Original Article: Comparison of Catheter Functionality and Post-Procedural Consequences in Vascular Access through Saphenofemoral Cutdown and Percutaneus Jugular Vein Catheterization among Children and Neonates

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ABSTRACT

The present study aimed to evaluate the patency of the two vascu-lar access catheterization techniques including percutaneus IJV cannulation and saphenofemoral cutdown in terms of the functional time of catheterization and the complications of these two vas-cular access methods among the neonatal and pediatric patients. This prospective interventional case series study was conducted on 88 children admitted to the intensive care unit (ICU) and needing an intravenous cannulation. The study population was randomly assigned into two groups undergoing vascu-lar catheterization by saphenous vein cutdown (n=59) and percutaneus internal jugular vein cathe-terization (n=29). The two groups were compared regarding the rates of catheter blockage; vein thrombosis and infection. The data were analyzed using SPSS software. The duration of catheter functionality was significantly shorter in the saphenofemoral vein cutdown group than that in the internal jugular vein catheterization group. However, we found no significant difference between the two groups in the prevalence rate of hematoma (p = 0.794), bleeding (p = 0.601), catheter blockage (p = 0.989), site infection (p = 0.684), sepsis (p = 0.937), vein thrombosis (P = 0.999), hemothorax (p = 0.937) and pneumothorax (p = 0.937). Vascular access through internal jugular vein resulted in a longer functional catheteriza-tion in ICU admitted children, compared with saphenofemoral vein cutdown.

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Introduction

Achievement of a vascular access in pediatric patients is a very difficult, time-consuming, and bor-ing process, [1] and is considered as an important responsibility for pediatric surgeons. During cathe-terization, efforts are made to insert the catheter in a site that is more accessible in less aggressive manner resulting in lower pain and more long-lasting function [1-3]. Intravenous cannulation facilitates the implementation of hydration therapy in a short time with high osmolarity, total parenteral nutri-tion, and chemotherapy. In addition, this technique can be used for exact hemodynamic monitoring and rapid drug injection [4-7].

Central venous access in infants could be obtained by cutdown in Cubital fossa, external jugular vein, and proximal saphenous vein. In the neonates weighing more than 3 kg, central venous access can be obtained from the internal jugular, and subclavian veins by percutaneous Seldinger method [8-11].

Internal jugular vein (IJV) is a suitable and trustable site for catheterization with a low rejection risk. The cannulation of the vein is classically performed by palpation and anatomical landmarks. There are various approaches for accessing to the IJV. The IJV access success rate depends on its anatomical variation, depth, and size, as well as the anatomical variation of the carotid artery. In 50% of the cases, IJV is anterior to the carotid artery and parallel to the sternocleidomastoid, and in 30% of the cases, it is located parallel to the cricoid cartilage [12-15].

Doppler sonography facilitates faster venous cannulation, thereby offering great benefits, especially in smaller children, difficult cases, and cases with a previous IJV cannulation [3]. Verghese *et al.* re-ported that IJV cannulation by ultrasound resulted in a success rate of 100% and carotid artery puncture rate of 0, while classic method ha67d 75% success and 25% puncture rate [16-19]. Venous cannula-tion is associated with some complications, including artery injury, hematoma, inappropriate cathe-ter placement, thrombosis, and pneumothorax. Jugular vein diameter differs noticeably during breathing, Valsalva maneuver, Trendelenburg position, and liver compression [20-22].

Femoral vein is one of the other suitable sites for central vein access rendering a high success rate and having lower possibility of femoral artery puncture. The femoral vein cannulation could be per-formed by even doctors who are not really professional in this domain. Moreover, it is a low-risk method and do not expose patients to severe complications of the thorax [23-25]. Accordingly, Stenzel et al., reported a lower complication incidence rate for femoral vein catheterization (3.7%), compared with that for non-femoral methods (7.3%). In the mentioned study, femoral vein thrombosis rate was demonstrated to range within 4-35% depending on patient's age and condition, as well as cath-eter size [26-28].

One of the methods used to obtain central venous access in neonatal and pediatric patients is sa-phenofemoral vein cutdown that is usually associated with many complications and is functional for a short period of time. The complications of this method are similar to those reported for femoral vein catheterization [29].

Overall, it seems that each venous access technique may be accompanied by potential limitations in spite of their advantages [30-33]. This is important in two ways. First, children and infants are far more like-ly than adults to be prone to complications from vascular catheterization, such as bleeding, infec-tions, or accessory displacement. Second, in case of needing long-term vascular catheter placement (for instance in chemotherapy or some major surgeries), it is essential to use the best vascular cathe-terization technique with the most patency and minimal complications to maintain and ensure the patient's survival. Hence, the present study aimed to evaluate the patency of the two vascular access catheterization techniques including IJV cannulation and saphenofemoral cutdown in terms of the functional time of catheterization and the complications of these two vascular access methods among the neonatal and pediatric patients [34].

Methods

Study population and procedures

This prospective interventional case series study was conducted on 86 consecutive neonatal and pe-diatric patients admitted to the Intensive Care Unit (ICU) of the Rasoul-e-Akram Hospital in Teh-ran, Iran between 2017 and 2019. All the participants' parents accepted voluntary participate and signed an informed consent before beginning the interventions. It was not possible to perform group allocation randomly owing to two reasons. First, since IJV catheterization should be per-formed under complete sedation, if the patient had no peripheral venous access, sedation was not possible; therefore, the researcher had to assign him/her to the femoral vein cutdown group. Second, the patients with repetitive central venous insertion caused by a long-term hospital stay should have placed in the femoral vein cutdown group as well. Thus, the participants were divided into two groups of saphenofemoral cutdown and IJV catheterization according to the required samples (ac-cording to the sample size calculation), the patients' clinical situation and also the physician judg-ment. According to the study by Hsu et al. (12), subclavian vein access was associated with a high-er rate of catheter complications compared with the venous cutdown technique with the Odds Ra-tio of 6.77. Considering the relative precision of 50%, confidence level of 80%, expected prevalence of the outcome of 20%, and expected odds ratio of 6.77, we estimated the required sample size for the study to be 29 patients in each arm, but we considered 29 patients in saphenofemoral vein cut-down group and 59 patients (about two times) in IJV catheterization group. In the former group, catheterization was performed through saphenofemoral cutdown under local anesthesia in supine position. This procedure was performed by surgical loupe magnification and fixing the lower limb in external rotation, followed by making a small incision on the skin under inguinal ligament according to the anatomic landmarks, i.e., 2 cm inferior and external to pubis tubercle. After finding the vein, we dissected toward saphenofemoral junction. Proximal and distal regions of the vein were held by 0-4 silk thread; then, the vein was cannulated with catheter (5F, 5 cm) and distal part of the vein was ligated. After ensuring the catheter function (by aspirating blood from catheter lumen) and ligatur-ing the distal vein to catheter to prevent bleeding, it was fixed to the skin. For the latter group, in order to insert internal jugular catheter, a complete venous sedation was induced in Trendelenburg position with neck in extension under ultrasound guidance. The IJV was cannulated, and the guidewire was passed into it. After passing the catheter through the guidewire, the guidewire was withdrawn. The catheter was fixed to the skin when its function was ensured. To control the place of catheter and its associated complications, all patients were subjected to chest X-ray [35].

Study endpoint

In addition to comparing baseline characteristics across the two interventional groups, we assessed the following parameters as the post-procedural outcome: a) the duration of catheter functionality and b) post-procedural complications including hematoma, bleeding, catheter blockage, site infec-tion, sepsis, and vein thrombosis [36-38].

Statistical analysis

The quantitative variables were presented as mean and standard deviation, and categorical variables were expressed as frequency and percentage. Mann Whitney U test was employed to compare the quantitative variables. Furthermore, the categorical variables were compared using the Chi-square test when more than 20% of cells with the expected count of less than 5 were observed. The Statis-tical Package for the Social Sciences (SPSS), (IBM Corp. Released 2013, IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp) was used for analysis. P values of 0.05 or less were considered statistically significant [39].

Results

Out of the 86 patients included in this study, 59 (67%) and 29 (33%) subjects were assigned into the IJV catheter and saphenofemoral vein

cutdown groups, respectively. The mean ages of the IJV catheter and saphenofemoral cutdown groups were 20.41±15.07 and 15.45±11.52 months, respec-tively. Furthermore, 54.2% (n=32) and 45.8% (n=27) of the patients in the IJV and saphenofemoral cutdown groups were male, respectively. The results of revealed a significant difference between the two groups regarding the duration of catheter functionality (P=0.021).

In addition, we found no significant difference between the two groups in the prevalence rate of hematoma (p = 0.794), bleeding (p = 0.601), catheter blockage (p = 0.989), site infection (p = 0.684), sepsis (p = 0.937), and vein thrombosis (P = 0.999). Additionally, hemothorax and pneumo-thorax were not observed in any patient in the IJV and cutdown group (Table 1).

Table 1. Post-procedural outcome in neonates undergoing vascular access techniques

Outcome	Cutdown (n = 29)	Jugular catheter (n = 59)	P value
Duration of catheter functionality	11.4±12.2	14.82±11.39	0.021
Hematoma	3 (10.3)	5 (8.5)	0.795
Bleeding	2 (6.9)	2 (3.4)	0.601
Catheter blockage	1 (3.4)	2 (3.4)	0.989
Site infection	3 (10.3)	4 (6.8)	0.684
Sepsis	1 (3.4)	0 (0.0)	0.937
Vein thrombosis	1 (3.4)	1 (1.7)	0.999
Hemothorax	0(0.0)	0 (0.0)	0.0
Pneumothorax	0 (0.0)	0 (0.0)	0.0

Discussion

According to our analysis, vascular access through saphenofemoral cutdown resulted in longer catheter functionality, compared with internal jugular access. However post-procedural rare compli-cations including the infection and thrombosis were not different across the two groups. Nonethe-less, patients were exposed to severe complications, such pneumothorax, hemothorax, and tam-ponade [40-42].

According to the results of the current study, the duration of catheter functionality was shorter in the children undergoing saphenofemoral cutdown compared with that in the IJV catheter group. To the best of our knowledge, there is no study in the literature comparing the duration of catheter functionality between two groups of IJV catheter and saphenofemoral cutdown. In line with our results, in a study performed by Hackbarth et al. (2007) on children with renal transplantation in the United States, the functional time of catheter through IJV cannulation was longer than that of fem-oral and subclavian catheters [43-45]. In a prospective study carried out in the United States, Murai et al. (2002) evaluated 26 and 34 infants undergoing 47 and 64 femoral and internal jugular catheteriza-tions, respectively (in total 60 infants with 111 catheters) [46-49]. They reported that the two catheterization methods were successful. Inconsistent with our results, in the mentioned study, the durations of catheter functionality were determined as 24 and 17 days for femoral and IJV catheterizations, re-spectively, which were significantly different between the two groups [50-53]. In another study, Zarei et al. (2012) evaluated 80 children admitted to ICU and undergoing central venous catheterization in Iran. In congruence with our findings, they demonstrated that most of the catheters were inserted through the IJV with a mean catheter duration of 14 days. As the complication incidence rate in fixing central venous catheter is acceptable, it could remain for long time in patients who are admit-ted in ICU [54-56]. Tismit et al. (2013) conducted a clinical trial on 2,128 patients with at least one IJV catheter (n=1001) or one femoral catheter (n=1,301) in France. They observed no difference be-tween the two groups in terms of the sepsis rate caused by catheter, although colonization risk for femoral catheter was higher

in women [57-59]. In the mentioned study, catheter remained for more than 4 days, and the risk of colonization of catheter between femoral and jugular group during less first 5 days was different [60-63]. They reported that femoral access group had a higher catheter colonization risk after 5 days, compared with the IJV group, which was the cause of changing the catheter place af-ter 5 days [64-66].

In the mentioned study, the incidence rate of pneumothorax was reported as 2% that could be re-duced by using ultrasound. Arterial injury and hematoma were also observed in less than 2 % of cases that could be corrected by direct pressure on arterial puncture site and correction of coagula-tion state. Hemothorax is a rare complication that is caused by many catheterization attempts and in difficult cases. Cardiac tamponade and venous laceration are caused by catheter or guide-wire trauma. Catheter blockage usually occurs when a thrombosis is present. Sepsis is caused by multi-lumen catheters, blood transfusion, malignancy, and bone marrow transplantation in infants [67].

Nazem *et al.* (2006) evaluated 20 infants and estimated the functional time of IJV catheter as 18±11.9 days with a maximum of 98 days. In the mentioned study, postoperative bleeding occurred in 9.5% of the infants and caused death in one case, who was premature and had hyaline membrane disease. Furthermore, liquid leakage was reported in 4.8% of the cases that was diagnosed by radi-ography [68-70]. Thrombosis also occurred in 9.5% of the cases despite the correct placement of catheter. However, in the mentioned study, sepsis, hemothorax, pneumothorax, hydrothorax, and cellulitis were not observed. In 40% of the cases, erythema was seen on the catheter insertion site when cath-eter remained for more than 10 days. Additionally, the incidental ejection of catheter with infant movement was reported in 9.5% of the cases [71-73].

Vascular access through IJV is a simple method; however, it is accompanied by two issue, using ultrasound guiding technique and infection risk [74]. In the present study, the results revealed no dif-ference between the two groups in terms of the incidence of such complications as hematoma, bleeding, catheter blockage, and vein thrombosis. Totally, IJV catheterization resulted in a higher complication incidence rate, compared with femoral catheterization. In addition, the insertion of IJV catheter requires a higher accuracy and attention in operation room than the placement of ve-nous other catheters [75].

Inconsistent with our results, Murei et al., found no difference between the IJV and femoral cathe-terizations in terms of mortality rate and complication incidence. They concluded that femoral cath-eterization is an effective and suitable vascular access, compared with jugular access [9]. Srisan et al., obtained results similar to our findings. In this regard, they concluded that in children admitted to ICU, one of the risk factors of complications of central venous catheters is to fix the catheter through internal jugular vein. In the mentioned study, IJV catheter was reported as the only risk factor for sepsis [76-78]. In another study conducted by Rus et al. (2016), it was demonstrated that fem-oral vein catheterization in children under hemodialysis had lower complications, compared with the IJV cannulation, which is in agreement with our findings [79-81]. Reyes et al. (2012) reported no as-sociation between the incidence of infection and catheter placement through femoral vein or IJV in children admitted to the ICU, which is in congruence with our study results [82].

Finally, according to the results of the previous studies and those of our study, IJV catheterization in the ICU admitted children can be claimed to be more effective in the functional time of catheter, compared with saphenofemoral cutdown. Nonetheless, it is noticeable that there was no significant difference between the two groups in terms of the incidence of such complications as hematoma, bleeding, catheter blockage, catheter site infection, and vein thrombosis, pneumothorax and hemo-thorax [83-85].

Conclusion

As the findings of the present study indicated, IJV catheterization in the ICU admitted children was more effective in the length of functionality

of catheter, compared with saphenofemoral cut-down. However, there was no significant difference between the IJV and saphenofemoral cutdown catheterizations regarding the incidence rate of such complications as hematoma, bleeding, catheter blockage, catheter site infection, and vein thrombosis.

Conflict of interest

All authors declare that they have no conflict of interest to disclose.

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