ORIGINAL ARTICLE

Comparison of Outcomes of Extended Dwell/Midline Peripheral Intravenous Catheters and Peripherally Inserted Central Catheters in Children

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Abstract

Background: *Insertion of extended dwell/midline peripheral intravenous (EPIVs) catheters is not common practice in pediatric hospitals. An interdisciplinary team in 1 pediatric hospital developed a venous access decision tree based on current standards that included EPIVs. The purpose of this evaluation was to assess the process and pediatric patient outcomes associated with use of EPIVs and with peripherally inserted central catheters (PICCs).*

Methods: *A retrospective record review over 22 months was conducted for 375 patients who received either a PICC (67.5%) or EPIV (32.5%). Data collected included patient demographic characteristics, diagnosis category, type and purpose of the line, insertion and removal dates, catheter size, placement location, and complications encountered.*

Results: *EPIVs were inserted with a 1.9F or 3F catheter, whereas PICCs generally used a 3F or 4F catheter. EPIVS were more commonly inserted in children younger than age 1 year, whereas children aged ≥ 11 years more often had a PICC inserted. EPIVs remained in place an average of 9 days compared with 20 days for PICC lines. Significantly more complications occurred during the placement of PICCs, whereas EPIVs had more complications during use such as leakage, dislodging, and infiltration.*

Conclusions: *EPIVs were a successful alternative to PICC or peripherally inserted venous catheters for children in an inpatient acute-care facility who need 30 days or fewer of nonvesicant intravenous therapy. The venous access decision tree provided useful guidance in determining the appropriate venous access device for pediatric patients and the decision tree was adhered to by the vascular access team.*

Keywords: *extended peripheral intravenous, midline intravenous catheters, pediatric vascular access, vascular access decision tree*

Introduction

Vascular access in hospitalized pediatric patients poses many challenges. Maintenance and preservation of vascular access is an important patient safety and quality concern. In our 263-bed full-service free-standing children's hospital, and in most other hospitals,[1] more than 90% of pediatric patients have some type of vascular access device placed while in the hospital.

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http://dx.doi.org/10.1016/j.java.2016.03.007

Background

Short peripheral intravenous (PIV) catheters, typically the first choice for obtaining vascular access, are appropriate for short-term, nonvesicant therapies and can be placed by staff nurses or the vascular access team. Although PIVs are relatively easy to place, they typically have short dwell times, particularly in neonates,[2] and require frequent replacement as a result of infiltration, leakage, occlusion, or dislodgement.[3] These limitations can lead to multiple attempts at reinsertion, causing patient pain and anxiety.

Peripherally inserted central catheters (PICCs) have been widely used in pediatrics as a less invasive means of gaining access to central vessels for long-term venous access or infusion of caustic agents. PICCs have also become widely used when a PIV is difficult to access or maintain. Unfortunately, there is greater risk of bloodstream infection with central venous catheters, including PICC lines, compared with peripheral lines.[4,5] Therefore, reduction of the use of PICC lines is a goal.

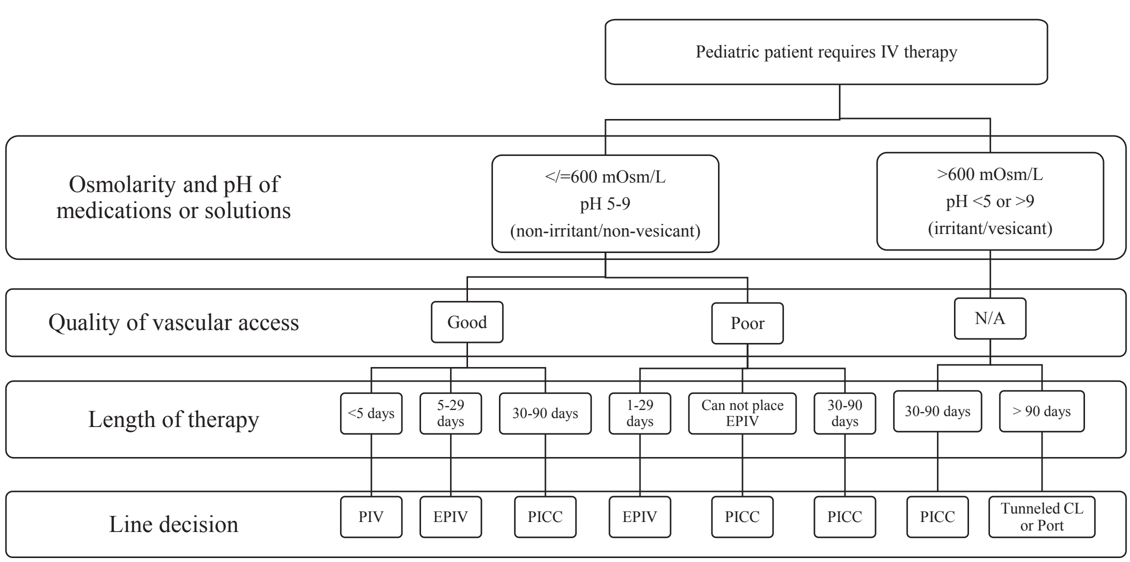
Extended dwell/midline peripheral intravenous catheters (EPIVs), which have been used with adults for more than 2 decades, are effective in delivering fluids and medications, and in allowing daily blood draws with a very low rate of infection or phlebitis.[5-7] Appropriate use of these catheters in place of PICC lines has also resulted in a decrease in central line-associated bloodstream infection.[5] EPIV catheters are shorter than PICC lines or central catheters, and may dwell in a peripheral vein for up to 29 days,[8-10] although in 1 study of 140 midline catheters, some were in place as long as 49 days without incident, prompting O'Grady et al[7] to recommend that extended dwell/midline catheters be replaced only when there is a specific indication. In children, EPIVs may be inserted in the upper or lower extremities or scalp.[7,11] EPIVs can often be inserted without sedation and do not require fluoroscopy for placement, thus avoiding exposure to radiation. Despite the potential benefits and low risks, EPIVs to date have not been widely used in pediatric populations.

Similar to other institutions,[12] the use of EPIVs in our pediatric hospital began in the neonatal intensive care unit with positive results. In 2013, vascular access nurses initiated placing EPIVs in other pediatric patient populations. Originally, EPIVs were considered a bridge between PIVs and PICCs for patients requiring reliable, noncentral access. The use of EPIVs was successfully expanded to include placement when venous access for longer periods of time was required, for infusing noncaustic agents such as pain medication or sedation, and in ventilated patients with respiratory syncytial virus or bronchiolitis who needed venous access for sedation drips. Other examples included cardiac pediatric patients requiring venous access as a precaution for their entire length of stay and patients receiving nonvesicant antibiotics for bacterial infections. Because EPIV lines can be used in children of all ages and in any area of the hospital they have provided a dependable venous access and a safe alternative to PICC line placement.

Venous Access Decision Tree

Choosing the most appropriate venous access device for pediatric patients can be challenging. As an aid in decision making, the vascular access team, in collaboration with physicians and pharmacists, developed a venous access decision tree (see the Figure). The tool was developed based on current Infusion Nursing Standards of Practice related to venous access device selection and placement[8] and is used regularly to guide clinicians in determining the safest and most appropriate venous access device for patients. Venous access devices included on the decision tree are PIVs, EPIVs, PICCs, and central lines.

As illustrated in the Figure, there are 2 main categories of infusates on the decision tree based on the drug's osmolarity and pH. Irritants and vesicants have an osmolarity > 600



Note: PIV = Peripheral intravenous catheter; EPIV = Extended dwell intravenous catheter; PICC = Peripherally inserted central catheter; CL = Central line

Figure. **Vascular access decision tree.**

mOsm/L and/or a pH < 5 or > 9. Nonirritant and nonvesicant infusates have an osmolarity ≥ 600 mOsm/L or less and a pH between 5 and 9. For a table of infusion drugs, their pH, osmolarity and reported phlebitis, see http://www.ctins.org/Marc%20Stranz%20Understanding%20pH%20and%20Osmolarity%20INS%202008.pdf.

Once the osmolarity and the pH of the solution are determined, the quality of vascular access sites and expected length of therapy are assessed. PIVs are placed in patients who have good venous access sites and who will receive nonvesicant medications for less than a week. EPIVs are placed in patients with good or limited venous access sites and who require 5-29 days of nonvesicant therapy. PICCs are placed in patients who require 30-90 days of therapy, or are receiving vesicant therapy, or for whom EPIV placement was unsuccessful. Tunneled and cuffed central line catheters are placed in patients requiring therapy for > 90 days.

EPIV Procedures

EPIVs are placed in upper extremities, lower extremities, or the scalp.[8] Insertion of EPIVs is a sterile procedure.[9] In our institution, vein capture is accomplished with a 22-gauge breakaway introducer for 3F catheters and a 26-gauge breakaway introducer for 1.9F catheters. The 1.9F catheters are 6 cm or 8 cm in length, whereas 3F catheters are 8 cm in length. EPIV catheters do not terminate in joint spaces or enter central circulation. EPIV catheters do not extend past the axilla, the external jugular, or enter the pelvic region.[7,8] EPIVs are placed at the bedside and do not require radiologic confirmation. EPIVs are not placed in patients with a history of a positive blood culture until a subsequent blood culture is negative or the patient has been on antibiotics for 48 hours. Patients are not sent home with EPIVs. EPIVs are maintained similarly to central lines and the vascular access team assesses sites daily. The EPIV dressings are changed every 7 days or if the dressing becomes soiled or nonocclusive. To prevent line occlusions, 1.9F catheters require continuously infused heparinized fluids at a slow rate to keep the vein open. A multidisciplinary team developed a standing order for heparinized fluids through the policy and procedure process.

Although vascular access team members reported observing positive outcomes with EPIVs, the team determined there was a need for a more systematic evaluation. The overall goal of this evaluation was to determine whether the vascular access decision tree had been successfully implemented with regard to EPIVs and PICC lines. A retrospective chart review was completed to evaluate the process and outcomes associated with use of EPIVs compared with the use of PICCs. The specific evaluation questions were:

1. How do pediatric patient characteristics differ for children with an EPIV compared with those with a PICC line?
2. Are there differences between EPIV and PICC lines used in pediatric patients with regard to catheter size, placement site, purpose, complications, and dwell days?
3. What specific complications were encountered with the EPIV lines during use and did these complications differ by patient characteristics?

Methods

After receiving approval from the University of Louisville Institutional Review Board, the contract review board for this hospital system, the team conducted a retrospective record review of all children who received a PICC or EPIV placed by a vascular access team nurse between May 1, 2013, and March 31, 2015. Neonates admitted to the neonatal intensive care unit were excluded from the study because their PICC and EPIV lines were placed by other practitioners. Neonates in other areas of the hospital were included.

Members of the research team collected demographic data, including age, sex, and diagnosis category (medical, surgical, or oncology) from the institution's electronic health record. Data were also collected concerning the type of line (EPIV or PICC), purpose of the line, insertion and removal dates, size of the catheter, placement location on the body, and any complications encountered during insertion of the line or during use (Table 1).

Extracted, de-identified data were entered into a Microsoft Excel (Redmond, WA) spreadsheet and then uploaded into IBM-SPSS Statistics version 22.0 (Armonk, NY) software and analyzed. Descriptive statistics were used to describe the sample. Comparisons of characteristics and outcomes between PICC lines and EPIVs were analyzed using nonparametric (χ^2 or ϕ) and parametric (t tests) depending on the level of the data. Alpha was set a priori at 0.05.

Results

Patient Characteristics

Between May 2013 and March 2015 there were 375 EPIV/PICC lines inserted in the facility by the vascular access team. The majority (67.5%) were PICC lines (Table 1). Significantly more children younger than age 1 year had an EPIV inserted (53.7% vs 17.7%) and significantly more children older than age 11 years had a PICC line inserted (10.7% vs 43.9%) ($\chi^2 = 68.4$; $df = 5$; $P < .001$). EPIV and PICC lines were inserted more often in boys than girls and in patients with a medical diagnosis compared with surgical or oncology patients. These differences were not statistically significant. Although the majority (71%) of PICC lines were inserted in the upper arm (brachial/basilic veins), significantly more EPIVs were inserted in either the antecubital/cephalic area (36%) or the lower extremities (22%) ($\chi^2 = 160$; $df = 4$; $P < .001$). Most EPIV and PICC lines were successfully inserted (86% and 87%, respectively).

Catheter Type, Placement Site, Purpose, and Dwell Days

Per protocol, all EPIVs were inserted with a 1.9F or 3F catheter and the insertions occurred either in the pediatric intensive care unit (70%) or on a medical/surgical unit (29%). PICC lines were generally inserted with a 3F or 4F catheter (78.8%) in the interventional radiology area (63%) or the PICU (26%). The primary rationale for insertion of EPIV and of PICC lines was to infuse antibiotics (with or without other medications) (55%). EPIVs were also largely inserted to maintain vascular access for infusion of other medications (43%). PICC lines were inserted to maintain vascular access

Table 1. **Patient Characteristics and Outcomes of Extended Dwell/Midline Peripheral Intravenous Catheters (EPIVs) and Peripherally Inserted Central Intravenous Catheters (PICCs) in Pediatric Patients (N = 375)**

Characteristic	EPIV (n = 122) n (%)	PICC (n = 253)
Age of patient (y)		
< 1	65 (53.7)	44 (17.7)
1-2	13 (10.7)	29 (11.7)
3-5	18 (14.9)	26 (10.5)
6-10	12 (9.9)	40 (16.1)
11-15	5 (4.1)	75 (30.2)
16-20	8 (6.6)	34 (13.7)
Sex of patient		
Female	54 (44.3)	112 (44.3)
Male	68 (55.7)	141 (55.7)
Patient diagnosis category		
Medical	89 (73.6)	164 (66.4)
Surgical	25 (20.7)	73 (29.6)
Oncology	7 (5.8)	10 (4.0)
Placement site		
Antecubital/cephalic	38 (35.8)	44 (20.0)
Brachial/basilic/upper arm	3 (2.8)	156 (70.9)
Wrist/hand/forearm	13 (12.3)	3 (1.4)
Scalp	29 (27.4)	17 (7.7)
Lower extremities	23 (21.7)	0
Successfully inserted catheter size	105 (86.1)	220 (87.3)
1.9F	56 (52.8)	1 (0.5)
2.6F	0	32 (14.5)
3F	50 (47.2)	62 (28.1)
4F	0	112 (50.7)
5F	0	14 (6.3)

(Continued)

Table 1. ***(Continued)***

Characteristic	EPIV (n = 122) n (%)	PICC (n = 253)
Area of hospital where line was placed		
Interventional radiology	0	156 (63.4)
Pediatric intensive care unit	80 (70.2)	63 (25.6)
Medical or surgical unit	33 (28.9)	0
Other	1 (0.9)	27 (11.0)
Purpose of intravenous line		
Antibiotics with/ without other medications	58 (55.2)	112 (51.4)
Vascular access and other medications	45 (42.9)	40 (18.3)
TPN/TPN with medications	0	50 (22.9)
Factor/factor and other meds	2 (1.9)	16 (7.3)
Dwell days		
Mean ± standard deviation	8.9 ± 5.9	19.6 ± 21.5
Median	8.0	13.0
Minimum, maximum	1, 30	3, 148
Complications encountered		
None	58 (48.7)	172 (69.4)
During placement	9 (7.6)	50 (20.2)
During use	52 (43.7)	25 (10.1)

TPN = Total parenteral nutrition.

(18%) and for total parental nutrition (23%). EPIVs remained in place an average of ∼ 9 days compared with ∼ 20 days for PICC lines ($t = 5.0$; $df = 273$; $P < .001$).

Complications Encountered With EPIV and PICC Lines

There were no documented complications for almost half of the EPIVs (49%) and 69% of the PICC lines. For the 136 (37%) lines for which a complication was noted, significantly more complications were documented during PICC placement procedures compared with EPIV placement (20.2% vs 7.6%; $\chi^2 = 9.5$; $df = 1$; $P = .002$) and significantly more complications were documented with EPIV lines during the duration of their use compared with PICC lines (43.7% vs 10.1%; $\chi^2 = 54.5$; $df = 1$; $P < .001$).

There were 52 complications identified with EPIV lines during their use (Table 2). Further exploration regarding these complications revealed that 30.8% (n = 10) of the complications were related to leakage, 26.9% (n = 14) to dislodging, 13.5% (n = 7) were infiltrated, 11.5% (n = 6) to occlusion, 11.5% (n = 6) to thrombophlebitis, and 5.8% (n = 3) were not recorded or had other miscellaneous complications. Analysis of the problem type by patient characteristic indicated that older children were more likely to have an infiltrated EPIV ($\phi = 0.345$; $P = .05$) compared with younger children. EPIVs inserted with 1.9F catheters were significantly more likely to be dislodged compared with EPIVs inserted with 3F catheters (79% vs 21%; $\phi = 0.428$; $P = .003$). There were no statistically significant differences in types of complications encountered regarding the EPIV placement site or length of EPIV insertion.

Discussion

This evaluation is the first to compare the use and outcomes of EPIVs compared with PICC lines in a pediatric inpatient population. The need for more stable peripheral access for pediatric patients who do not necessarily need central intravenous access was identified by the vascular access team. This evaluation showed that EPIVs could be a practical and safe bridge between PIVs and PICC lines for pediatric patients. Findings indicated that the venous access decision tree was adhered to with regard to EPIVs and PICC lines. EPIV insertion only employed 1.9F and 3F catheters, only nonvesicant fluids were administered via EPIVs, and the course of treatment with EPIVs was limited to 30 days or fewer with the average dwell time of 9 days.

About half of those patients with an EPIV during the evaluation period completed their course of treatment without complications, yet the introduction of EPIVs presented the vascular access team with challenges and lessons to be learned. For EPIVs inserted with a 1.9F catheter, the most common problem was dislodgement, which occurred 11 times. Dislodgment occurred after the EPIV was in place for an average of 10 ±

Table 2. Complications Encountered During Extended Dwell/Midline Peripheral Intravenous Catheter Use by Patient Characteristics

Characteristic	Leaking (n = 16) n (%)	Dislodged (n = 14)	Infiltrated (n = 7)	Occluded (n = 6)	Thrombophlebitis (n = 6)
Age of patient					
< 12 mo	8 (50.0)	10 (71.4)	1 (14.3)	4 (66.7)	1 (16.7)
1-5 y	3 (18.7)	2 (14.3)	1 (14.3)	2 (33.4)	1 (16.7)
6-20 y	5 (31.3)	2 (14.3)	5 (71.4)	0	4 (66.7)
Catheter size					
1.9F	5 (31.3)	11 (78.6)	1 (14.3)	4 (66.7)	1 (16.7)
3F	11 (68.8)	3 (21.4)	6 (85.7)	2 (33.3)	5 (83.3)
Placement site					
Brachial/basilic/upper arm	2 (12.5)	0	0	0	0
Hand/wrist/forearm	1 (6.3)	1 (7.1)	2 (28.6)	0	3 (50.0)
Antecubital/cephalic	5 (31.3)	2 (14.3)	2 (28.6)	2 (33.3)	2 (33.3)
Lower extremities	3 (18.8)	8 (57.1)	3 (42.9)	2 (33.3)	1 (16.7)
Scalp	5 (31.3)	3 (21.4)	0	2 (33.3)	0
Dwell days					
1-10	12 (75.0)	9 (64.3)	7 (100)	5 (83.3)	5 (83.3)
11-30	4 (25.1)	5 (35.7)	0	1 (16.7)	1 (16.7)

6.6 dwell days, primarily in patients younger than age 12 months who were not sedated and were active. EPIV leakage generally occurred after the EPIV was in place for 4-5 days. To mitigate the leaking, a securement device and skin closure strips were added to stabilize the catheter under the dressing and an arm board was secured if the EPIV was on an extremity. Another noted problem when EPIVs were first implemented in the institution was occlusion. To prevent occlusions, infusing heparinized fluids was added to the EPIV protocol. In addition, nursing staff members were educated to not use the 1.9F EPIVs for lab draws because this precipitated occlusion.

For EPIVs inserted using 3F catheters, the most common problem was leakage. Although 2 lines leaked within the first 72 hours after insertion, exploration into insertion sites and other potential concerns did not reveal a consistent problem. The vascular access team considered several causes, including the size of the insertion needle and how the line was secured. Neither of these causes was found to have occurred consistently and a root cause for the leaking found with the 3F EPIV catheters has yet to be determined.

Another problem noted in maintaining EPIVs was infiltration of the line. Infiltration occurred in 7 EPIV lines, 6 of which were inserted with a 3F catheter. Three of these lines infiltrated within the first 24 hours of insertion and the problem was attributed to difficult vascular access for those patients. One of the infiltrated EPIVs did not occur till 9 days into treatment. One patient had 3 EPIVs, 2 of which infiltrated and 1 that developed a thrombophlebitis. This child had multiple health problems and received multiple medications, blood products, and lab draws. Mechanical thrombophlebitis was seen with 1 insertion on the top of the hand. The hand/wrist location is not the optimal site, but if this site needed to be used, we recommend close observations for complications. Phlebitis occurred minimally in 4-6 days in EPIV lines but redness was seen at the distal end of the catheter, possibly as a result of a chemical phlebitis from medication and not a mechanical phlebitis from the catheter.

Three additional problems were documented during use of EPIVs that were not otherwise categorized in Table 2. The nature of 2 of these complications was not recorded. The problem that was recorded involved an EPIV catheter that broke in half at the securement hub. This catheter had been in place for more than 20 days, the child was gravely ill and on a ventilator, and the staff turned him from prone to supine every 12 hours. The movement of the frequent turning of the child may have caused the catheter to become weak and separate. The lesson learned involved the need to educate staff on the importance of not twisting lines when turning their patients. For critically ill children, we attempt to secure the EPIV differently to keep the line from twisting.

Limitations

Findings from this evaluation cannot be generalized beyond the data collected. Misclassification errors could have occurred because the abstracted data were not verified by a second data abstractor. Although every effort was made to include all patients with an EPIV or PICC line, it is possible that some were inadvertently omitted. Information on complications encountered during insertion and use of EPIV and PICC lines were not always thoroughly recorded and it is possible that additional complications were encountered and not recorded.

Conclusions

EPIVs were most beneficial in younger patients admitted to the children's hospital with a medical diagnosis, because 79% of patients who had an EPIV placed were aged 5 years or younger and the EPIV was used for infusion of antibiotics and other medications. The EPIV added an alternative device to a PICC line that does not require radiography for placement in younger patients. However, maintenance of EPIVs in the younger population was noted to be more difficult than with older patients due to movement of extremities. Therefore, strategic placement and securement of the line are key factors in the maintenance of EPIVs in younger patients. The optimum placement is the antecubital area for older children and the scalp for infants.

EPIVs are a successful alternative to PICCs or PIVs for children in an inpatient acute-care facility who have good or limited venous access and who need 30 days or fewer of nonvesicant intravenous therapy. The venous access decision tree provided useful guidance in determining the appropriate venous access device for pediatric patients and the decision tree has been adhered to by the vascular access team. Future research should systematically test the application of the venous access decision tree in a randomized clinical trial.

Recommendations for Practice

Although the venous access decision tree was found to be useful in determining the appropriate venous access device to use for pediatric patients, challenges related to working in a large university teaching facility have arisen. Educating the medical interns and resident physicians who rotate through different teams has been a challenge. Recommendations include implementing a consistent educational training on the venous access decision tree for medical interns, resident physicians, and new nursing staff members by the vascular access team.

The implementation of the venous access decision tree resulted in clear guidelines regarding the appropriate venous access device for use in a pediatric population. This evaluation demonstrated that few complications were encountered during EPIV placement and that the complications encountered during EPIV use can be addressed and minimized. We therefore recommend the use of EPIVs in pediatric populations as a viable option for avoiding more invasive procedures such as a PICC lines when the need for vascular access is < 30 days.

Disclosures

The authors have no conflicts of interest to disclose.

Acknowledgment

The authors thank Jill Berger for her work on this project.

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