

The Outcomes of Peripherally Inserted Central Catheter (PICC) Insertion in Pediatric Patients at Siriraj Hospital

Niracha Wongchompoo, BNS, Khanita Kasikan, BNS, Prasert Sawasdiwipachai, M.D.

Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

ABSTRACT

Objective: Peripherally Inserted Central Catheters (PICC) are widely used for intermediate to long term venous access. Venipunctures and catheterizations in pediatric patients can be challenging and traumatizing to children's veins due to frequent and painful needle sticks. This study aims to demonstrate the outcomes of PICC insertion and management in pediatric patients by the Anesthesia Line Service Team (ALiST) at Siriraj Hospital.

Materials and Methods: This is a retrospective, descriptive study, collecting data from January 2018 to December 2021. The inclusion criteria were pediatric patients aged 15 years with body weight equal to or exceeding 5 kg with no history of previous complicated central venous accesses. The primary outcome is the success rate of insertion. The characteristics of patients, sizes and types of catheter, reason of removal and complications were also reported.

Results: 124 PICCs were inserted in pediatric patients. The median age of patients was 5.0 years with a median height of 107.8 cm and a median weight of 10.0 kg. The successful insertion rate was 96.92% and all insertions were inserted using ultrasound-guided technique with or without fluoroscopy. No acute complications were noted during insertion. Most patients received either intravenous sedation (39.5%) or general anesthesia (26.6%) during the procedure. The mean duration of catheter indwelling was 66.48 days. Reasons for removal of PICC included completion of therapy and patient demise (70.97%), catheter malfunction (8.06%), accidental removal (4.03%), infection (8.06%) and patient non-adherence (1.61%).

Conclusion: Our research demonstrates a notably high rate of successful PICC placement among pediatric patients with data indicating a minimal occurrence of complications and an extended duration of catheter usage.

Keywords: Peripherally inserted central catheter; pediatric PICC; complications (Siriraj Med J 2024; 76: 135-143)

INTRODUCTION

The Peripherally Inserted Central Catheter (PICC) is a single or multi-lumen catheter inserted from a peripheral vein into a central vein. Although the upper arm is the most common insertion site in adults, lower extremities, scalp veins (for small babies) may be occasionally utilized if the vein's caliber is large enough, providing an uninterrupted path to the superior vena cava or inferior vena cava (in the lower torso).^{1,2} Pediatric PICC was initially introduced in the 1970s for parenteral nutrition in neonates.¹⁻³ PICC

is considered an alternative and/or a supplement to conventional venous lines.⁴ Over time, PICC has also found uses in providing long-term intravenous access for medications such as antibiotic regimens in children. PICC is also an alternative to a Totally Implantable Venous Access (TIVAD) devices for pediatric cancers since placing TIVAD in small children poses multiple concerns.⁵

Generally, the indwelling duration of a PICC ranges from 0 days to 6 weeks.¹ An uncomplicated PICC represents

Corresponding author: Prasert Sawasdiwipachai

E-mail: prasert.saw@mahidol.ac.th

Received 30 November 2023 Revised 9 January 2024 Accepted 13 January 2024

ORCID ID: <http://orcid.org/0000-0002-4296-1155>

<https://doi.org/10.33192/smj.v76i3.266562>



All material is licensed under terms of the Creative Commons Attribution 4.0 International (CC-BY-NC-ND 4.0) license unless otherwise stated.

the best practice for children to receive medications, intravenous fluids, or have blood samples taken (for PICCs larger than 2 French). PICC has gained popularity in pediatrics because of its ability to establish safe, long-term intravascular access, provide comfort, reduce the need for repeated venipunctures, and facilitate the transition to home intravenous therapy.^{6,7}

Currently, PICC placements in our institution is a collaborative effort involving multidisciplinary specialties including pediatricians, interventional radiologists, and the anesthesiologists. We initiated involvement in PICC placement in 2010, and over time, it expanded from a one-man service to a team-based approach with the official establishment of the Anesthesiology Line Service Team (ALiST) which comprises of 25 physicians and 14 nurse anesthetists in our institute in 2018. The elective PICC placement service was initiated when the primary care team sent a request to the ALiST. Each individual patient was evaluated for suitability, device type, location of placement, appropriate sedation or anesthetic technique (if required). The nurse co-ordinator then queued up the patients for placement within 24-48 hours. NPO (Nil Per Os) order was selectively ordered for all children required sedation or anesthesia. The scope of this service includes in-hospital patients, critically ill individuals, and ambulatory patients of various ages, ranging from children weighing as small as 5 kg to adult patients.

The objective of this study is to outline the effectiveness and results of PICC insertion in pediatric patients. This encompasses various aspects, such as catheter specifications, selection of anesthetic techniques during insertion, post-insertion complications, and factors influencing catheter removal. Furthermore, the study investigates the relationship between complications and variables like catheter size and patient body weight.

MATERIALS AND METHODS

Following an approval from Siriraj Institutional Review Board (approval number Si 1033/2021, date of approval: December 27th, 2021), written informed consent was exempt for this retrospective chart review. The data was collected for pediatric patients who had PICC inserted by ALiST between January 1st, 2018 to December 31st, 2020. The inclusion criteria included pediatric patients aged 15 years or younger with a body weight of 5 kg or greater. Patients with a known history of central vein stenosis were excluded. Hospital numbers and patient details, as well as procedural information, were retrieved from the ALiST team database within the Department of Anesthesiology, Faculty of Medicine

Siriraj Hospital. Other data were retrieved from patients' medical records which were stored in electronic files.

PICC insertion technique

All patients' preparation and procedural consents were obtained in adherence to the standard hospital protocol. After administering appropriate anesthesia or sedation, venous sono-anatomy was examined on the selected extremity to determine the optimal route for PICC insertion. The upper extremity of the patient was positioned with 45-degree shoulder rotation, allowing for up to a 90-degree elbow flexion. For lower extremity insertion, the patient was placed in a supine position with the hip externally rotated and the knee flexed at approximately 45 degrees to expose the medial thigh. The skin at the proposed insertion site was disinfected with a 2% chlorhexidine gluconate in 70% isopropyl alcohol. The procedure performing anesthesiologist surgically scrubbed their hands and donned sterile gowns and gloves. An additional anesthesiologist or nurse anesthetist was assigned to manage anesthesia or sedation specifically. A local infiltration of 1% plain lidocaine was administered prior to venipuncture with a 21Ga ultrasound enhanced-tipped needle under direct ultrasound guidance. Subsequently, either a 0.018 inch flexible-tipped or spring wire was inserted through the needle, which was then exchanged to a dilator or dilator with peel-away sheath. In case of trimmable PICCs, the catheter was trimmed to a premeasured length, estimated from the in-situ wire from the puncture site to either the distal superior vena cava (SVC, for upper extremities) or distal inferior venacava (IVC, for lower extremities). The PICC was then inserted over the guidewire (using the Seldinger technique) or through a peel-away sheath (using a modified Seldinger technique). When inserting a PICC in the upper torso, intracavitary electrocardiogram (iECG) was used for tip confirmation, while in lower torso insertions, fluoroscopy was used for tip confirmation. For non-trimmable PICCs, the excess portion was carefully coiled externally near the exit site. The location of the catheter tip was later radiographically confirmed using a portable x-ray machine. The tip was considered appropriately positioned if it resided in either the SVC, or the IVC. In younger children (under 10 years of age), the PICC was sutured with 4-0 nylon, while older pediatric patients who could cooperate had a non-suturing securing device used for stabilization. Finally, the exit site was covered with a chlorhexidine impregnated gel patch and a transparent bio-occlusive dressing.

The ALiST nurse provided guidance to caregivers (floor nurses or parents) and maintained regular contact

with all PICC patients, either through phone conversations or in-person visits until the PICC was removed or in the unfortunate event of the patient's passing. Detailed follow-ups included monitoring for occlusion, exit-site related issues, dislodgements, infections, and other relevant concerns, all of which were systematically recorded. The available PICC options at our institution included a 3 French single-lumen Nutriline PICC (Vygon, France), a 4 French single lumen, a 5 French double-lumen Arrow® (Teleflex Inc, USA) and a 5 French double-lumen Power-PICC (Bard Inc, USA).

The post-catheter insertion care order sheet was provided to ward or ICU nurses. Additionally, a twice-daily reminder sheet for normal saline (NSS) flush and heparinized NSS lock was introduced. To minimize excessive pressure generated by smaller barrel syringes, only a 10-mL syringe was allowed for saline flush and lock. For pre and post-medications, a 5-mL NSS flush volume (using a 10-mL syringe) was recommended. A 10 units/mL heparinized NSS solution was utilized for PICC lock unless heparin was contraindicated. Dressings were changed weekly unless they became saturated or obviously soiled.

In cases where a port could be flushed but did not yield any blood return (for PICCs larger than 2-Fr), it was categorized as a withdrawal occlusion. Total occlusion was identified when a port was impossible to flush or withdraw. The caregiver was instructed to notify the ALiST service in case of both withdrawal and total occlusion. Treatment options, including observation, gentle 10-mL NSS flush with push-pause technique or thrombolytic lock therapy, was considered in accordance with the established PICC occlusion guideline. The patient's care team also had to oversee the exit site for any signs of bleeding, redness, exudative discharge, limb edema as well as any catheter malfunctions such as dislodgement, breakage or leakage.

Statistical analysis

Data collection included patient demographics, PICC characteristics, procedure outcomes (success or failure), indwelling duration and complications including catheter occlusions, suspected infections, leakages, breakages or ruptures.

Descriptive statistical analysis was used to calculate and report quantitative data, including mean \pm standard deviations, median with minimum and maximum values, or interquartile range (IQR). For categorical data, frequencies and percentages were used. Appropriate statistical tests, such as the Chi-square test, unpaired T-test, and Mann-Whitney U test were used to analyze categorical variables.

All the data was compiled and analyzed using SPSS Statistics v.29.0 (SPSS, Inc., Chicago, IL, USA). A p-value of <0.05 was considered statistically significant.

Definition

Catheter occlusion can be categorized as withdrawal occlusion when the port can be flushed but fails to yield blood return. If the catheter becomes uninjectable, it is defined as total or complete occlusion. Suspected catheter related infection is considered in patients with an indwelling PICC for over 48 hours who experience fever, leukocytosis and/or clinical signs of sepsis with positive hemoculture taken from either port of the PICC. Catheter dislodgement is defined as the mark on the PICC at the exit site being displaced or shifted from its previous position by more than 10 cm. Catheter malfunctions included breakage, leakage, perforation, retention of foreign bodies (tip of syringe or stopcock), discoloration, or deformity (flaccid, floppy or catheter rigidity).

The termination of PICC was determined by the following conditions: 1) completion of therapy or patient demise, 2) catheter malfunctions, 3) inadvertent removal, 4) suspected infection and 5) patient non-adherence.

RESULTS

During the study period, a total of 1,096 consultations for PICC insertions were compiled. Among these, 149 patients were 15 years old or younger. However, 19 patients were ineligible due to weighing less than 5 kg or less, and two more were excluded because of their history of central venous abnormalities. This resulted in a final cohort of 130 patients for data collection. Furthermore, four patients ultimately received central venous catheter insertions instead of PICCs, and two patients had missing data. Consequently, there were 124 pediatric PICC insertions available for analysis, as illustrated in Fig 1.

Patient's demographics data was shown in Table 1. There was a slightly higher proportion of female patients, accounting for 52.4% (65 out of 124). Most patients fell within the 2-10 years age group, comprising 54.8% (68 out of 124), with a median weight of 16 kg. The majority of patients, 96.0%, underwent PICC placement in the operating theater, while only 4.0% (5 patients) had the procedure done at the bedside. The primary indications for PICC placement were intravenous access (54.0%), total parenteral nutrition (28.2%) and chemotherapy (17.7%).

The successful insertion rate was 96.92% (with a 95% confidence interval (CI) ranging from 92.4% to 98.8%).

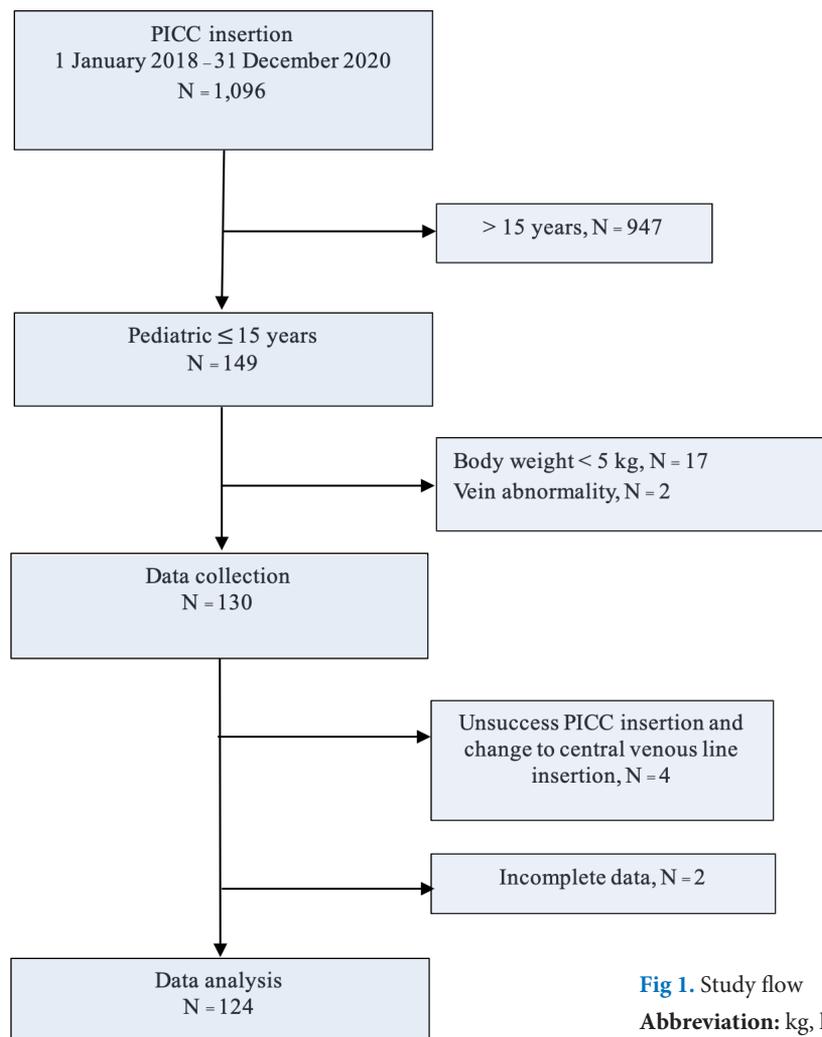


Fig 1. Study flow
Abbreviation: kg, kilogram

TABLE 1. Baseline characteristics of patients.

	n (%)
Total number of patients	124 (100%)
Sex	
Male	59 (47.6%)
Female	65 (52.4%)
Age (year), median (range)	5.0 (0.3-15.0)
Age (year), median (IQR)	5.0 (2.0, 8.9)
Age	
3 months-2 years	30 (24.2%)
>2 years-10 years	68 (54.8%)
>10 years	26 (21.0%)
Body weight (kg), median (IQR)	10.0 (10.0-25.8)
Height (cm), median (IQR)	109.0 (85.0-126.0)
Setting	
Operating theater	119 (96.0%)
Bedside	5 (4.0%)
Indications	
Intravenous access	67 (54.0%)
Total parenteral nutrition	35 (28.2%)
Chemotherapy	22 (17.7%)

All PICCs were inserted with ultrasound guidance, with or without real-time fluoroscopy. Notably, there were no immediate complications observed during insertion.

The PICC sizes and accessed veins are presented in [Table 2](#) which revealed 75% of patients had PICCs placed in the upper extremities. For infants requiring PICCs larger than 2-Fr due to frequent blood sampling needs, these were placed in their lower extremities. In this study, the most used catheter sizes were 4-French (41.1%), followed by 5-French (29.8%) and 3-French (29.1%) as detailed in [Table 2](#). Since our PICC services did not formally extend to babies smaller than 5 kg, the 3-French PICC represented the smallest size included in our study. We primarily employed iECG to verify the placement of PICCs in the upper torso or when inserting PICCs at the bedside (48.4%). Fluoroscopy was utilized for confirmation in cases of PICCs placed in lower extremities or for small infants (50.0%). Landmark-guided placement was recorded in only 2 patients (1.6%) in this study.

Majority of children received some form of sedation or anesthesia. The intravenous sedation was employed for most patients (38.7%), followed by general anesthesia (26.6%). There are some large and cooperative children exclusively received only local anesthesia during the procedure (28.2%). Details about the anesthesia techniques can be found in [Table 2](#).

We identified 11 documented catheter-related infections, accounting for 9.73% of cases, as shown in [Table 3](#). No statistically significant correlation was observed between the infection rate and factors such as catheter size, catheter placement site, or the duration of the indwelled catheter.

Nonetheless, we encountered 26 instances of catheter malfunctions, which emerged as the most prevalent post-insertion complication in this study, comprising 20.97% of cases. While it appeared that catheter malfunction might occur more frequently with smaller catheter sizes, these differences did not reach statistical significance, as shown in [Table 4](#).

The mean duration of indwelling catheter was 66.48 days (4 – 402 days). Most patients, 66.94%, retained their catheters until therapy was completed or until their passings. Detailed reasons for PICC removal are presented in [Table 5](#).

DISCUSSION

In our study, we observed that PICC insertion in the pediatric population accounted for 11.3% of all PICC insertions carried out by anesthesiologists in our institute, demonstrating a notably high success rate of 96.92%. The late complications most frequently encountered in this population were catheter malfunction and catheter infection.

TABLE 2. Catheter sizes, accessed veins, confirmation techniques and anesthesia techniques.

n = 124 (100%)	
Catheter sizes	
3-French	36 (29.1%)
4-French	51 (41.1%)
5-French	37 (29.8%)
Veins accessed	
Upper arm veins (Basilic vein, Brachial vein, Cephalic vein)	93 (75.0%)
Lower extremity veins (Saphenous vein, distal Femoral vein)	31 (25.0%)
Confirmation techniques	
Landmark	2 (1.6%)
iECG (intracavitary ECG)	60 (48.4%)
Fluoroscopy	62 (50.0%)
Anesthesia techniques	
Local anesthesia	35 (28.2%)
Intravenous sedation	49 (39.5%)
General anesthesia	33 (26.6%)
N/A	8 (6.5%)

NA = not applicable or missing information regarding anesthesia technique

TABLE 3. Factors associated with infections.

Factor	Infection (n=10)	Non-infection (n=114)	p-value
Catheter size			
3-French	5 (13.9%)	31 (86.1%)	0.325
4-French	3 (5.9%)	48 (94.1%)	
5-French	2 (5.4%)	35 (94.6%)	
Site			
Upper extremity veins (basilic vein, brachial vein, cephalic vein)	3 (9.7%)	28 (90.3%)	0.710
Lower extremity veins	7 (7.5%)	86 (92.5%)	
Duration of catheter (weeks)			
≤ 6 weeks	4 (6.0%)	63 (94.0%)	0.510
> 6 weeks	6 (10.7%)	50 (89.3%)	

TABLE 4. Factors associated with catheter malfunctions.

Factor	Catheter malfunction (n=26)	Catheter well-used (n=98)	p-value
Catheter size			
3-French	11 (30.6%)	25 (69.4%)	0.193
4-French	10 (19.6%)	41 (80.4%)	
5-French	5 (13.5%)	32 (86.5%)	
Body weight (kg), median (range)	13.8 (7.0-73.2)	16.6 (5.0-73.0)	0.214

TABLE 5. Reasons for PICC removal.

Reason	n (%)
Total number	124
Missing data or loss to follow up	9 (7.26%)
Completion therapy & Demise	88 (70.97%)
Catheter breakage, rupture, occlusion	10 (8.06%)
Inadvertent removal	5 (4.03%)
Suspected infection	10 (8.06%)
Patient non-adherence	2 (1.61%)

Placing PICC in children presents numerous challenges. The vascular anatomy in pediatric patients differs significantly from that in adults and is influenced by factors such as body size and the activities associated with their development stage.⁸ Infants younger than one year are not predominantly engaged in activities that involve standing or use of arms extensively. As a consequence, this leads to the development of smaller limbs and smaller limb vessels when compared to adults, making PICC placement more difficult.⁹ The placement of PICC smaller than 3-Fr made blood sampling nearly impractical.¹⁰ Co-operation and immobility of extremities are not guaranteed. Confirming the tip location is also fraught with extreme technical difficulties. PICC placement in pediatric patients requires a more intricate setup, which is time-consuming when compared to the relatively simpler process of placing one in adults. The procedure requires an experienced team, and we often provide sedation or anesthesia to facilitate the procedure and lessen the psychotraumatic experience of the small children. Following an official PICC consultation, the preliminary screening was performed by an ALiST nurse to determine the appropriate location for the procedure (bedside or OR). The anesthesiologist was then consulted to confirm the plan, the type of PICC, the choice of sedation or anesthesia including the proper NPO time. The parents or legal guardians were then approached for an informed consent. The procedure was usually executed on the following day or the first day after the weekend. Almost all PICCs placed in children larger than 5 kg in our institution were placed by the ALiST, while some were serviced by the radiology team who also take care of babies smaller than 5 kg and patients with complicated central venous access history (children born with diseases that mandate lifelong total parenteral nutrition and have been accessed for central veins multiple times). For small neonates, the PICCs were inserted by the neonatologist team.

In this study, all pediatric PICCs were performed by experienced anesthesiologists who have extensive skills in both pediatric and adult PICCs. Notably, most of our patients also received either intravenous sedation or general anesthesia, providing limb inactivity and ensuring the serenity of both the patient and the team. Safe sedation/anesthesia also offers children and their legal guardians' acceptance and comfort. Even pediatric PICC placements by radiology interventionists in our hospital (not included in this report) were all performed under sedation or anesthesia. In the Neonatal Intensive Care Unit (NICU), PICCs are usually inserted without the direct involvement of the anesthesia team. However, it's

worth noting that many neonatologists often administer mild sedation to these tiny infants, and their delicate and underdeveloped limbs can usually be easily physically restrained. This combined effort ensures safe and successful PICC placement in the NICU setting.^{11,12}

The study determined that the size of the catheter and the patient's body weight did not show a significant association with catheter malfunction. Smaller catheter sizes, however, are associated with a higher occurrence of occlusions.¹² The selection of the appropriate PICC size should be based on the size of the access vein and the necessary therapies, rather than being solely determined by the patient's age. Generally, smaller catheters with fewer lumens are associated with fewer complications. However, it is important to note that very small catheters are more prone to occlusion. If blood sampling through the PICC become necessary, a minimum size of 3 French (3Fr) or larger is required. The incidence of catheter infections in our study was reported in 11 cases (9.73%), which is approximately 3 folds of that reported by earlier studies which were ranging from 2-4%.¹³⁻¹⁵ However, our study had the remaining catheters in place for an average of 66 days, whereas the other studies had an average placement duration of 14 to 45 days. This suggests that our study indicates a potential relationship between the infection rate and the number of days the catheters remain in place.

We also encountered another time-consuming aspect of PICC placements involving children with complex venous anatomy. These patients typically have a history of multiple bowel surgeries or lifelong short bowel syndrome, often requiring hospitalizations since birth and having a history of multiple prior central venous accesses. In these patients, the venipunctures under ultrasound guidance typically proceed without significant issues. However, the process of threading a wire or placing a PICC becomes unfeasible. Venography reveals a network of collateral veins instead of a large prominent vein leading to the SVC or IVC. Due to our limited expertise and inadequate equipments (including hydrophilic wires, balloon catheters, and a dedicated radiology suite), we subsequently compiled a list of these patients and referred them to seek PICC placements from intervention radiologists or vascular surgeons, who possess the necessary resources and skills to handle these cases effectively.

As our service is exclusively managed by the anesthesiology department, the convenient availability of anesthesia during the procedure has led to a significant increase in the number of patients undergoing the procedure with either sedation or general anesthesia. Despite the

rising costs and increased personnel requirements, this approach may enhance acceptance among parents and older children. A tranquil and calm patient during the procedure may potentially result in a higher success rate.

This report had several limitations. First, it was based on dataset with a limited number of patients. The study design was a retrospective chart review, which inherently lacked the capability to address specific questions or establish causality for different therapeutic approaches. Key details, such as the number of insertions attempts and the duration of insertions, were not documented. Furthermore, there are significant gaps in information, particularly regarding follow-up data. Nonetheless, this report plays a crucial role in shedding light on the occurrence of complications, prompting the involved team to maintain vigilance in monitoring potential complications that may occur following PICC insertion in a pediatric population.

Establishing the PICC service by the anesthesiologists at our institution presents a unique and potentially challenging model that may be hard to replicate. Its origin trace back to an individual's initiative to provide intravenous accesses primarily to private patients by special requests which later expanding to encompass regular patients. The service gained traction among junior anesthesia colleagues who shared similar interests, leading to its acceptance as a viable solution by administrators. What began as a one-person service has evolved into a team-based approach. We are currently in the process of transforming this service further into a multidisciplinary approach. We are incorporating information technology for database management and improving accessibility for other specialties providing similar services. Collaboration with the hospital quality development, the infectious control unit, and experts such as radiologists and vascular surgeons has propelled the initiative towards becoming a comprehensive hospital PICC center. By consolidating human workforces and minimizing redundancy, we aim to enhance unit efficiency and take it to the next level.

CONCLUSION

This study represents the first report of PICC insertion in pediatric patients within a university hospital in Thailand. Our findings demonstrated a notably high success rate of insertions and no immediate complications were identified during the study period. The prevalent complications observed were catheter malfunctions and infection. The participation of fully trained medical personnel and attentive caregivers is vital to guarantee proper post-insertion care and to maintain a complication-free experience for the entire duration of PICC use. The

ALiST team at Siriraj is available by direct contact to provide a consult or assist the other institutions to start the PICC service.

ACKNOWLEDGMENTS

Associate Professor Dr. Arunothai Siriussawakul, MD., Assistant Professor Aphichat Suphathamwit, MD., and Assistant Professor Taniga Kiatchai, MD. from the Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, for their contributions to manuscript preparation. The authors thank Ms. Chusana Rungjindamai, Mr. Suthipol Udompunturak and Ms. Julaporn Pooliam, research coordinators and statistical analysts. Ms. Sudta Parakkamodom, M.Sc. for anesthesia database.

Data availability

The dataset can be provided upon request to the corresponding author.

Conflict of interest

The authors declared no conflict of interest.

Funding

This study supported by Siriraj Research Development Fund (Managed by Routine to Research: R2R), Grant Number (IO) R016535024.

REFERENCES

1. Thiagarajan RR, Ramamoorthy C, Gettmann T, Bratton SL. Survey of the use of peripherally inserted central venous catheters in children. *Pediatrics*. 1997;99(2):E4.
2. Grewal S, Towbin R, Schaefer C, Aria D. How We Do It: Peripherally Inserted Central Catheter Placement (PICC). *Appl Radiol*. 2020;1(1):1.
3. Anthony KK, Gil KM, Schanberg LE. Brief report: Parental perceptions of child vulnerability in children with chronic illness. *J Pediatr Psychol*. 2003;28(3):185-90.
4. Delarbre B, Dabadie A, Stremmer-Lebel N, Jolibert M, Cassagneau P, Lebel S, et al. Introduction of the use of a pediatric PICC line in a French University Hospital: review of the first 91 procedures. *Diagn Interv Imaging*. 2014;95(3):277-81.
5. Badheka A, Bloxham J, Schmitz A, Freyenberger B, Wang T, Rampa S, et al. Outcomes associated with peripherally inserted central catheters in hospitalised children: a retrospective 7-year single-centre experience. *BMJ Open*. 2019;9(8):e026031.
6. Laochareonsuk W, Boonsanit K, Chotsompancharoen T, Sangkhathat S. An Appraisal of Totally Implantable Venous Access Devices in Pediatric Cancers. *Siriraj Med J*. 2020;72(2): 95-102.
7. Jumani K, Advani S, Reich NG, Gosey L, Milstone AM. Risk factors for peripherally inserted central venous catheter complications in children. *JAMA Pediatr*. 2013;167(5):429-35.
8. Raina R, Mittal A, Sethi SK, Chakraborty R. Challenges of Vascular Access in the Pediatric Population. *Adv Chronic*

- Kidney Dis. 2020;27(3):268-75.
9. Naik VM, Mantha SSP, Rayani BK. Vascular access in children. *Indian J Anaesth.* 2019;63(9):737-45.
 10. Wrightson DD. Peripherally inserted central catheter complications in neonates with upper versus lower extremity insertion sites. *Adv Neonatal Care.* 2013;13(3):198-204.
 11. Kwon S, Son SM, Lee SH, Kim JH, Kim H, Kim JY, et al. Outcomes of bedside peripherally inserted central catheter placement: a retrospective study at a single institution. *Acute Crit Care.* 2020;35(1):31-7.
 12. Westergaard B, Classen V, Walther-Larsen S. Peripherally inserted central catheters in infants and children - indications, techniques, complications and clinical recommendations. *Acta Anaesthesiol Scand.* 2013;57(3):278-87.
 13. Tariq M, Huang DT. PICCing the best access for your patient. *Crit Care.* 2006;10(5):315.
 14. Gunst M, Matsushima K, Vanek S, Gunst R, Shafi S, Frankel H. Peripherally inserted central catheters may lower the incidence of catheter-related blood stream infections in patients in surgical intensive care units. *Surg Infect (Larchmt).* 2011;12(4):279-82.
 15. Limprayoon K, Borisut C, Vichainsarn S. The Quality Improvement of Central Venous Catheter Associated Blood Stream Infection (CABSI) by New Clinical Practice Guideline in Pediatric ICU Siriraj Hospital. *Siriraj Med J.* 2007;59(4):181-3.