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Development and Implementation of a Bedside PICC Service in a Pediatric Intensive Care Unit

Thomas W. Conlon, MD^{1,5}, Adam S. Himebauch, MD^{1,5}, Anne Marie Cahill, MD^{1,2}, Blair M. Kraus, RN, MSN¹, Chinonyerem R. Madu, MPH¹, Mark D. Weber, RN, CRNP-AC³, Carol A. Czajka, RN⁴, Ruby L. Baker, RN⁴, Torron M. Brinkley, RN⁴, Melanie D. Washington, RN⁴, Anne Marie Frey, RN⁴, Eileen M. Nelson, RN³, Cara T. Jefferies, MSN, RN, CCRN⁴, Charlotte Z. Woods-Hill, MD¹, Heather A. Wolfe, MD, MSHP^{1,5}, and Daniela H. Davis, MD, MSCE^{1,5}

¹The Children's Hospital of Philadelphia, Department of Anesthesiology and Critical Care Medicine

²The Children's Hospital of Philadelphia, Department of Radiology

³The Children's Hospital of Philadelphia, Department of Nursing- Critical Care

⁴The Children's Hospital of Philadelphia, Department of Nursing- Imaging

⁵Perelman School of Medicine at the University of Pennsylvania

Abstract

Objective: To create a Bedside PICC Service (BPS) to increase placement of bedside peripherally inserted central catheter (PICC) in Pediatric Intensive Care Unit (PICU) patients.

Design: Two phase observational, pre-post design.

Setting: Single-center quaternary non-cardiac PICU.

Patients: All patients admitted to the PICU.

Interventions: From June 1, 2015 to May 31, 2017 a BPS team was created (Phase I) and expanded (Phase II) as part of a quality improvement initiative. A multi-disciplinary team developed a PICC evaluation tool (PICU PET) to identify amenable patients and to suggest location and provider for procedure performance. Outcome, process and balancing metrics were evaluated.

Results: BPS placed 130/493 (26%) PICC lines resulting in 2447 hospital central line days. A shift in bedside PICC centerline proportion occurred during both Phases. Median time from order to line placement was reduced for PICCs placed by BPS compared to placement in IR [6h (IQR 2h-23h) vs. 34h (IQR 19h-61h), $p<0.001$].

Successful access was achieved by BPS providers in 96% of patients with central tip position in 97%. BPS central line-associated blood stream infection (CLABSI) and venous thromboembolism

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Corresponding Author/Address for Reprints: Thomas Conlon, MD, The Children's Hospital of Philadelphia, 3401 Civic Center Blvd., Philadelphia, PA 19104, (215) 590-6129, conlont@email.chop.edu.

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(VTE) rates were similar to rates for PICCs placed in IR (All CLABSI 1.23 vs. 2.18, $p=0.37$; VTE 1.63 vs. 1.57, $p=0.91$). PICC lines in PICU patients had reduced VTE rate compared to PICU temporary catheter rate (1.59 vs. 5.36, $p<0.001$).

Conclusion: BPS implementation increased bedside PICC placement and employed a patient-centered and timely process. Balancing metrics including CLABSI and VTE rates were not significantly different between PICC lines placed by BPS and those placed in IR.

Keywords

Peripherally Inserted Central Catheter; Vascular Access; Quality Improvement; Implementation; Central Line Associated Bloodstream Infection; Venous Thromboembolism

A peripherally inserted central catheter (PICC) is used for reliable delivery of medical therapies and blood sampling. In the pediatric intensive care unit (PICU), PICCs are an important option for patients with a history of difficult intravenous access and those with prolonged requirements for central vascular access. Limited pediatric data suggest that PICC lines have a reduced rate of central line-associated blood stream infection (CLABSI) compared with temporary central venous catheters (CVC).¹ In addition, smaller caliber lines may reduce venous thromboembolism (VTE) rates while obviating the risk of infiltration associated with peripheral intravenous (PIV) catheters. There are no published pediatric guidelines regarding patient selection criteria for PICC placement and this task is often left to the discretion of front line providers in the PICU.

There is also no single or multi-institution literature describing bedside PICC placement practice in PICU populations. Within our institution, PICC lines for PICU patients historically were almost exclusively placed in the Interventional Radiology (IR) suite using fluoroscopic guidance by trained IR specialists. Placement of a PICC line in IR requires order placement, scheduling and transport to and from the PICU setting. This workflow results in potential delays in timely PICC placement, removal of vital staffing resources from the PICU, and extraction of critically ill patients from the resource-rich PICU environment. Neonatal literature from our institution previously described successful translation of PICC placement performance and safety from the IR suite to the bedside.²

We developed a two-phase iterative PICU Bedside PICC Service (BPS) quality improvement (QI) initiative. The primary aim for Phase I was to develop criteria identifying PICU patients that would benefit from PICC line placement and to distinguish subsets amenable to bedside PICC placement resulting in a PICU PICC Evaluation Tool (PICU PET). The secondary aim for Phase I was successful implementation of BPS as measured by overall percentage of PICC lines placed at the bedside of PICU patients and balanced by BPS performance and patient safety metrics. The aim for Phase II was to increase BPS providers for bedside PICC placement in critically ill patients with continued evaluation of implementation outcome, process measures and balancing metrics.

Methods

Training, Process Development and Implementation

This QI intervention took place in a large quaternary care medical-surgical PICU with 55 beds averaging over 3800 admissions per year. Two PICU physicians (TC, AH) trained in PICC placement by performing a minimum 10 ultrasound-guided upper extremity PICC line placements supervised by IR physicians. Simultaneously, IR and PICU specialists in vascular access developed expert consensus criteria identifying PICU patients for PICC line placement and patient characteristics suggesting optimal location and provider for technical performance resulting in PICU PET (Figure 1). Patients with characteristics rendering them high-risk for transportation were “suggested” for PICC placement in the PICU whereas characteristics benefitted by use of fluoroscopy during the procedure were “suggested” for placement in IR. Patients with characteristics associated with difficult access or increased risk of complication were “suggested” for PICC placement by an IR specialist. All other patients were considered “amenable” for BPS provider placement. PICU PET was disseminated among PICU and IR providers as part of ongoing education and program implementation and final decision for line placement location was undertaken by the primary care service in coordination with BPS providers and IR.

BPS was integrated in clinical care on June 1, 2015 (Phase I) comprised of the two trained PICU physicians. These physicians screened PICU patients with PICC line orders using guidance from PICU PET to identify appropriate patients for bedside PICC placement. After achieving targeted performance goals during Phase I, BPS expanded September 1, 2016 (Phase II) to include VAS providers with PICC placement privileges in IR (CC, RB, TB, MeW) as well as a nurse practitioner with prior bedside PICC experience at a different institution (MaW). All BPS PICC lines were placed using ultrasound guidance. Workflow process mapping resulted in translation of PICU PET to an electronic assessment note built within the electronic health record (EHR; EPIC, Verona, WI) to improve inter-disciplinary communication.

Implementation outcome, process measures and balancing metrics

All patients with bedside PICC lines placed by BPS had demographic information extracted including age, weight and sex from the EHR. Other patient characteristics within PICU PET were extracted from the EHR including active vasoactive infusion, “advanced” ventilator support (including high frequency oscillatory ventilation, high-frequency percussive ventilation or airway pressure release ventilation), institutionally defined “critical airway,” history of prior VTE, history of prior difficult PICC line placement, active anticoagulation infusion, history of cardiac anesthesia requirement, presence of non-temporary central line and concern for future dialysis requirement. Data collected were initially transferred to an electronic REDCap database (Nashville, TN). An automated data visualization application, QlikView (Lund, Sweden), extracted patient characteristic data from the EHR and categorized patients by suggested provider and location for placement. After verifying no discrepancies between the REDCap database and QlikView application during Phase I, Phase II data was directly exported from the QlikView application.

Our primary outcome was the proportion of PICC lines placed at the bedside of PICU patients compared to other locations.

Process measures included concordance of provider and placement location with PICU PET, percentage completion of the electronic assessment note and time to PICC placement for BPS placed PICCs vs. those placed in IR. Concordance was measured with the term “Suggested” as targeted goal for location and provider for placement as per PICU PET criteria. PICC lines placed in PICU patients in an operating room or cardiac catheterization laboratory were excluded for assessment of concordance. Time to PICC placement was defined as the time from EPIC order to documentation of line insertion.

Balancing metrics were categorized as performance or safety. Performance metrics for BPS PICC placement included successful venous access and central tip position (within the superior vena cava to the right atrium for upper extremity PICCs, inferior vena cava to the right atrium for lower extremity PICCs). We targeted >90% success in vascular access and central tip position as defining feasibility of concept to move to Phase II. Safety outcomes were CLABSI [including Mucosal Barrier Injury Laboratory-Confirmed Bloodstream Infections (MBI-LCBI) and non-MBI-LCBIs³] and central line-associated VTE. Data were extracted from an institutional safety and harm prevention QlikView application and cross-referenced with our developed PICU PICC QlikView application. BPS rates were compared to rates in IR as well as to rates of temporary CVCs in PICU patients. Temporary CVCs were defined as non-tunneled central venous access devices placed in PICU patients within our institution excluding PICCs, ports, Broviacs and apheresis/dialysis catheters. All rates are expressed using in-hospital line days.

Data were reviewed from June 1, 2015 to May 31, 2017 with a 12 month run-in for primary outcome displayed in statistical process control (SPC) charts. Descriptive statistics were used to characterize patient population, process measures and safety metrics. Fisher’s Exact test was used to compare categorical data, Mann Whitney test for continuous data and Fisher’s Exact with mid-P correction for CLABSI and VTE incidence density rates with significance level 0.05. The study was deemed exempt from Institutional Review Board review at The Children’s Hospital of Philadelphia.

Results

Primary Outcome

During Phase I, 282 PICC lines were placed in PICU patients with BPS placing 68 (24%) bedside PICCs. During Phase II, 211 PICCs were placed in PICU patients with BPS placing 62 (29%) bedside PICCs. Patient characteristics for PICC lines placed by BPS and lines placed in IR are described in Table 1. Overall, 71/282 (25%) of PICC lines were placed at the bedside of PICU patients during Phase I and 73/211 (35%) during Phase II (Figure 2). Between Phase I and Phase II there was an increase in the number of bedside PICCs placed in the ICU by IR physicians (2/71 vs. 11/73, $p=0.02$) as well as an increase in the number of bedside PICCs placed by VAS providers (1/71 vs. 23/73, $p<0.001$).

Process Measures

Overall concordance between assessment tool and location/provider are demonstrated in Table 2. The PICC assessment note was completed by BPS providers in 42% (88/211) of evaluable patients during Phase II. The time from order to successful PICC placement was significantly reduced in patients with BPS line placement [n=121, median 6h (IQR 2h-23h)] compared with IR line placement [n= 326, median 34h (IQR 19h-61h); $p<0.001$].

Balancing Metrics: Performance

During phase I, venous access was achieved by BPS in 94% (68/73) of attempted patients with central tip position in 94% (64/68) of patients successfully accessed. During phase II, venous access was achieved by BPS in 98% (62/63) of attempted patients with central tip position in 100% of patients successfully accessed.

Balancing Metrics: Safety

CLABSI rates for PICCs placed by BPS were similar to rates for PICCs placed in IR (Table 3). Only one BPS CLABSI occurred within 48 hours of line placement and, after review, was identified as an MBI-LCBI. Femoral PICCs accounted for 6/22 (27%) of all PICU PICC CLABSI which was not significantly different from rates in upper extremity PICCs ($p=0.25$). PICCs with CLABSI had significantly longer duration of catheter use compared to PICCs without CLABSI [median 24d (IQR 15d-38d) vs. median 13d (IQR 7d-26d), $p<0.001$].

Catheter-associated VTE rates for PICCs placed by the BPS were similar to rates placed in IR (Table 3). Overall, femoral PICCs accounted for 5/18 (28%) of VTE and their VTE incidence (5/88, 6%) was not significantly different from incidence in upper extremity PICCs [13/405, 3%; $p=0.34$]. Temporary femoral catheters accounted for 22/33 (67%) of temporary CVC VTEs and their proportion of contribution to overall temporary CVC VTE rate is significantly higher than the proportion of contribution by femoral PICCs to overall PICC VTE rate ($p=0.01$).

Discussion

Through a multi-disciplinary collaboration and a QI approach, we developed a standardized PICU PICC Evaluation Tool (PICU PET) to identify patients and suggest location and personnel for patient-centered PICC placement. We demonstrated that the creation and spread of a team comprised of trained physicians, nurse practitioners, and vascular access nurses specialized in bedside PICC techniques can result in a sustained increase in PICC lines placed at the bedside in critically ill children. Process measures and balancing metrics highlight programmatic timeliness with shorter time to PICC insertion and safety with no significant difference in CLABSI and VTE rates compared to PICCs placed in IR.

Neonatology departments have published literature describing the implementation of successful nursing-led PICC services though no literature describes the development of such services within the PICU setting.⁴ Further, there is a paucity of literature suggesting *when* a patient requires a PICC. An international consensus panel recently published suggested

indications for adult PICC placement.⁵ Since pediatric consensus guidelines do not exist regarding indications for PICCs, we developed PICU PET to help standardize our institutional practice. By Phase II of the program, 35% of PICU patients requiring PICCs had one placed at the bedside, whether by BPS or IR providers. Thus, vital resources such as nursing staff, respiratory therapists and physician providers could remain on the unit involved in the care of other critically ill children. Bedside PICC placement also obviates risks of physiologic instability and medically necessary device dislodgements related to intra-hospital transport.^{6–10}

We found that the largest proportion of BPS placed PICCs were in patients amenable to BPS as identified by PICU PET (92/130, 71%). This suggests that BPS providers were adherent to the evaluation tool for the majority of their lines placed. We also found strong concordance (87%) when our tool suggested PICC placement by IR specialists in the IR suite. This is not surprising since, prior to BPS, this was our unit-based standard practice. There was low concordance in patients suggested for PICU location and amenable to BPS. BPS placed a similar number of lines (24/48, 50%) in this population as in patients amenable to both PICU location and BPS (68/147, 46%), a category in which there was high concordance. We believe that these data reflects limitations to the number of BPS providers available rather than problems with the selection tool, but this will be tested further with spread of BPS trained providers. Further, the overall number of BPS PICC lines placed from Phase I to Phase II actually decreased (68 vs. 62). This is likely due to a shift in workflow to prioritize VAS utilization within the context of their ongoing training and program development over ICU physician PICC placement which is supported by the increased number of VAS BPS lines placed in Phase II.

We did not find strong concordance in PICU bedside placement by IR physicians, though we identified an overall increase in the number of lines placed at the bedside by IR physicians from Phase I to Phase II. Multi-departmental collaboration and improved communication may have led to buy-in regarding bedside placement by our IR colleagues. As there is a potential cost to transporting critically ill patients from the ICU to the IR suite, there is also a cost to removing IR providers from their own practice environment, an important metric likely taken into consideration during procedural planning though unable to be quantified within the scope of our program implementation. Developing improved methods of assessing the characteristics of tool performance and strengthening workflow processes is a next step in our program build.

Balancing metrics resulted in important data to guide program development as well as identify future research and QI targets. Successful procedural performance by BPS PICU physicians in Phase I demonstrated concept feasibility and supported inclusion of VAS and NP experienced providers within the BPS framework. Notably our BPS PICC CLABSI rate was lower than the rate of PICCs placed in IR, though not reaching statistical significance. There are a number of factors likely contributing to this trend. Selection bias was purposeful within PICU PET. Some patient factors selected for IR (younger age, history of underlying cardiac disease, presence of indwelling non-temporary CVCs) are also factors associated with CLABSI.^{11–13} PICC lines placed in IR were also present for, on average, a greater number of in-hospital days compared to BPS placed lines. Our PICC data is limited to total

in-hospital line days and bloodstream infection does not necessarily indicate line removal within our institution. Thus our association of CLABSI with line duration, as described in prior pediatric studies, should be interpreted within this context.¹⁴⁻¹⁵ Further studies in pediatric populations using larger datasets and structured methodology should focus on the complex interactions between patient characteristics, device selection, as well as performance and line maintenance practices on PICC CLABSI rates.

We chose to review our PICU temporary CVC data during the two years of BPS integration. Our temporary CVC CLABSI rates trended lower, though not reaching statistical significance, than our PICC CLABSI rates. Though we have reason to suspect PICCs reduce CLABSI risk,¹ other data suggest that PICC lines may not be the panacea we envision. A recent Canadian group reviewed central line placement data from 1995–2013 and found that all other types of lines assessed had a statistically significant decrease in CLABSI rates compared to PICC lines on univariate analysis.¹⁶ In assessing the clinical associations with PICC infections, Advani et al. found that PICU exposure alone increased the rate of infection (IRR 1.80; 95% CI 1.18–2.75; $p=0.01$), a finding observed in adult populations as well.^{14,17}

There was no statistically significant difference in VTE rates between BPS placed PICCs and PICCs placed in IR. Although there is increasing interest in the pediatric community to investigate vascular access risk factors associated with VTE, providers currently have minimal published data to guide decisions.¹⁸ We did find higher rates of VTE associated with temporary CVCs, particularly when placed in a lower extremity. Adult literature demonstrates higher risks of VTE with PICCs vs. temporary CVCs as well increased risk of VTE for temporary femoral CVCs vs. subclavian or jugular CVCs.^{18–20} There are no data on VTE risks comparing catheter type in pediatric populations, though literature supports the femoral vessel as portending higher VTE risk for all catheter types.^{21–22}

There are many limitations to our study. Some of the findings may not be applicable to all PICU practice environments particularly as units may already employ bedside PICC placement services and/or have access to portable fluoroscopy equipment for procedural guidance. Regarding safety metrics, there were changes in the CLABSI-prevention strategies during the two-year study period but these changes were implemented on all PICCs throughout our PICU so any effects should be seen in both bedside and IR-placed PICCs. We also do not track transport-associated patient complications so our program implementation is unable to determine the effect of bedside PICC placement on this measure.

Conclusion

A unit-specific PICC evaluation tool (PICU PET) was developed through multidisciplinary collaboration within the context of a departmental quality improvement initiative to develop a bedside PICC program (BPS). Vascular access specialists were able to integrate PICU PET in a PICU practice environment resulting in increased bedside PICC placement. BPS PICC line placement improved value and quality of care through reduced time to procedural

performance while maintaining CLABSI and VTE rates statistically similar to those of PICCs placed in IR.

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References

1. Yamaguchi RS, Noritomi DT, Degaspere NV, et al. Peripherally inserted central catheters are associated with lower risk of bloodstream infection compared with central venous catheters in paediatric intensive care patients: a propensity-adjusted analysis. *Intensive Care Med.* 2017;43:1097–1104. [PubMed: 28584925]
2. Gaballah M, Krishnamurthy G, Keller MS, et al. US-guided placement and tip position confirmation for lower-extremity central venous access in neonates and infants with comparison versus conventional insertion. *J Vasc Interv Radiol.* 2014;25:548–555. [PubMed: 24674213]
3. Bloodstream Infection Event (Central Line-Associated Bloodstream Infection and non-central line-associated Bloodstream Infection) as found on. <https://www.cdc.gov>.
4. Linck DA, Donze A, Hamvas A. Neonatal peripherally inserted central catheter team. Evolution and outcomes of a bedside-nurse-designed program. *Adv Neonatal Care.* 2007;7:22–29. [PubMed: 17536330]
5. Chopra V, Flanders SA, Saint S, et al. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): Results from a multispecialty panel using the RAND/UCLA appropriateness method. *Ann Intern Med.* 2015; 163:S1–40. [PubMed: 26369828]
6. Schwebel C, Clec'h C, Magne S, et al. Safety of intrahospital transport in ventilated critically ill patients: a multicenter cohort study. *Crit Care Med.* 2013;41:1919–1928. [PubMed: 23863225]
7. Krishnaiah A, Soothill J, Wade A, et al. Central venous catheter-associated bloodstream infections in a pediatric intensive care unit: effect of the location of catheter insertion. *Pediatr Crit Care Med.* 2012;13:176–180.
8. Parmentier-Decrucq E, Poissy J, et al. Adverse events during intrahospital transport of critically ill patients: Incidence and risk factors. *Ann Intensive Care.* 2013;3:10. [PubMed: 23587445]
9. Beckman U, Gillies DM, Berenholtz SM, et al. Incidents relating to the intra-hospital transfer of critically ill patients. *Intensive Care Med.* 2004;30:1579–1585. [PubMed: 14991102]
10. Harish MM, Siddiqui SS, Prabu NR, et al. Benefits of and untoward events during intrahospital transport of pediatric intensive care unit patients. *Indian J Crit Care Med.* 2017;21:46–48. [PubMed: 28197051]
11. Jumani K, Advani S, Reich NG, et al. Risk factors for peripherally inserted central venous catheter complications in children. *JAMA Pediatr.* 2013;167:429–435. [PubMed: 23549677]
12. Wylie MC, Graham DA, Potter-Bynoe G, et al. Risk factors for central line-associated bloodstream infection in pediatric intensive care units. *Infect Control Hosp Epidemiol.* 2010;31:1049–1056. [PubMed: 20731595]
13. Concannon C, van Wijngaarden E, Stevens V, et al. The effect of multiple concurrent central venous catheters on central line-associated bloodstream infections. *Infect Control Hosp Epidemiol.* 2014;35:1140–1146. [PubMed: 25111922]
14. Advani S, Reich NG, Sengupta A, et al. Central line-associated bloodstream infection in hospitalized children with peripherally inserted central venous catheters: extending risk analysis outside the intensive care unit. *Clin Infect Dis.* 2011;52:1108–1115. [PubMed: 21454298]
15. Sengupta A, Lehman C, Diener-West M, et al. Catheter duration and risk of CLA-BSI in neonates with PICCs. *Pediatrics.* 2010;125:648–653. [PubMed: 20231192]
16. Carter JH, Langley JM, Kuhle S, et al. Risk factors for central venous catheter-associated bloodstream infection in pediatric patients: A cohort study. *Infect Control Hosp Epidemiol.* 2016;37:939–945. [PubMed: 27139311]

17. Chopra V, O'Horo JC, Rogers MA, et al. The risk of bloodstream infection associated with peripherally inserted central catheters compared with central venous catheters in adults: a systematic review and meta-analysis. *Infect Control Hosp Epidemiol*. 2013;34:908–918. [PubMed: 23917904]
18. Jaffray J, Bauman M, Massicotte P. The impact of central venous catheters on pediatric venous thromboembolism. *Front Pediatr*. 2017;5:5. [PubMed: 28168186]
19. Wilson TJ, Stetler WR, Jr., Fletcher JJ. Comparison of catheter-related large vein thrombosis in centrally inserted versus peripherally inserted central venous lines in the neurological intensive care unit. *Clin Neurol Neurosurg* 2013;115:879–882. [PubMed: 22948189]
20. Parienti JJ, Mongardon N, Megarbane B, et al. Intravascular complications of central venous catheterization by insertion site. *N Eng J Med*. 2015;373:1220–1229.
21. Gray BW, Gonzalez R, Warrier KS et al. Catheterization of central venous catheter-associated deep venous thrombosis in infants. *J Pediatr Surg*. 2012;47:1159–1166. [PubMed: 22703787]
22. Shah SH, West AN, Sepanski RJ et al. Clinical risk factors for central line-associated venous thrombosis in children. *Front Pediatr* 2015;3:35. [PubMed: 26000265]

Suggested Criteria for PICC Line Placement:

- Existing temporary central catheter in place for > 7days
- Anticipated intravenous medical therapies for >3 days amenable to single or double lumen access
- Difficult access patients with ≤ 2 available sites for peripheral vein access
- Anticipated need for venous blood sampling > Q6h for >48h without blood drawing access
- Patients with PIVs and anticipated dosing of vesicants >48h
- Patients with ≥2 PIVs and ongoing therapies anticipated for >48 more hours
- Poor IV access in at least 1 upper extremity site due to:
 - Contracture
 - Congenital anomaly
 - Burn/Wound
 - Infection
 - Poor skin integrity (e.g. GVHD, epidermolysis bullosa)

Assessing for PICU Bedside Placement:**(1) Patients who should be strongly considered for a bedside PICC (Suggested PICU):**

- Presence of anticipated hemodynamic instability and/or requiring active titration or inotropes/vasopressors (e.g. epinephrine, norepinephrine, dopamine, dobutamine, milrinone, phenylephrine)
- Patients with existing or anticipated Critical Airway
- Patients with anticipated instability if transported on mechanical ventilation support other than “conventional” support (e.g. HFOV, VDR, APRV, ECMO)

(2) Patients who the clinical team may additionally consider for a bedside PICC (Amenable PICU):

- Complex patients or anticipate high risk for transport, such as those with:
 - Respiratory compromise: Non-invasive positive pressure ventilation, history of difficult airway, difficult airway
 - Existing or anticipated hemodynamic instability: Ongoing fluid resuscitation, vasopressor or inotrope support within the past 24h
 - Anticipated equipment challenges: External ventriculostomy drains, inhaled nitric oxide, chest tubes, large ICU pole setup, inhaled nitric oxide
- Primary Treatment Team Request

(3) Patients who should be strongly considered for fluoroscopic guidance in Interventional Radiology Suite (Suggested IR):

- Known history of deep vein thrombosis in the candidate extremity in the targeted upper extremity
- History of difficult upper extremity PICC placement (per FYI tab in EPIC)
- Repositioning a PICC line using re-wiring technique

Assessing PICU Bedside PICC Service vs. Interventional Radiologist Provider Request:

IR physician should be considered for performing PICC placement (whether bedside or IR suite) for the following patients (Suggested IR Physician):

- < 10kg
- Active or recent (<12 hours) anticoagulation infusions
- Anticipation of future chronic dialysis requirement
- Hereditary or acquired thrombophilia anticipated to have high risk for deep vein thrombosis
- Congenital heart disease previously requiring cardiac anesthesia for sedation
- Diagnosis of pulmonary hypertension requiring chronic or acute pharmacologic interventions
- Concurrent non-temporary lines including broviac, port, tunneled central line
- Current temporary dialysis or apheresis catheter
- Patients with identified mediastinal mass

Figure 1:

Pediatric Intensive Care Unit Peripherally Inserted Central Catheter Evaluation Tool (PICU PET).

Figure 2:

PICU bedside PICC line placement P-Chart (June 1, 2014 through May 31, 2017). A center line shift characterized by eight consecutive points above the prior center line are noted at the times of respective Phase implementation.

Table 1:

Characteristics of Patients with PICCs Placed at Bedside by BPS vs. PICCs Placed in IR

Clinical Characteristics	BPS PICC (n=130)	IR PICC (n=342)	<i>p</i> -value
Male Sex (%)	72 (55)	184 (54)	0.84
Median Age (in years; IQR)	11.3 (5.5–15.6)	2.6 (0.9–10.3)	<0.001
Median Weight (in kg; IQR)	35.2 (19.6–53.6)	13.0 (8.1–28.3)	<0.001
Vasopressor or Inotrope Utilization n (%)	21 (16)	43 (13)	0.37
Advanced Ventilator Support n (%)	6 (5)	7 (2)	0.20
Critical Airway n (%)	10 (8)	39 (11)	0.31
History of Deep Venous Thrombus n (%)	3 (2)	27 (8)	0.03
History of Difficult PICC n (%)	3 (2)	33 (10)	0.006
Anticoagulant infusion n (%)	3 (2)	9 (3)	1.00
History of Cardiac Anesthesia n (%)	0	0	1.00
Non-temporary Central Line n (%)	6 (5)	29 (8)	0.17
Concern for Future Dialysis n (%)	3 (2)	14 (4)	0.42
Lower Extremity Placement n (%)	1 (1)	72 (21)	<0.001

PICC=peripherally inserted central catheter; BPS=Bedside PICC Service; IR=Interventional Radiology; IQR=interquartile range

Table 2:

Concordance of Provider and Location of PICC Line Placement with PICU PET

Location	Provider	
	Suggested IR Physician	Amenable BPS
Suggested IR	46 Concordance: 87% (40/46) 40/46 IR by IR Physician 1/46 PICU by IR Physician 5/46 PICU by BPS
Suggested PICU	75 Concordance: 7% (5/75) 5 in PICU by IR Physician 58 in IR by IR Physician 4 in IR by VAS 8 in PICU by BPS	48 Concordance: 54% (26/48) 2/48 in PICU by IR Physician 24/48 in PICU by BPS 21/48 in IR by IR Physician
Amenable PICU	169 Concordance: 86% (145/169) 140 in IR by IR Physician 5 in PICU by IR Physician 24 in PICU by BPS	147 Concordance: 100% (147/147) 79 in IR by IR Physician 68 in PICU by BPS

PICC=peripherally inserted central catheter; PICU PET=Pediatric Intensive Care Unit Peripherally Inserted Central Catheter Evaluation Tool; IR=Interventional Radiology; PICU=Pediatric Intensive Care Unit; VAS=Vascular Access Service; BPS=Bedside PICC Service

Table 3:
CLABSI and VTE Rates in PICU Patient Populations (June 1, 2015 through May 31, 2017)

Line Type	# Lines	Line Days	All CLABSI	MBI-LCBI	All CLABSI Rate (per 1000 line days)	p-value	Non-MBI-LCBI Rate (per 1000 line days)	p-value	VTE	VTE Rate (per 1000 line days)	p-value
BPS PICC	130	2447	3	1	1.23	0.37	0.82	0.17	4	1.63	0.91
IR PICC	342	8270	18	0	2.18		2.18		13	1.57	
All PICU PICC	493	11317	22	1	1.94	0.13	1.86	0.08	18	1.59	<0.001
All PICU Temporary CVC	923	6155	6	1	0.97		0.81		33	5.36	

CLABSI=central line-associated bloodstream infection; VTE=venous thromboembolism; MBI-LCBI=Mucosal Barrier Injury Laboratory-Confirmed Bloodstream Infections; PICU=Pediatric Intensive Care Unit; PICC=peripherally inserted central line; BPS=Bedside PICC Service; IR=Interventional Radiology; CVC=central venous catheter