# RESEARCH



# Vascular access modalities in a pediatric intensive care unit in tertiary hospital indications and outcomes: a single-center cross-sectional study



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# Abstract

**Background** Vascular access is a mainstay of pediatric critical care. The selection of the route of access and equipment used will depend on patient- and provider-specific factors, which constantly need revision to achieve more effective assessment and management.

**Objective** To evaluate the use, indication, and outcome of different vascular access modalities in critically ill children in the Emergency Pediatric Intensive Care Unit (ER-PICU) of a tertiary university hospital.

**Patients and methods** This cross-sectional descriptive study was based on data collected by reviewing all modes of vascular access used for 168 consecutive patients admitted to ER-PICU during a 6-month period from May to October 2020.

**Results** Among the study group (n = 168), there were 92 males (54.8%) and 76 females (45.2%). The median age of cases was 18 months. 333 vascular access devices were observed: 219 peripheral (65.8%) and 114 central catheters (34.2%). Catheters lasted a total of 1920 catheter days. Central venous catheters lasted significantly more than peripheral lines (P < 0.001); median of 8.5 and 3 days, respectively. The incidence of peripheral line complications (35.2%) was found significantly higher compared to central venous catheters (22.8%) (P.=0.021). Longer dwell time of central access was associated with a higher incidence of catheter-related bloodstream infection. The incidence of catheter-related bloodstream infection was 9.05 per 1000 catheter days. Mortality rate was 24.4%.

**Conclusions** Despite having lower incidence of complications than peripheral lines, central venous catheters' complications are considered more serious. Dwell time of central venous catheters (CVC) should be revised daily to avoid the occurrence of infection.

Keywords Catheter-related bloodstream infection, Central venous catheters, PICU, Vascular access devices

# Background

A vascular access device (VAD) is required by most hospitalized infants and children. Though important, These devices come with risks [1]

To provide life-sustaining therapy, including but not limited to fluid resuscitation, antibiotics, vasopressors, or parenteral nutrition, and for hemodynamic surveillance, vascular access devices are typically placed, often in a time-sensitive manner, in critically ill patients [2].

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Forms of vascular access include arterial access (as umbilical, radial, and posterior tibial catheters), venous access which is further divided into central (as peripherally inserted central catheter (PICC), central umbilical venous catheter, tunneled, non-tunneled catheters and implantable ports), and peripheral (as umbilical catheters, midline catheters, and peripheral cannula) and finally intraosseous access (as in proximal tibia, distal tibia, distal femur, and humerus) [3].

In children, vascular access can be difficult. In individuals with a known history of difficult venous access, various techniques have been used to enhance first pass success rates, including surface landmarking, local warming, transillumination, ultrasonography, epidermal nitroglycerin, central venous access, intraosseous positioning, and venous cutdown. The use of novel aid devices and techniques improves the peripheral catheter placement success rate in infants [4].

The most common serious complication linked to CVCs is probably infection. The term used when a colonized CVC is known to be the source of a systemic infection is "catheter-related bloodstream infection" (CRBSI). The requirement for this diagnosis is that a particular organism must be cultured, from blood samples taken both from the CVC and from a peripherally taken venous sample. The colony count of the CVC-derived sample should be at least three times greater than that obtained from the peripherally drawn blood sample [5].

There are a range of difficulties associated with the acquisition and maintenance of vascular access [6]. Today, technological improvements in catheter design and imaging techniques have significantly facilitated line placement and increased the available options for vascular access [3].

The aim of the study was to evaluate the current practice of vascular access insertion in the emergency PICU of a tertiary university hospital regarding types, indications, and possible complications. We were limited however by the COVID pandemic which decreased the admission rate as positive cases were referred from triage to specialized isolation hospital.

# Methods

This was a cross-sectional descriptive study to evaluate the use, indication, and outcome of different vascular access modalities in critically ill children in the ER-PICU of a tertiary university hospital (which comprises 23 beds and has an estimated admission rate of 725cases/year). The study included 168 consecutive critically ill pediatric patients of both genders aged from 1 month to 12 years admitted to the ER-PICU during a 6-month period; from May 2020 to October 2020.

# Inclusion criteria

Age: 1 month to 12 years, which is the age range permitted to be admitted in our hospital; both genders and all critically ill patients admitted in ER-PICU during 6 months.

# **Exclusion criteria**

None.

# Scientific and ethical committees' approval

This study was approved by the scientific committee of the Pediatrics Department, Faculty of Medicine, Cairo University, and by the Research Ethics Committee (REC) the 16th of August 2020 under IRB: "MS-232–2020," Faculty of Medicine, Cairo University. Guardians of all included patients gave verbal consent before enrollment in the study.

#### Study procedure and data collection

Data were collected by reviewing all modes of vascular access used for every admitted patient in the PICU during the study period while filling a specially structured data collection sheet containing the following information for each eligible participant.

(1) Patient's data collected: numerical code, date of admission, duration of ICU stay (in days), age (in months), and weight (in kilograms), gender, diagnosis, and system failures on admission.

(2) For each access the following was recorded:

Indication(s) of vascular access: medication/ infusion, blood product transfusion, and others (specified).

Urgency of insertion: emergency: inserted while the patient was hemodynamically unstable and lacking other functional vascular access modality. Elective: inserted while the patient was relatively stable and lacking other functional vascular access modality, or, replacing a less suitable/efficient precedent device. All lines that had been inserted in the ED were counted as "emergency" accesses.

Type of catheter: for central access, triple-lumen polyurethane non-tunnelled central venous catheters were used. Sizes: 3Fr, 4Fr, 5Fr, and 6Fr.

For peripheral access: peripheral cannulas made from fluorinated ethylene propylene, polyurethane, and polytetrafluoroethylene. Sizes: 24G (yellow), 22G (blue), 20G (pink), and 18G (green).

Site of insertion: central or peripheral and exact site of insertion.

Duration of catheter use until removal (in days): day of catheter insertion and day of removal were counted as full days. Complication(s): infection-related: local infection, bloodstream infection, thrombophlebitis and cellulitis. Mechanical complications and deep vein thrombosis (DVT): catheter damage, extravasation, catheter occlusion, vein thrombosis, and distal ischemia. Cannulation-related complications: hematoma, bleeding, pneumothorax, arrhythmia, and malposition.

# Reason for line change/removal

Prevention of infection: the catheter was removed when it had surpassed the recommended number of days in order to prevent infection, Expendable: the catheter was removed as another more suitable access was established, due to complication(s), discharge of patient or death, without complications, or others (specified).

(3) Patient's length of stay and survival to discharge

Statistical analysis: Analysis of data was performed using software MedCalc v. 19. (MedCalc Software Ltd Acacialaan 22, 8400 Ostend, Belgium info@ medcalc.org). Description of variables was presented as follows: comparison between qualitative variables was carried out by chi-square test, which was used to test the statistical significance of differences in a classification system (one-way classification) or the relationship between two classification systems (two-way classification) [7]. The significance of the results was assessed in the form of *P* value where *P*.<0.05 was considered significant.

#### \*Sample size\*

Using Epi info calculator for survey studies; with 0.05 alpha error, confidence interval 95%, and percent of representable sample to present modalities of vascular access in the pediatric intensive care unit is about 50%.

The average number of cases entering PICU and needing vascular access is about 10–15 patients per week, expected to have a population of 300 patients in 6 months data collection period. The low number of cases was due to COVID-19 pandemic where the majority of cases were admitted in isolation ICUs. During the pandemic, we were not allowed to admit COVID-positive cases; instead, they were triaged in a separate zone and then transferred to another building.

The sample size calculated is 168 patients.

## \*Sampling technique\*

A random sample of patients who entered PICU and needed vascular access with the inclusion and exclusion

criteria were assigned into study till reaching total sample size calculated.

## Results

This was a descriptive cross sectional study of current practice of vascular accesses used in critically ill children in the ER-PICU of a tertiary university hospital. The study group consists of 168 patients (Table 1). Among the study group there were 92 males (54.8%) and 76 females (45.2%). The median age of cases was 18 months, and the median weight was 10 kg; a median *z* score of -0.27.

Table 2 lists the different causes of admission; postoperative was the most common diagnosis within the studied group (19.6%), then pneumonia (14.3%), foreign body aspiration (11.9%), heart failure (8.9%), and sepsis (8.9%).

Within the study group, 32.1% of cases had cardiovascular failure, 35.1% respiratory failure, 32.1% neurological failure, 6.5% hepatic failure, 10.1% hematological failure, and 19.04% renal failure (Fig. 1).

Table 3 demonstrates the 333 vascular access modalities that were used which lasted a total of 1920 catheter days; 219 peripheral lines were inserted and lasted 705 (36.7%) days, and 114 CVCs were inserted and lasted 1215 (63.3%) days.

As per Fig. 2, most lines were inserted for medications and fluid infusions (99.7%), while 18.3% were used for blood product transfusion.

Regarding the urgency of line insertion, most lines were elective (85.3%) and 14.7% were urgent as per Fig. 3. Definition of the emergency line is not related to the condition as all cases included are critically ill; hence, they are emergency cases. However, emergency line is the line inserted in the emergency department or as a rescue line which is usually the peripheral line. The central line, however, was found to be inserted in a more preparatory manner in our hospital in the ICU, rather than the emergency department.

Table 1	Demograp	hic data	of the stu	ıdy group
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		N=168
Gender	Female, n. (%)	76 (45.2%)
	Male, n. (%)	92 (54.8%)
Age (m)	Mean ± SD	37.54±43.73
	Median (IQR)	18 (5–60)
	Range	1-156
Weight z score	Median (IQR)	-0.27 (-0.68-0.32)
	Range	- 1.08-5.57
	$Mean \pm SD$	0.2992±1.1083
Weight (kg)	Median (IQR)	10 (5.75–16)
	Range	1.6-70
	Mean ± SD	12.7±10.3

m Months, kg Kilograms, IQR Interquartile range

# **Table 2** Diagnosis of the study group (n = 168)

Diagnosis		Patient group (n = 168)	
	n	%	
Postoperative/bronchoscopy	33	19.6	
Pneumonia	24	14.3	
Foreign body aspiration	20	11.9	
Heart failure	15	8.9	
Sepsis	15	8.9	
Acute kidney injury	13	7.7	
Encephalopathy	12	7.1	
Intractable convulsions without encephalopathy	7	4.2	
Life-threatening anemia (with disturbed consciousness or autoimmune hemolytic anemia + mismatch)	4	2.4	
Bleeding (coagulopathy)	3	1.8	
Electrolyte imbalance	3	1.8	
Intracranial hemorrhage	3	1.8	
Poisoning	3	1.8	
Cavernous sinus thrombosis	2	1.2	
Hypertension	2	1.2	
Others <sup>a</sup>	9	5.4	

<sup>a</sup> Others: acute liver failure, foreign body ingestion, bronchial asthma,

bronchiectasis with respiratory failure, near drowning, Guillain barre syndrome, pneumothorax, stridor, trauma. (n = 1, 0.6% each)

As per Table 4, 78.1% of peripheral lines were electively inserted while 21.9% were urgent. While CVCs were mostly inserted electively 99.1% and only 0.9% were urgently inserted. Significantly, peripheral lines were mostly used when emergency access was needed 98% compared to CVC (P<0.001), which only comprised 2% of emergency access.

Table 5 shows that there was statistically significant correlation between mean age/weight and size of chosen central catheter (P. < 0.001).

CVCs observed lasted significantly more than peripheral lines (P. < 0.001); median 8.5 and 3 days, respectively, which is demonstrated in Fig. 4.

Nearly 35.2% of peripheral lines caused complications, while 22.8% of CVCs caused complications (Fig. 5). The incidence of catheter-related bloodstream infection was 9.05 per 1000 catheter days.

As shown in Fig. 5, peripheral lines showed significantly more incidence of complications (p value = 0.021). Figure 6 shows that most common complications of peripheral lines were extravasation (41.6%), hematoma (36.4%), and catheter occlusion (20.8%). Most common complications of CVCs were catheter occlusion (46.2%), bloodstream infection (42.3%) and local infection (15.4%) with P values  $\leq$  0.05. Significantly, extravasation and hematomas were only observed in peripheral lines (P < 0.001) while bloodstream infections were only observed in CVCs (P = < 0.001). Incidence of catheter occlusions and local infection was significantly higher in CVCs with P values 0.012 and 0.044, respectively.

Table 6 and Fig. 7 show that reasons of removal significantly varied for each access type (P < 0.001); 69.3% of CVCs vs 41.6% of peripheral lines were removed prior to discharge of the patient. They show that 22.8% of CVCs vs 35.2% of peripheral lines were removed after causing complications, while 7.9% vs 19.2% were removed to prevent infection. Only 4.1% of peripheral lines were

#### Table 3 Types of vascular access (n = 333)

		Peripheral line	сус
Number of devices		219	114
Duration	Median (IQR)	3 (2–4)	8.5 (5–15)
	Range	1–7	1–35
Total catheter days		705 (36.7%)	1215 (63.3%)

CVC Central venous catheter, IQR Interquartile range



Fig. 1 System failures on admission



**Fig. 2** Indications of vascular access (*n* = 333)



removed for being expendable while none of the CVCs were found expendable.

More than 75.6% of cases in the study group survived, and 24.4% of cases died as shown in Fig. 8.

Table 7 shows a highly significant correlation between time spent in ICU and mortality (*p* value < 0.001) where the median length of ICU stay was higher in the mortality group. Regarding individual system failures, mortality was highly associated with cardiovascular, neurological, respiratory failure followed by renal failure with *P* values  $\leq$  0.005, while hepatological and hematological failure were nonsignificant. Cardiovascular system failure on admission increases the likelihood of patient death and so on. Table 7 also shows the clear association found between the number of systems failure on admission and mortality of the patient with a P value 0.001. The highest mortality (100%) in patients admitted with failed 4 systems.

# Discussion

Our study is based on data collected by reviewing all modes of vascular access used for 168 consecutive patients admitted to ER-PICU during a 6-month period from May to October 2020.

In our study, most access devices were indicated for administration of medication and fluids' infusions (99.7%) and 18% for transfusion of the blood or blood product which is consistent with others who studied access' indications as Alexandrou et al. [8] whose indications of vascular access were 95% for medications and fluids and 5% for blood products and Abdelaziz et al. [9] who found 92.1% for medications and fluids and 7.9% for blood products' transfusion.

Elective accesses represented 85.3% while 14.7% of accesses were urgently inserted. Closely similar results were observed in other literature, where 91% were elective in Alexandrou et al. [8], while 59.4% were elective as per another study [10]. Our results showed that peripheral lines were mostly chosen for emergency vascular access (P < 0.001).

Table 4 Urgency of vascular access insertion peripheral line versus CVC

	Peripheral line		сус		Test value <sup>*</sup>	P value
	n	%	n	%		
Emergency	48	21.9%	1	0.9%	26.448	< 0.001
Elective	171	78.1%	113	99.1%		

CVC Central venous catheter, Sig. Significance

P value > 0.05, non-significant (NS); P value < 0.05, significant (S); P value < 0.01, highly significant (HS)

\* Chi-square test



 Table 5
 Relation between size of catheter and age and weight by Kuskal-Wallis test

Size of catheter	Age (months)	Weight z score		
	Median (IQR)	Median (IQR)		
Peripheral line				
18G	120 (66–156)	0.71 (0.71-4.11)		
20G	24 (9–72)	-0.12 (-0.46-0.51)		
22G	18 (6–48)	-0.27 (-0.65-0.22)		
26G	11 (5–36)	-0.46 (-0.65-0.22)		
P.value	0.038 (S)	0.041 (S)		
CVC				
4Fr	3.25 (2-4.75)	-0.78 (-0.850.7)		
5Fr	45 (17–72)	0.03 (-0.27-0.51)		
6Fr	132 (114–144)	1.63 (1.44–1.92)		
P.value	<0.001 (HS)	<0.001 (HS)		

*IQR* Interquartile range, G Gauge, Fr French (needle measurement system), CVC Central venous catheter

The different definition for an "emergency/elective" access in each was found to be the main cause of the difference between the results, as per our methodology "All lines that had been inserted in the ED". Notably, all lines inserted in the ED were peripheral lines.

No consistency was found between the literature, and our results obtained in this study regarding distributions of VAD type and site. External jugular vein was significantly more often the access of choice for peripheral access (47%) in ER-PICU, while its usage in most similar studies was very limited or even nonexistent; in Melyon et al.'s study of 458 peripheral lines' [10], Alexandrou et al. [8]'s and Rickard et al. [11]'s all favored superficial limb veins, while external jugular vein was rarely used; most probably for the approach being more invasive thus increased risk of relatively major complications as pneumothorax compared to limb veins [12].

Our results regarding duration of peripheral and central access device use are consistent with the most recent recommendations by the American Academy of Pediatrics (AAP) recommending use of non-tunneled central venous catheters for durations less than 14 days Naik et al. (3) which was also later supported by the series of miniMagic studies in Ullman et al. [13] and US's Center of Disease Control (CDC)'s guidelines recommending changing peripheral lines every 3 days to prevent increased risk of complications [14]. Other types of access were neither used nor available.

In our study, the incidence of VAD complications among all inserted devices (n=333) was 30.9%, the reasons for catheter removal were 51.1% completion of treatment, and 30.9% were removed due to complications, 15.3% to prevent infection, and 2.7% as they were found expendable, mostly replacing peripheral access with central access.

Regarding reasons for removal, a significant variation was noted depending on the type of vascular access used (P < 0.001); 35.2% of peripheral lines were removed due to complications while only 22.8% of CVC were removed upon causing complications, which is consistent with the complication rates as it was found that peripheral lines cause more but less life-threatening/serious complications.

Peripheral line complications were found at 35.2%. The most common complications recorded were extravasation (41.6%), hematoma (36.4%), and catheter occlusion (20.8%).



Fig. 4 Comparing peripheral line and CVC dwell time







**Fig. 6** Prevalence of different complications for each type

Reason of removal	Peripheral line		CVC		P value	
	n	%	n	%		
Prevention of infection	42	19.2%	9	7.9%	0.0013*	
Expendable	9	4.1%	0	0.0%	0.0286*	
Due to complication(s)	77	35.2%	26	22.8%	0.0246*	
Discharge of patient	91	41.6%	79	69.3%	< 0.001*	

Table 6 Relation between reason of removal and type of access

P value > 0.05, non-significant (NS); P value < 0.05, significant (S); P value < 0.01, highly significant (HS)

\* Chi-square test

According to previous literature, peripheral lines studied by Alexandrou et al. [8] showed a 12% incidence of complications, 25% by Malyon et al. [10], and 51.9% by Abdelaziz et al. [9], and Hathaway and Magee [15] reported 30.1% incidence of complications.

Regarding peripheral line-specific complications and reason for removal, in Malyon et al. [10]'s study, they were removed due to device failure, and infiltration represented 14.3%, accidental dislodgement 5%, blockage 2.6%, and phlebitis 1.5% with a total of 24.8% of catheters removed due to complications while 75.2% were removed due to completion of treatment, which is consistent with Foster et al. [16]'s study earlier that concluded 74.6% of 370 catheters were removed uncomplicated when they were no longer required.

The incidence of CVC-related complications was 22.8%, and the most common complications were occlusion (46.2%), bloodstream infection (42.3%), and local infection (15.4%).



Fig. 7 Comparing reasons of removal for each type of access



Fig. 8 Survival of study group

The rate of complications associated with vascular access in our ICU was found high. Choices of access were found limited to peripheral lines and non-tunneled central venous catheters, relevant choices of access modalities were underutilized, and guidance of U/S was not used as the staff lacked the training needed. Vascular access-related decisions were broad and lacked basis. And there were no specific guidelines or protocols to assist the staff choosing the optimal access for patients based on their specific needs such as anticipated duration of access, infusate characters, and decision was instead left solely to the pediatrician or nurses on duty.

The prevalence of specific complications was consistent with other studies, except for CRBSI whose incidence is higher in our ICU, and the prevalence of pneumothorax which was not observed in our study varied in the literature from 1% as in Howthan and Mersal's study [15] up to 41.3% in a study by Magee [17].

The incidence of CRBSI in our ICU was 9.05 per 1000 catheter days, which is consistent with studies conducted in developing countries but relatively high compared

to developed countries. Howthan et al. (2021)'s study resulted in 3.2 per 1000 catheter days [17].

The reported incidence of CRBSI varies from country to country and even from hospital to hospital. A meta-analysis conducted at The Johns Hopkins Hospital revealed that bloodstream infections (BSIs) were the third leading cause of hospital-acquired infections.

Preventive measures must be planned and implemented in a systematic manner in order to reduce the rate of CRBSI and, as a result, improve healthcare quality. Knowledge of evidence-based interventions may help to reduce infection risks, and research into CRBSI epidemiology and pathogenesis is critical for improving pediatric healthcare quality [18].

Different reasons for admission were found; the most common are postoperative (19%) and pneumonia (14.3%). In Abdelaziz et al. (2017)'s study, most common admission causes were respiratory diseases (24.5%), infections (15.3%), and hematological diseases (18.3%) [9]. In our study period, patients admitted with pneumonia and chest-related conditions were relatively lower as the COVID-19 pandemic impacted the type and quality of the studied group, and COVID-19 patients were referred to specialized isolation hospitals directly from the emergency department (ED).

Our mortality rate is considerably higher than mortality rates in other developing countries as in Siddiqui et al. [19]'s study of 1919 patients admitted to a private-sector PICU located in Pakistan which only 248 died (12.9%). And our mortality was even higher when compared to developed countries' PICUs such as in Burns et al. [20]'s study conducted in 5 US teaching hospitals that included 9516 pediatric patients of which only 227 died with an overall mortality of 2.39%.

		Survived		Died		P value
		n. = 127		n.=41		
Age (months)	Mean ± SD	38.49±43.93		34.01±43.51		0.216#
	Median (IQR)	18 (6–60)		10 (3.5–48)		
	Range	1–156		1–144		
Gender	Female	53 (41.7%)		23 (56.1%)		0.108*
	Male	74 (58.3%)		18 (43.9%)		
Weight (kg)	Median (IQR)	10 (6–18)		9 (4–14)		0.126#
	Range	1.6–70		2–30		
Weight z-score	Median (IQR)	-0.27 (-0.65-0.51)		-0.36 (-0.85-0.12)		0.126#
	Range	- 1.08-5.57		- 1.04-1.68		
ICU Days	Median (IQR)	6 (3–8)		11 (6–24)		< 0.001#
	Range	1–76		1-101		
No. of lines	Median (IQR)	2 (1-3)		3 (1–3)		0.083#
	Range	1–5		1–8		
Type of system failur	e on admission					
Cardiovascular			21 (16.5%)		33 (80.5%)	< 0.001
Respiratory			30 (23.6%)		29 (70.7%)	< 0.001
Neurological			24 (18.9%)		30 (73.2%)	< 0.001
Hepatological			7 (5.5%)		4 (9.8%)	0.339
Hematological			12 (9.4%)		5 (12.2%)	0.612
Renal			18 (14.2%)		14 (34.1%)	0.005
Number of system fa	ilure					
0 (n = 37)			37		0 (0%)	0.001
1 (n=76)			70		6 (7.9%)	
2 (n = 25)			18		7 (28%)	
3 (n = 19)			2		17 (89.5%)	
4 (n = 11)			0		11 (100%)	

Table 7 Relation between survival and age, gender, weight, and time spent in ICU

P value > 0.05, non-significant (NS); P value < 0.05, significant (S); P value < 0.01, highly significant (HS)

\* Chi-square test, <sup>≠</sup>Mann–Whitney test

\*\* IQR Interquartile range, Sig. Significance, kg Kilograms, n Number, ICU Intensive care unit

The relatively high mortality rate may be explained by the difference in the severity of diseases in admitted patients as our hospital is a tertiary center and is a destination for referral of the most complicated conditions, also the relatively lower resources, socioeconomic, and educational status of our patients' families contributes greatly to the outcome.

The median length of the ICU stay was 6 days which is consistent with Abdelaziz et al. [9] who also found the exact same median duration of the ICU stay (6 days), whereas longer stay was found in other studies as per Lin et al. (2017), the average length of stay was 12 days [21].

# Limitations

The COVID-19 pandemic impacted the type and quality of the studied group, and the suspected COVID-19 patients were referred to specialized isolation hospitals directly from the emergency department. The choices of access were found limited to peripheral lines and non-tunneled central venous catheters.

## Conclusion

The number and type of system failures on admission were early predictors for mortality. CVCs observed lasted significantly more than peripheral lines. The peripheral line insertion site was most commonly the external jugular vein, while the preferred site for CVC was the internal jugular vein. Peripheral line complications were found at 35.2%. Most common complications recorded were extravasation, hematoma, and catheter occlusion, with a median duration per peripheral line 3 days.

## Abbreviations

- BSI Bloodstream infection
- CDC Center of disease control

AAP American Academy of Pediatrics

- CRBSI Catheter-related bloodstream infection CVC Central vascular catheter DVT Deep venous thrombosis
- ED Emergency department
- PICC Peripherally inserted central catheter
- PICU Pediatric ICU
- REC Research ethics committee
- VAD Vascular access device

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#### Authors' contributions

All authors have contributed significantly, and all authors are in agreement with the content of the manuscript. All authors revised the manuscript and agreed on publication. MMA followed the results, searched in the literature, revised the final manuscript, and is the corresponding author. HB participated in the choice of the issue of the study and followed the results. ASA participated in collecting the data of the patients, followed the results, and searched in the literature. DH Followed the results.

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#### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

#### Ethics approval and consent to participate

This study was approved by the scientific committee of the Pediatric Department, Faculty of Medicine, Cairo University, and by the Research Ethics Committee (REC) the 16th of August 2020 IRB: "MS-232–2020," Faculty of Medicine, Cairo University. All legal guardians gave an informed written consent before enrollment.

#### **Consent for publication**

Not applicable.

#### **Competing interests**

The authors declare that they have co competing interests.

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