Survey of the Use of Peripherally Inserted Central Venous Catheters in Children

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ABSTRACT. *Objective.* **Use of peripherally inserted central venous catheters (PICCs) to provide prolonged intravenous (IV) access in children is increasing. Our goal was to describe the children treated with PICCs in our institution, and to study catheter features such as catheter life, completion of therapy, and complications. Furthermore, we also evaluated PICC use in children completing therapy after discharge from our institution.**

Methods. **A prospective study of all PICCs inserted at the Children's Hospital and Medical Center (CHMC), a university-affiliated teaching institution, during a period of 18 months (January 1994 to July 1995).**

Results. **A total of 441 PICCs were inserted in 390 patients. Patient age ranged from 0 to 22 years with a mean of 5.4 ± 6.0 years. No insertion complications occurred. Treatment of infectious disease (46%) was the most frequent reason for PICC insertion. All pediatric medical and surgical services used PICCs. Average catheter life was 13 ± 12 days. Sixty-one percent of PICCs were used entirely at CHMC, while 39% were also used at home or at an outside hospital. Completion of therapy was achieved in 69% of PICCs. Among children who completed therapy outside our hospital, there was no difference in the rates of occlusion, accidental dislodgment, or infection.**

One hundred twenty-nine (29%) PICCs were removed for complications. Occlusion (7%), accidental displacement (8%), and suspicion of sepsis (8%) were the most common complications. Only 2% of PICCs had documented catheter-associated sepsis.

Conclusions. **PICCs provide reliable and safe access for prolonged IV therapy in neonates and children. The low incidence of complications with PICCs make them an attractive device for prolonged IV access. Similar complication rates with use in and out of hospital suggest that home IV therapy can be safely delivered with PICCs, avoiding expensive hospitalization.** *Pediatrics* **1997;99(2). URL: http://www.pediatrics.org/cgi/content/full/99/2/e4;** ***peripherally inserted central venous catheter, vascular access, catheter related sepsis, completion of therapy, occlusion, accidental dislodgment, home therapy, phlebitis.***

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ABBREVIATIONS. PICC, peripherally inserted central venous catheter; IV, intravenous; TPN, total parenteral nutrition; CHMC, Children's Hospital and Medical Center; SVC, superior vena cava; IVC, inferior vena cava.

Peripherally inserted central venous catheters (PICCs) are frequently used to provide prolonged intravenous (IV) access in both acute and home care settings. Shaw described PICC use in 1973 as a method of providing reliable vascular access for total parenteral nutrition (TPN) in neonates.[1,2] PICCs were subsequently used to provide IV access for administration of prolonged antibiotic courses in children with cystic fibrosis during pulmonary exacerbations.[3] PICCs lasted twice as long as conventional peripheral IV cannulae, reducing the number of venipunctures by half and enabling home therapy.[3] PICC utilization has continued to increase because these catheters are easy to insert and have a low incidence of complications compared with other surgically placed central lines.[2,4–10]

PICCs are made of biocompatible material, usually polyurethane or silicone. Insertion is simple and is usually done by nursing personnel who have completed a recommended certification process.[6] The success rate for insertion of PICCs ranges from 78% to 92%.[4,5,11,12] Veins of the antecubital fossa are commonly used; however, the saphenous, axillary, or even scalp veins can be used.[3,6,9] Complications associated with PICC insertion are infrequent, but include bleeding, tendon or nerve damage, cardiac arrhythmias, chest pain, catheter malposition, and catheter embolism.[5–7]

Few studies have examined the use of these catheters in a large pediatric population. We examined PICC utilization in a university-affiliated children's hospital. Our goals were to describe the patient population treated with PICCs as well as catheter features such as average catheter life, completion of therapy, reasons for removal, and complications. Finally, we compared PICC-related data of children receiving therapy at home, or at an outside hospital, with those hospitalized for the entire time of PICC use.

METHODS

Information was prospectively collected on all PICCs inserted at Seattle Children's Hospital and Medical Center (CHMC) during an 18-month period from January 1994 to July 1995. PICCs were inserted primarily by the IV nursing team. Referrals for catheter

placement occurred at the discretion of the patient's primary physician and were made directly to the IV team.

All insertions were done as inpatient procedures. Per-Q-Cath (Gesco Inc, San Antonio, TX) or L-Cath (Luther Medical Products Inc, Tustin, CA) catheters of sizes ranging from 2- to 5-French (catheter size 23-gauge to 16-gauge) were used. The size and choice of catheter was determined by the IV team member inserting the catheter. Anesthesia was provided with 1% lidocaine local infiltration or EMLA cream (Astra Pharmaceuticals, Westborough, MA), supplemented when needed with oral chloral hydrate or IV midazolam.

Patient preparation and insertion techniques were standardized by hospital protocol. After a suitable vein for insertion was identified, the area of skin at the proposed insertion site was cleaned with povidone-iodine solution, and covered with sterile drapes. The IV team member inserting the catheter wore a cap, mask, sterile gown, and sterile gloves. After infiltrating the site with 1% lidocaine, the vein was punctured using the introducer needle. The catheter was then inserted through the needle, to a premeasured length. The needle was then removed and the exit site was dressed with dry sterile gauze. The dressing was changed every week, or earlier if soiled. The location of the catheter tip was determined radiographically. When the tip was not easily visible by the plain radiograph, contrast material injected through the catheter was used to delineate the tip. The tip was considered to be in a central vein if it was placed in the superior vena cava (SVC), the inferior vena cava (IVC), or subclavian vein. Afterwards, catheter care was administered by the nurses caring for the patient. At insertion, patient demographic information was recorded on a log sheet by the IV team member inserting the catheter. The IV team monitored these catheters closely and recorded complications for the duration of catheter use on the log sheet.

PICCs were used for IV fluid therapy, administration of medication, and blood products. TPN solutions with dextrose concentrations of more than 12.5% were administered through centrally placed catheters. Catheters were accessed continuously or intermittently. For PICCs accessed continuously, the use of heparin to maintain line patency was at the discretion of the primary physician. When PICCs were accessed intermittently, they were flushed with heparin-containing saline solution after each use. Insertion and removal complications were noted. For patients who were discharged home or to another institution with a catheter in situ, care was given by local nursing personnel, maintaining telephone contact with the IV team at CHMC.

PICCs were removed for various reasons including: completion of therapy, occlusion, accidental dislodgement, and suspicion of catheter-associated infection. The following definitions were used to define infectious complications: 1) phlebitis was defined as inflammation tracking along the course of the vein from the insertion site, with or without a palpable venous cord; 2) exit-site infection was present when inflammation and purulent discharge were noted at the insertion site; and 3) catheter-associated sepsis was diagnosed in patients with fever without another identifiable source, who had a positive blood or catheter-tip culture (Maki roll technique).

To compare catheter use and function in different age groups, patients were divided into four groups: 0 to 30 days old; 31 days to 1 year old; 1 to 5 years old; and older than 5 years. Continuous data were compared with analysis of variance and the t test. Adjustments for multiple comparisons were done with the Tukey-B test. Categorical data were compared using the χ^2 and Fisher's exact tests. Significance was defined as $P < .05$.

RESULTS

A total of 444 PICCs were inserted in 390 patients during the 18-month period. Data was complete for 441 of 444 PICC insertions. Demographic information of the study subjects is presented in Table 1. The median age of patients in the group was 3.4 years (range 0 days to 22 years). No complication from insertion was noted.

Catheter size ranged from 2- to 5-French (Table 2). Three-French catheters were most frequently used in all ages (48%). Two-French was the most commonly used catheter size in the 0 to 30 day group (93%) and in infants 31 days to 1 year old (85%), while 3-French was most commonly used in children 1 to 5 years old (60%) and older than 5 years (82%). The veins most commonly accessed were antecubital (89%). The tip was located in a central location in 53% of insertions and a peripheral location in 47% of insertions.

TABLE 1. Patient Demographic Information

	n (%)
Total number of patients	390
Total PICC lines (N)	441
Males	252 (57)
Females	189 (43)
Age	
0–30 days	118 PICCs (27)
30 days–1 year	66 PICCs (15)
1–5 years	62 PICCs (14)
>5 years	195 PICCs (44)
CHMC use only	271 (62)
Outside use	170 (38)

Abbreviations: PICC, peripherally inserted central venous catheters; CHMC, Children's Hospital and Medical Center.

TABLE 2. Catheter Characteristics

	n	%
Catheter size		
2-French	192	43
2.7-French	1	0.2
3-French	212	49
4-French	31	7
5-French	5	1
Veins accessed		
Antecubital	393	89
Saphenous	37	9
Others	11	3
Tip placement		
Deep arm	178	40
Superior vena cava	106	24
Subclavian	99	22
Deep leg	18	4
Right atrium	12	3
Inferior vena cava	10	2
Iliacs	8	2
Not recorded	10	2

Antecedent medical diagnosis and services referring patients for PICC placement are outlined in Tables 3 and 4. Treatment of infectious disease was the most common cause for PICC insertion (46%). Referral for PICC insertion was most commonly made by the general pediatric service (20%); however, PICCs were used by most pediatric medical and surgical subspecialty services.

Sixty-one percent of PICCs were used entirely in CHMC, while 39% were also used at home or in a referring community hospital. The average catheter life was 13 ± 12 days. Neither patient age nor catheter lumen size were significantly related to catheter life. Catheter lives for each lumen size were 2-French (12.9 days), 2.7-French (11 days), 3-French (12.4 days), 4-French (16.6 days), and 5-French (13.4 days). Completion of therapy was achieved with 69% of catheters. Significantly fewer PICCs used entirely at CHMC (69%) completed therapy compared with those used outside the institution (77%), ($P = .01$).

A total of 129 PICCs (29%) were removed for complications (Table 5) with accidental dislodgement

TABLE 3. Antecedent Diagnosis

Diagnosis	n	%
Infectious diseases	205	46
Prematurity	77	18
Cystic fibrosis	51	12
Malignancy	27	6
Surgical abdomen	21	5
Inflammatory bowel disease	5	1
Dehydration	5	1
Miscellaneous	49	11
Not recorded	1	0.2

TABLE 4. Referring Services

Service	n	%
General pediatrics	90	20
Neonatal ICU	76	17
Pulmonary	66	15
General surgery	65	15
Hematology-oncology	32	7
Cardiothoracic surgery	20	5
Renal	16	4
Pediatric intensive care unit	11	3
Gastroenterology	9	2
Cardiology	5	1
Other medical services	5	1
Other surgery	44	10
Not recorded	2	0.5

(8%), suspected infection (8%), and occlusion (7%) being the most common reasons. No increase in occlusion rate between home and hospital use was found. Occlusion was significantly more common with smaller lumen sizes. Eleven percent of 2-French catheters became occluded compared with 4% of 3-French and 7% of 4-French catheters. Accidental dislodgement was more common with older infants 31 days to 1 year old and children 1 to 5 years old (17% and 11.3%, respectively) than in those 0 to 30 days old or children older than 5 years (5.9% and 4.6%, respectively). The influence of the methods used to secure PICCs on the incidence of dislodgement could not be determined. Rate of dislodgement did not differ between out of CHMC use and CHMC use.

A total of 37 PICCs (8%) were removed for suspected catheter infection. Fourteen PICCs (3%) were removed because of fever without another identifiable source. Nine (2%) were associated with a positive blood or catheter tip culture (catheter-associated sepsis). Of these, 8 PICCs were used only in CHMC, while 1 PICC was used outside CHMC. Coagulase negative staphylococcus species, enterococcus, *Escherichia coli*, and candidia species were the organisms cultured from blood or catheter tip in patients with documented catheter-associated sepsis. Eight PICCs (2%) were removed due to purulent drainage and inflammation at exit site. Of these, 6 PICCs were used in CHMC and 2 outside. Phlebitis resulted in the removal of 16 PICCs (3.6%)—10 during use at CHMC compared with 6 during outside use. Patients whose PICCs were removed for exit site infection or phlebitis did not have fever or other signs of systemic sepsis.

TPN solutions were administered in 34% of catheters. TPN administration did not decrease catheter life (14.1 days) compared with catheters not used for

TABLE 5. Reason for Removal of Peripherally Inserted Central Venous Catheters: CHMC vs Outside Use

Reason	Total n (%)	CHMC Use n (%)	Outside Use n (%)
Total number	441	271	170
Therapy complete	305 (69)	175 (65)	130 (77)
Suspected infection	37 (8)	28 (10)	9 (5)
Occlusion	32 (7)	20 (7)	12 (7)
Accidental dislodgement	34 (8)	21 (8)	13 (8)
Leakage	7 (2)	6 (2)	1 (1)
Breakage	8 (2)	6 (2)	2 (1)
Infiltration	9 (2)	8 (3)	1 (1)
Catheter rupture	2 (1)	1 (0.4)	1 (1)
Placement incorrect	2 (1)	2 (1)	0 (0)
Removed after death	5 (1)	4 (2)	1 (1)

Abbreviation: CHMC, Children's Hospital and Medical Center.

TPN administration (12.2 days). Seven cases of catheter-associated sepsis occurred in children receiving TPN; however, this association was not statistically significant. No complications were noted during catheter removal and no deaths were directly attributed to PICC use.

One infant developed bilateral pleural effusions 1 week after PICC placement for TPN administration with the catheter tip located in the SVC. Fluid drained from the pleural space had glucose and triglyceride levels similar to the TPN administered through the PICC, which was removed. The pleural effusions did not recur and the infant recovered.

DISCUSSION

Our study demonstrated that PICCs are a safe and reliable IV access device in neonates and children. They are also safe in the home setting if parents and home nursing personnel are properly instructed in catheter care and recognition of catheter complications.

In our study, PICCs were used by a wide range of pediatric subspecialties, therapy was completed in two thirds of PICCs inserted and the incidence of phlebitis and catheter-associated sepsis was low. Patients using PICC for therapy outside our institution had similar catheter life and completion of therapy rates. Complications associated with PICC use outside were fewer compared with their exclusive hospital use. This is not surprising because hospitalized children are typically sicker and have increased risk of nosocomial infections and exposure to multiple medications, increasing the risk of thrombophlebitis.

Prior reports of therapy completion have ranged from 50% to 96% in patients with a single PICC.[6,8] Our study demonstrated therapy completion in 69% of PICCs. The increased occlusion rate in smaller-lumen catheters, however, did not significantly lower the rate of completion of therapy in infants compared with older children. PICCs in our study were used in many patients who required prolonged IV access. An average catheter life of almost 2 weeks provided prolonged uninterrupted IV access. The longest catheter life in our study was 132 days. No limits as to the duration of leaving the catheter in situ have been established.[6,13]

No complications were related to catheter insertion. Risks associated with placement of PICCs are

very low; thus, catheters can be replaced at another site without putting a patient at significant risk.[9,10] Furthermore, accessibility of peripheral veins for compression make control of bleeding easy during insertion. Therefore, PICCs can be used safely in patients with a bleeding diathesis to provide central access for therapy.[9]

About 30% of PICCs in our study were removed for complications. Occlusion was more common in 2-French catheters (the smallest lumen) than with others. This finding is similar to the study in adults, where occlusion was more common in smaller catheters (18-gauge vs 20-gauge).[9] Occlusion can sometimes be relieved by flushing with urokinase.[6,8,9] However, excessive force to flush catheters may result in catheter rupture or cause thromboembolism.[9] Occluded catheters that cannot be relieved with gentle flushing should be removed and replaced.[9] Although catheters can break or rupture at the external portion, they can be repaired with the repair kit supplied without having to replace the catheter.[6]

Catheter-associated sepsis requires removal of the catheter and appropriate antibiotic therapy. The incidence of catheter-associated sepsis with PICCs ranged from 0 to 2.2% in previous studies.[6,8,9,12] In our study, the incidence of catheter-associated sepsis (2%) was similar to previous reports and lower than catheter-associated infection associated with other central venous devices (3% to 20%) or peripheral venous catheters (4.6% to 9%).[9,10,14,15] The incidence of infections tended to be higher with PICCs used in the hospital and with TPN administration; however, this was not statistically significant.

The occurrence of pleural effusion in one patient was a serious complication of PICC use. Although, no complications were noted with PICC removal, difficulty with removal attritubable to fibrin deposition around the catheter may occur as a rare complication.[6]

In conclusion, PICCs are a reliable method of providing prolonged IV therapy in children of all ages. Decreased number of catheter placements, compared with peripheral IV catheters per therapy, can be expected to decrease patient pain and apprehension.[3,4,6–8] PICCs have fewer insertion and infectious complications compared with other central venous devices. Furthermore, these catheters allow safe completion of IV therapy outside the hospital setting, saving continued expensive hospitalization. Measures to prevent accidental dislodgement in infants and children younger than 5 years old must be reinforced. Care givers of patients discharged home with an indwelling catheter must be taught good aseptic techniques and be advised to seek medical advice if the patient develops fever or catheter-related pain. PICCs can provide safe and prolonged IV access for neonates and children in the hospital or home setting.

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