



# Evaluating the Efficacy of Ultrasonography Guidance in Pediatric Intensive Care Unit Patients with Central Vein Catheter

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## Abstract

**Introduction:** Central venous catheterization (CVC) is a substantial, commonly used approach in the treatment and follow-up of critically ill patients. This study aims to review the use of central catheters in pediatric intensive care unit and evaluate the efficacy of venous access procedures performed under ultrasonography (USG) guidance.

**Methods:** The records of 51 patients hospitalized in the Pediatric Intensive Care Unit between 01 May 2017 and 01 May 2018 and were implanted with CVC for various reasons were retrospectively examined. In this study, the data on age, body weight, diagnosis, CVC implantation region, indication, USG use, number of punctures during the procedure, procedure duration, implantation duration, prognosis, and complications that occurred during patient monitoring were recorded. Shapiro-Wilk test was used for evaluating the agreement of the parameters with a normal distribution, and for the quantitative data comparison, the Student t-test was used for comparing two groups for parameters with a normal distribution, while the Mann-Whitney U test was used for comparing two groups for parameters without normal distribution. For qualitative data comparison, Fisher's Exact test and Continuity (Yates) Correction were used.

**Results:** In this study, 51 patients implanted with CVC (28 (54.9%) female and 23 (45.1%) male) were included. No statistically significant difference was detected between patients for whom implantation was performed with and without USG considering age, gender, body weight, PRISM (Pediatric Risk of Mortality) score, intensive care unit hospitalization duration, mechanical ventilator use, catheter use duration ( $p < 0.05$ ). Nonetheless, it was noted that the number of punctures and the duration of catheter use reduced in patients implanted with CVC under USG ( $p = 0.000$  and  $p = 0.049$ ).

**Discussion and Conclusion:** The findings obtained in this study suggest that it is safe to perform central venous catheterization procedures required for the monitoring and treatment of patients in pediatric intensive care unit under ultrasonography and it clearly reduces the duration of the procedure and number of punctures.

**Keywords:** Central venous catheterization; ultrasonography; pediatric intensive care.

Central venous catheterization is a substantial, commonly used approach in the treatment and follow-up of critically ill patients. Central venous catheters (CVC) are used in intensive care units and emergency rooms with a

wide range of patient populations, in particular. CVC is often performed for many treatments and follow-up procedures, such as hemodynamic monitorization (e.g., Central venous pressure), long-term use of intravenous fluids, an-

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**Submitted Date (Başvuru Tarihi):** 22.09.2019 **Accepted Date (Kabul Tarihi):** 15.10.2019

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tibiotics, total parenteral nutrition and hemodialysis [1,2]. The most commonly used sites for this procedure are the internal jugular vein (IJV), femoral vein (FV) and subclavian vein (SCV). There may be technical challenges in veins previously catheterized or anatomical and morphological variations in veins [3]. Although it has many advantages, CVC insertion can be a risky or even fatal procedure due to rare complications, such as cardiac tamponade, massive cervical hematoma and puncture of endotracheal tube cuff [4,6]. Therefore, CVC indications should be determined based on the patient's needs. Also, the type of central catheter and application site (vein) must be individually determined for each patient [7,8]. During this planning stage, reducing complication rates should be aimed. Low complication rates have been reported for venous access procedures performed under ultrasonography (USG) guidance [9].

This study aims to review the use of central catheters in pediatric intensive care unit and evaluate the efficacy of venous access procedures performed under USG guidance.

## Materials and Methods

Health Sciences University Ümraniye Training and Research Hospital ethics committee granted approval on 21 November 2018 for doing a cross-sectional descriptive study.

The records of 51 patients hospitalized into Health Sciences University Ümraniye Training and Research Hospital, Pediatric Intensive Care Unit (PICU) of 10 beds between 01 May 2017 and 01 May 2018 and were implanted with CVC for various reasons were retrospectively examined. In this study, the data on age, body weight, diagnosis, CVC implantation region, indication, USG use, number of punctures during the procedure, procedure duration, implantation duration, prognosis and complications that occurred during patient monitoring were recorded.

The patients were implanted with CVC for total parenteral nutrition, fluid and medication administration, continuous renal replacement treatment, plasmapheresis and central venous pressure monitorization.

FV, IJV and SVC were the sites preferred. IJV and SCV catheterization were performed under USG. All patients were sedated with midazolam and administered with fentanyl for analgesic effects. Ketamine was used as a sedative for patients with hypotension. Patients were examined with chest X-rays for catheter location and complications upon the implantation of IJV and SCV catheters.

## Statistical Analysis

IBM SPSS Statistics 22 (IBM SPSS, Turkey) program was used for statistical analysis of study findings. Shapiro Wilks test was used for evaluating the agreement of the parameters with a normal distribution. For the comparison of descriptive statistical methods (Mean, Standard deviation, frequency) along with quantitative data, Student t-test was used for comparing two groups for parameters with a normal distribution, while the Mann-Whitney U test was used for comparing two groups for parameters without normal distribution. For qualitative data comparison, Fisher's Exact test and Continuity (Yates) Correction were used. Significance of  $p < 0.05$  was used.

## Results

In this study, 51 patients implanted with CVC (28 (54.9%) female and 23 (45.1%) male) were included. The average age of the patients was  $52.8 \pm 55.01$  months, average hospitalization duration was  $27.5 \pm 27.02$  days, average body weight was  $17.59 \pm 14.87$  kg, average pediatric mortality risk score (PRISM) was  $16.81 \pm 7.29$ , and implantation duration was  $16.1 \pm 11.13$  days. The average hospitalization duration of the patients in PICU was  $27.5 \pm 24.2$  days. The largest patient group was made up of patients with respiratory system disorders ( $n=13$ ). This was followed by patients with neurological disorders ( $n=12$ ) and patients with hematology/oncology disorders ( $n=7$ ) (Table 1). Nine (20.5%) of the patients died due to underlying diseases. 41 (80.4%) of the patients required respiration support with a mechanical ventilator. The indications for implanting catheters were noted as fluid and medication administration in 37 patients (72.5%), continuous hemodiafiltration in eight patients (15.7%) and therapeutic plasma exchange in six patients (11.8%). Arterial puncture was performed in three patients (5.9%) during the procedure where the catheter site was femoral vein. We noted bloodstream infection in two patients (3.9%), catheter occlusion due to thrombus in four patients (7.8%), pneumothorax in one patient (2%) and

**Table 1.** Pediatric intensive care unit admission diagnosis

	n	%
Pulmonary disease	13	25.40
Neurological disorder	12	23.50
Oncological disorder	7	13.80
Sepsis	5	9.80
Cardiological disorder	5	9.80
Surgical disorder	4	7.90
Other	5	9.80

catheter dislocation in one patient (2%) during monitoring. Forty-six of the patients (90%) were free of any complications. 27 (52.9%) of the catheter placement procedures were performed under USG. IJV was used in 29 (56.9%), FV was used in 16 (31.4%) and SCV was used in six (11.8%) cases. When evaluated on the basis of USG use; no statistically significant difference has been detected between patients for whom placement was performed under USG or not concerning age, gender, body weight, PRISM score, intensive care unit hospitalization duration, mechanical ventilator use, catheter use duration ( $p < 0.05$ ). However, it was noted that the number of punctures and the duration of catheter use were less in patients implanted with CVC under USG ( $p = 0.000$  and  $p = 0.049$ ) (Table 2). When patients

were compared for catheter placement sites, the number of punctures was significantly higher and the duration of the placement was longer in FV than IJV and SCV ( $p = 0.000$  and  $p = 0.049$ , respectively) (Table 3).

## Discussion

CVC is an invasive method preferred for monitoring vital signs in ICU, liquid electrolyte treatment, antibiotherapy and blood transfusion [7,10].

As usually in intensive care units, CVC was used mainly for medication and fluid administration to patients and rarely for hemofiltration and therapeutic plasma exchange in our hospital's PICU. Following successful applications in adults,

**Table 2.** Comparison of the parameters between central venous catheterization with and without ultrasonography guidance

	USG		p
	Yes Mean±SD (median)	No Mean±SD (median)	
Age (month)	50.37±50.32	55.54±60.83	<sup>1</sup> 0.741
Number of punctures	1.19±0.4 (1)	2.42±1.79 (2)	<sup>2</sup> 0.000*
PRISM	18.43±7.81	14.53±6.01	<sup>1</sup> 0.115
Duration of the procedure	9.19±3.87 (8)	13.46±8.09 (11)	<sup>2</sup> 0.049*
Catheter use duration	14.48±8.11 (12)	17.87±13.66 (16)	<sup>2</sup> 0.450
Body weight (kg)	18.26±15.59 (15)	16.83±14.31 (14)	<sup>2</sup> 0.806
PICU hospitalization duration	23.91±24.94 (18)	31.84±29.44 (27)	<sup>2</sup> 0.234
Gender, n (%)			
Female	16 (59.3)	12 (50)	<sup>3</sup> 0.703
Male	11 (40.7)	12 (50)	

<sup>1</sup>Student t-Test; <sup>2</sup>Mann-Whitney U Test; <sup>3</sup>Continuity (Yates) Correction; \* $p < 0.05$  (PRISM: Pediatric Risk of Mortality); PICU: Pediatric Intensive Care Unit).

**Table 3.** Evaluation of the parameters based on application sites

	Catheter site		p
	Femoral Mean±SD (median)	IJV+SCV Mean±SD	
Age (month)	70.13±67.7	44.89±47.14	<sup>1</sup> 0.130
Number of punctures	2.38±1.78 (2)	1.49±1.1 (1)	<sup>2</sup> 0.006*
PRISM	15.4±6.98	17.35±7.47	<sup>1</sup> 0.481
Duration of procedure	14.06±7.92 (13)	9.89±5.41 (8)	<sup>2</sup> 0.049*
Use duration (days)	18.5±15.68 (16)	14.91±8.03 (13.5)	<sup>2</sup> 0.637
Body weight (kg)	19.81±16.28 (16)	16.57±14.31 (13)	<sup>2</sup> 0.483
PICU hospitalization duration	39.17±34.28 (30)	22.83±22.53 (18)	<sup>2</sup> 0.074
Gender, n (%)			
Female	9 (56.3)	19 (54.3)	<sup>3</sup> 1.000
Male	7 (43.8)	16 (45.7)	

<sup>1</sup>Student t-Test; <sup>2</sup>Mann-Whitney U Test; <sup>3</sup>Continuity (Yates) Correction; \* $p < 0.05$  (PRISM: Pediatric Risk of Mortality); PICU: Pediatric Intensive Care Unit).

it is becoming more and more used in pediatric intensive care units for its benefits [7].

With the increase of experience in CVC procedures in children and improvement in care, CVC is becoming more widely used. While it was only possible to perform CVC under general anesthesia, open surgical intervention or percutaneous intervention in previous years, the proliferation of USG dispenses the need for general anesthesia and surgical conditions. It can be performed in a shorter period and on the bedside is another essential factor.

IJV, SCV and FV are frequently used sites for percutaneous implantation of central venous catheters. IJV is especially used for applications in children and it is gaining in popularity [11]. IJV was used in 56.9% of the cases in our study. This can be associated with our clinical experience and the easily applicable nature of the procedure. The number of punctures and procedure duration were higher in femoral vein catheterization than the other two sites in our study. With that in mind, we preferred to use IJV for reducing both punctures and the duration. IJV also results in fewer cases of dislocation when compared with SCV. SCV catheterization related complications impose a high risk of mortality in coagulation and bleeding disorders, and therefore, extra-thoracic veins, such as IJV or FV, are used [12-14] Although IJV is more widely used, the catheter site must be determined upon a full examination of the patient.

During the early stages of CVC implantation, the patient may suffer from various complications, such as arterial puncture, nerve injury, infection, air or thrombus embolism, arrhythmia, hematoma, pneumothorax, hydrothorax, chylothorax, cardiac perforation or adjacent nerve and vein injury. In the advanced stages, the patient may suffer from secondary complications due to sepsis, thrombosis, vena cava superior syndrome [15,16]. For 5.9% of the patients, the arterial puncture was performed rather than vein puncture. Arterial puncture was performed on femoral vein cannulation without USG guidance. Arterial puncture complications were significantly reduced under USG guidance.

It is possible to encounter more common complications, such as pneumothorax, hemothorax, arterial puncture, along with rare complications, such as brachial plexus injury secondary to SVC catheterization or massive retroperitoneal hemorrhage due to femoral catheterization [17,18] In this study, there was no case with these rare complications and only 2% of the patients developed pneumothorax. Patients were treated upon early diagnosis with routine X-rays performed with the aim of validating the catheter location. This suggests the requirement to validate the cath-

eter location via X-rays upon IJV and SCV access. It enables early diagnosis of complications, such as hemothorax and pneumothorax.

Another reason for developing complications in the early stage is related to frequent needle insertion. Anatomical variations and non-palpable veins cause this [19]. Nonetheless, it was noted that the number of punctures and the duration of catheter use were less in patients implanted with CVC under USG. Even with anatomical variations, catheterization under USG provides a safer procedure. We believe that USG will be even more widely used due to the reason that it shortens the duration of the procedure, reduces the complications and is safe.

Leading late complications are catheter infections and thrombus. Late complications are related to the duration of use. The duration of use for temporary catheters should not exceed 3-4 weeks for IJV and SCV catheters and two weeks for FV catheters [20]. In this study, we observed bloodstream infection in 3.9% of the patients and catheter occlusion due to thrombus in 7.8% of the patients. The average duration of use was a maximum of two weeks.

The literature data suggest that the frequency of thrombus due to FV catheter is higher than that of SCV and IJV [21]. Femoral vein should be the last option for cases where longer duration of use is estimated.

In conclusion, for CVC applications required for the monitoring and follow-up of critically ill patients in PICU, the site should be determined upon clinical experience and care should be exercised for the possible complications. It will be safe to perform the procedure under USG since it significantly reduces the duration of the procedure and the number of punctures.

**Ethics Committee Approval:** Ümraniye Training and Research Hospital Clinical Research Ethics Committee was approved on 21/11/2018 with the number B.10.1.TKH.4.34.H.GP.0.01/131.

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions:** Concept: C.S.; Design: C.S.; Data Collection or Processing: M.A.; Analysis or Interpretation: S.E.; Literature Search: C.S.; Writing: C.S.

**Conflict of Interest:** None declared.

**Financial Disclosure:** The authors declared that this study received no financial support.

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