	No CRBSI (%)	*p* value
Sex						
Male (n=25)	13 (54.2)		8 (33.3)		8 (33.3)	
Female (n=19)	9 (47.4)	0.658	5 (26.3)	0.619	5 (26.3)	0.619
Gestational age						
Mature=0 (n=28)	15 (55.6)		9 (33.3)		8 (29.6)	
Premature=1 (n=16)	7 (43.8)	0.454	4 (25.0)	0.565	5 (31.3)	0.911
The length of remaining small intestine						
≤75 (n=28)	12 (42.9)		8 (28.6)		7 (25.0)	
>75 (n=16)	10 (66.7)	0.137	5 (33.3)	0.746	6 (40.0)	0.307
Birth weight						
＜2500=0 (n=11)	4 (36.4)		3 (27.3)		2 (18.2)	
≥2500=1 (n=33)	18 (56.3)	0.255	10 (31.3)	0.809	11 (34.4)	0.313
Age when PICC was inserted						
<90d (n=19)	8 (44.4)		6 (33.3)		2 (11.1)	
≥90d (n=48)	21 (43.8)	0.960	9 (18.8)	0.208	12 (25.0)	0.219
Weight when PICC was inserted						
≥4 (n=22)	5 (22.7)		3 (13.6)		2 (9.1)	
<4 (n=45)	24 (54.5)	0.014	12 (27.3)	0.213	12 (27.3)	0.089
Mean weight during the PICC dwelling						
≥4 (n=26)	7 (26.9)		4 (15.4)		3 (11.5)	
<4 (n=41)	22 (55.0)	0.025	11 (27.5)	0.251	11 (27.5)	0.121
PICU Exposure						
Yes (n=34)	17 (51.5)		8 (24.2)		9 (27.3)	
No (n=33)	12 (36.4)	0.215	7 (21.2)	0.769	5 (15.2)	0.228
Size of PICC						
3f (n=6)	1 (16.7)		1 (16.7)		0 (0)	
1.9f (n=61)	28 (46.7)	0.158	14 (23.3)	0.710	14 (23.3)	0.183
Site of PICC Insertion†						
Upper Extremity (n=51)	25 (50.0)		13 (26.0)		12 (24.0)	
Lower extremity (n=12)	4 (33.3)		2 (16.7)		2 (16.7)	
Head and neck (n=4)	0 (0)	0.109	0 (0)	0.421	0 (0)	0.482
Catheter dwell time						
>14d (n=47)	19 (40.4)		12 (25.5)		7 (14.9)	
≤14d (n=20)	10 (52.6)	0.366	3 (15.8）	0.392	7 (36.8)	0.048