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ORIGINAL ARTICLE

Real Time Ultrasound Guided Practice in Passing Central Venous Pressure Line in Pediatric Population

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ABSTRACT

Objective: To assess the success of ultrasound guided central venous catheter (CVC) placement, its associated factors, and complications among patients admitted to pediatric intensive care unit (PICU).

Methods: A retrospective cross-sectional study was conducted at Department of Pediatrics, Pak Emirates Military Hospital from October 2018 to November 2019. All patients admitted in PICU who underwent ultrasound guided CVC placement were consecutively enrolled. The number of previous ultrasound lines placed, comfort with the ultrasound device, and opinion of the utility of the ultrasound device were recorded. Moreover, type of procedure, preferred side attempts, single attempt to success, CVC size used, sedation required, and complications were noted.

Results: Of total 108 children, the mean age was 5.15 ± 3.4 years. There were 69 (63.9%) males and 39 (36.1%) females. There were 12 (11.1%) children found with complications of passing central venous pressure (CVP) line. Of these 12 children, arterial puncture was found in 9 (75%) children, pneumothorax in 2 (17%) children, and hematoma in 1 (8%) child. The complications of passing CVP line was found significantly higher among children with organ failure diseases 9 (17.6%) as compared to other diseases 3 (5.3%) (p-value 0.041).

Conclusion: The use of ultrasound in CVC procedures is an asset to all trained personnel who conduct this procedure as it reduces the time required to complete the procedure and substantially minimizes potential complications.

Keywords: Complications, Pediatrics, Ultrasound, Central Venous Catheter.

INTRODUCTION

Central venous catheter (CVC) placement is a widely used procedure in emergencies and intensive cases for multifunctional purposes. These include hemodynamic monitoring, antibiotic management, parenteral nutrition, and hemodialysis.[1]

The internal jugular, subclavian, and femoral veins are the common sites that is used for the placement of central venous catheter.[2] The administration of CVC involves considerable risks and complications. Studies have reported cervical hematoma, cardiac tamponade, bleeding or pneumothorax while performing the CVC placement procedure.[3,4]

The anatomical visualizations or palpations have traditionally been used for the administration of central venous catheter. Nevertheless, most of the central catheter insertion is now carried out by ultrasound guided CVC which was first described by Yonei et al. in 1986.[5] Various studies have reported ultrasound guidance as the preferred method for the choice of the CVC in the use of both adults and children.[6-8]

Although there is clearly agreement on the benefits of the ultrasound-led central venous catheters in adults, there is limited, uncertain or nonexistent evidence for the related benefit of ultrasound guided central venous catheters in pediatrics.[5,7,9]

The purpose of this current study was to determine the use of real-time ultrasound-guided CVC insertion in pediatric patients. Given the problems like number of attempts, time to access, patient discomfort, and the high rate of accidental arterial punctures in children. The use of ultrasound in real time could have a role in the care of children who require central venous catheters.

METHODS

This retrospective cross-sectional study was conducted at Department of Pediatrics, Pak Emirates Military

Hospital from October 2018 to November 2019. All patients admitted in pediatric intensive care unit who underwent ultrasound guided CVC placement were consecutively enrolled. All procedures which were performed outside pediatric intensive care unit or procedure performed by non-critical care healthcare provider was excluded. The site of catheter placed was selected by the operator inserting the catheter.

By using OpenEpi sample size calculator taking 95% success rate of arterial and venous cannulation,[10] level of confidence 99%, 5% margin of error. The estimated sample size was 126. However, we enrolled 108 patients.

The ultrasound guided CVC placement was performed using a SonoSite 180 plus (SonoSite, Bothell, WA) in which ultrasound was used to visualize and guide the needle into the vessel. The SonoSite probe was dressed in a telescopically folded sterile sheath (CIVCO Medical Solutions, Kalona, IA); although the use of needle guides was permitted, none were used during the study. The vessel to be catheterized was located in the transverse plane with the ultrasound probe perpendicular to the skin, and the needle was directed at the vessel in real time. Once a blood flash was obtained, the CVC was placed. The ultrasound probe was used to direct the needle until successful wire placement was achieved, or to begin another needle entry into the skin.

The number of previous ultrasound lines placed, comfort with the ultrasound device, and opinion of the utility of the ultrasound device were recorded. Furthermore, information about type of procedure (emergency, elective, resident, or consultant), preferred side attempts, single attempt to success, CVC size used, sedation required, and complications (pneumothorax, arterial puncture or hematoma) were noted along with the baseline characteristics like age, gender and primary disease.

Data entry and analysis were done using a Statistical Package for Social Sciences (SPSS) version 20.0. Mean ± SD were computed for quantitative variables like, age (years) and weight (kg) while frequency and percentages were computed for categorical variables like, gender, complications, primary diseases, operation procedure, sizes of central venous pressure (CVP), and application of therapeutic support. Inferential statistics were explored using Independent sample t-test, Chi-square/Fisher exact test for comparison of complications, with general and clinical characteristics and One-way ANOVA test for mean comparison of sizes of CVP with age and weight. The p-value ≤ 0.05 was considered statistically significant.

RESULTS

Of total 108 children, the mean age was 5.15 ± 3.4 years (age ranges 2 month to 12 years). There were 69 (63.9%) males and 39 (36.1%) females. The mean weight of children was 9.12 ± 6.9 kg. Emergency procedure was performed among 17 (15.7%) and routine in 91 (84.3%) children. There were 12 (11.1%) children found with complications of passing CVP line.Organ failure was the most common primary disease observed in 51 (47.2%) patients.

Frequency of sizes of CVP was higher in 5 Fr 8 cm 33 (30.6%) and 5 Fr 6 cm 30 (27.8%) followed by 4 Fr 6 cm 21 (19.4%), 5.5 Fr 8 cm 17 (15.7%), 9 Fr 12 cm 4 (3.7%), and 8 Fr 11 cm 8 3 (2.8%). Application of therapeutic support was higher in children with sedation 93 (86.1%) as compared to ventilated children 43 (39.8%), ionotropic support 21 (19.4%), previous CVC 10 (9.25%), neuromuscular blockade 2 (1.85%).

There were 12 (11.1%) children found with complications of passing CVP line. Of these 12 children, arterial puncture was found in 9 (75%) children, pneumothorax in 2 (17%) children and hematoma in 1 (8%) child. (Figure 1) A significant mean difference of sizes of CVP was found with age (p-value 0.010) and weight (p-value 0.001) of children. (Figure a & b)

Success rate of passing CVP line in first attempt was found significantly higher in right site access 79 (83.2%) as compared to left site access 7 (53.8%) (p-value 0.024). While mean of number of attempts was found significantly lower in right site access 1.25 ± 0.6 as compared to left site access 1.92 ± 1.3 (p-value 0.003). (Table 1)

The comparison of complications with primary disease showed that complications was found significantly higher in organ failure diseases 9 (17.6%) as compared to other diseases 3 (5.3%) (p-value 0.041). An insignificant mean difference of complication of passing CVP line was found with age (p-value 0.559) and weight (p-value 0.051). (Table 2)

DISCUSSION

This study was conducted to evaluate the success of ultrasound guided CVC placement among patients in a pediatric population. Almost all of the CVP procedure in this study were performed by consultants while about sixteen percent of the lines were placed as emergency procedures. This is in concordance with previous studies that have emphasized the need for enough practice and experience in the technique to be able to carry out the procedure successfully.[11] This practice has

Table 1: Comparison of success of passing CVP line and number of attempts with general and clinical characteristics (n=108)

	Total	Success of passing CVP line			No. of attempts	
		Yes (n=86)	No (n=22)	p-value	Mean ± SD	p-value
Age						
≤5 years	64	50 (78.1)	14 (21.9)	0.809^	1.31 ± 0.6	0.737$
>5 years	44	36 (81.8)	8 (18.2)		1.36 ± 0.8	
Gender						
Male	69	57 (82.6)	12 (17.4)	0.307^	1.30 ± 0.7	0.607$
Female	39	29 (74.4)	10 (25.6)		1.38 ± 0.7	
Weight						
≤9 kg	71	56 (78.9)	15 (21.1)	0.787^	1.36 ± 0.8	0.543$
>9 kg	37	30 (81.1)	7 (18.9)		1.27 ± 0.6	
Site Access						
Right	95	79 (83.2)	16 (16.8)	0.024~*	1.25 ± 0.6	0.003$*
Left	13	7 (53.8)	6 (46.2)		1.92 ± 1.3	
Complications						
Yes	12	8 (66.7)	4 (33.3)	0.260~	1.75 ± 1.2	0.047$*
No	96	78 (81.3)	18 (18.8)		1.28 ± 0.6	
Neuromuscular blockade						
Yes	2	2 (100.0)	0 (0.0)	0.999~	1.00 ± 0.0	0.541$
No	106	84 (79.2)	22 (20.8)		1.33 ± 0.7	
Sedation						
Yes	93	72 (77.4)	21 (22.6)	0.297~	1.37 ± 0.8	0.151$
No	15	14 (93.3)	1 (6.7)		1.06 ± 0.2	
Inotropes						
Yes	21	19 (90.5)	2 (9.5)	0.233~	1.19 ± 0.6	0.348$
No	87	67 (77.0)	20 (23.0)		1.36 ± 0.7	
Ventilation						
Yes	43	37 (86.0)	6 (14.0)	0.178^	1.25 ± 0.7	0.399$
No	65	49 (75.4)	16 (24.6)		1.38 ± 0.7	
Previous CVP						
Yes	10	8 (80.0)	2 (20.0)	0.999~	1.30 ± 0.6	0.887$
No	98	78 (79.6)	20 (20.4)		1.33 ± 0.7	
Primary Disease						
Organ failure/disorder	51	39 (76.5)	12 (23.5)	0.441^	1.37 ± 0.7	0.620$
Miscellaneous	57	47 (82.5)	10 (17.5)		1.29 ± 0.7	

- CVP: Central Venous Pressure, CVC: Central Venous Catheter
- Success defined as CVP insertion in first attempt
- Complications included: Arterial puncture, Pneumothorax and Hematoma

$Independent sample t-test and ^Chi-square/~Fisher exact test applied, *p-value ≤ 0.05

also been encouraged in the guidelines issued by National Institute of Clinical Excellence (NICE) which recommend that ultrasound guidance be used for all elective and considered for all emergency central venous cannulations in the National Health Service (England and Wales).[12]

Since most CVP placements in our study required less than 2 attempts it would appear that this technique guided by ultrasound, appears to be a safe procedure for patients, as long as the technique is employed by experienced personnel. A similar result was reported in a meta-analysis by Keenan SP[13] that included 18 studies comparing the passage of catheters guided by ultrasound versus placement using anatomic landmarks, failure rates as low as sixteen percent and a decreased complication risk of twenty four percent,

Table 2: Comparison of complications with general and clinical characteristics (n=108)

	Total	Complications		p-value
		Yes (n=12)	No (n=96)	
Age, years	5.15 ± 3.4	5.70 ± 3.4	5.08 ± 3.4	0.559$^{\$}$
Age				
≤5 years	64	5 (7.8)	59 (92.2)	0.222~
>5 years	44	7 (15.9)	37 (84.1)	
Gender				
Male	69	7 (10.1)	62 (89.9)	0.753~
Female	39	5 (12.8)	34 (87.2)	
Weight, kg	8.95 ± 6.9	12.6 ± 8.9	8.49 ± 6.6	0.051$^{\$}$
Weight				
≤9 kg	71	6 (8.5)	65 (91.5)	0.333~
>9 kg	37	6 (16.2)	31 (83.8)	
Primary Disease				
Organ failure/disorder	51	9 (17.6)	42 (82.4)	0.041^*
Miscellaneous	57	3 (5.3)	54 (94.7)	

- Complications included: Arterial puncture, Pneumothorax and Hematoma

$^{\$}$Independent sample t-test, ^Chi-square/~Fisher exact test applied, *p-value ≤ 0.05 considered significant

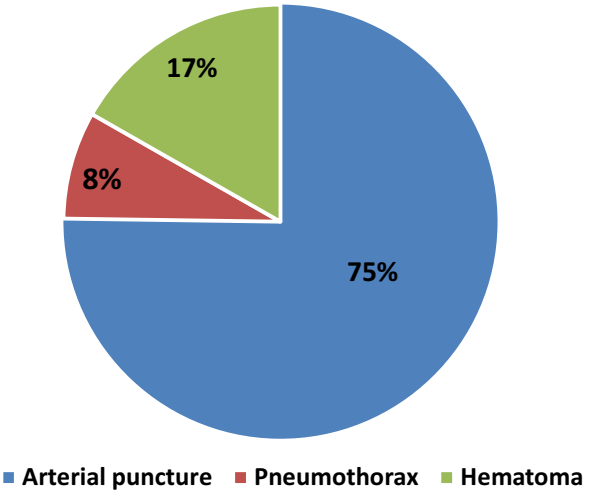

Figure 1: Complications in passing CVP line (n=12)

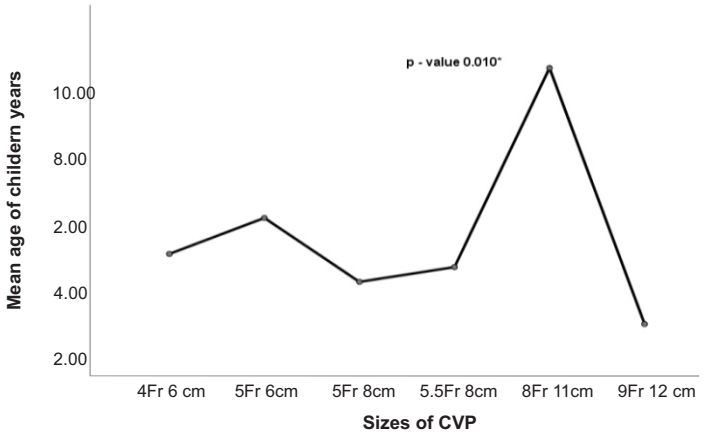

Figure 2a: Line graph showing mean difference of sizes of CVP with age distribution
*** One-way ANOVA test applied**

both favoring ultrasound, were observed, without increases in procedural time.[13]

Central venous catheters are commonly placed in patients, while their placement is a common practice across hospitals, it is often noted that their use may be associated with adverse effects that are hazardous to patients.[11] Central venous cannulation of the internal jugular vein (IJV) is safe, but not without the risks of failure and procedural complications. The process is particularly challenging in children because the likelihood for a positive outcome is largely associated with the weight and age of the patient, and a successful placement is generally considered more difficult in the pediatric population. A study conducted by Hayashi et

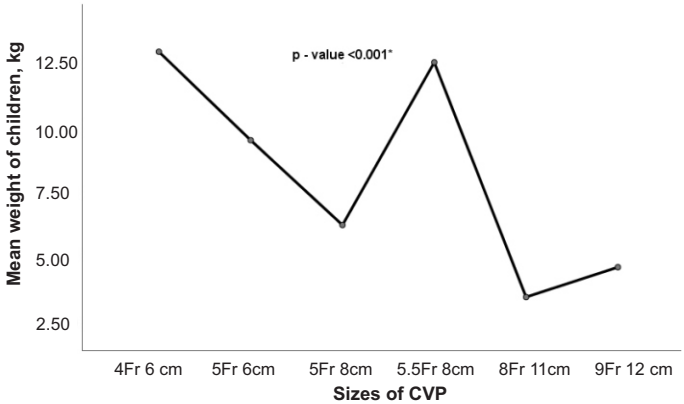

Figure 2b: Line graph showing mean difference of sizes of CVP with weight distribution
*** One-way ANOVA test applied**

al reported ninety seven percent cannulation success in children, but only eighty one percent success in infants less than 3 months old.[14] Another study conducted by Åsheim P et al among infants and children reported cannulation was achieved in ninety five percent of the patients on the first attempt, with no complications.[15] One of the factors leading to technical difficulties and increased complication risk in children is variation in anatomy.[16] To this end it is considered that ultrasound imaging can be used as a tool to decrease the number of attempts and possible complications of CVC placement. Choraria S et al in their study also stated that ultrasound has the added advantage of helping to navigate difficult venous access, identifying epidural space, and help localize nerve plexuses for nerve blocks, as well as in transesophageal echocardiography.[17]

In our study the indications for the placement of CVC were fairly similar to other studies by Ares et al[18] and Bhatt et al[19] and international guidelines[20] with the most common diagnoses being CNS disorders followed by renal and respiratory failure and sepsis. Other diagnoses included trauma, hematoma and cases of malignancy, all conditions in which early monitoring of perfusion and early use of vasoactive drugs have been recommended by international guidelines.[21]

Lau et al.[6] in their meta-analysis reported a lower success rate with the use of US-guided CVC insertion.

In the current study, it is revealed that the mean number of attempts to be 1.36 ±0.80, and no failures were reported in the 4 patients who had a previous history of CVC lines. This finding also matched with a meta-analysis by Keenan SP in which it was reported that in all the included trials, number of attempts were lower in the ultrasound group.[13] However, in our study it was observed that patients with hematomas development resulted in a considerably higher number of attempts before a successful outcome was reached.

The most common complication found in our study population was artery punctures, followed by hematomas and pneumothorax. These are in line with various similar studies done in both pediatric and adult populations.[22,23] A recent study conducted by Abdelmoneim et al in 2020 found complications of CVC placement in the pediatric intensive care unit including failed insertion, arterial puncture, false passage, bleeding with hematoma, arrhythmia and pneumothorax.[23]

The findings of this study could be highlighted in the light of limitation that since this was a retrospective study, no additional data regarding the technique or procedural complications could be collected. Additionally, due to constraints in the number of patients as well as study population, no comparisons were performed with the usual technique of anatomic landmarks. Regardless of this, the findings of this study are comparable to those described in the literature.

CONCLUSION

The use of ultrasound in CVC procedures is an asset to all trained personnel who conduct this procedure as it reduces the time required to complete the procedure and substantially minimizes potential complications.

ETHICAL APPROVAL: This study was approved by Institutional Review Board & Ethics Committee, Pak Emirates Military Hospital Rawalpindi, Pakistan.

AUTHORS' CONTRIBUTION: AM & FS: Design, analyses, interpretation of work. Revised the manuscript critically for important intellectual content. TI & SKH: Acquisitions of data review. All authors approved final version of the manuscript.

CONFLICT OF INTEREST: The authors declare no conflict of interest.

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