



Determination of central venous catheter complications: Internal jugular vein versus femoral vein catheterization

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Abstract

Aim: This research aimed to compare the mechanical, thrombotic, and infectious complication ratio of the internal jugular vein with those of femoral vein catheterization.

Materials and Methods: It is a single-center retrospective study. One hundred seventy-nine pediatric patients undergoing central venous catheter insertion in the intensive care unit were selected from February 2020 to August 2021. The patients were divided into 2 groups based on catheter type; internal jugular versus femoral venous catheterization. Procedure complications rates were assessed. However, jugular catheterization was performed under ultrasound guidance, and femoral venous catheterization was inserted via an original landmark-based technique. Thromboprophylaxis was performed on all patients without coagulopathy.

Results: The overall rate of procedural complications was 20%. The subcutaneous hematoma was the most common mechanical complication and higher in femoral attempts ($p=0.001$), followed by arterial injury ($p=0.002$). Thrombotic complications were similar between the two groups ($p=0.053$). Infections complications were higher in femoral venous catheterization ($p=0.016$).

Conclusion: Femoral venous catheterization is associated with a greater risk of mechanical and infectious complications than internal jugular venous catheterization. Usage of ultrasound during catheterization procedures decreases mechanical complications.



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Introduction

Central venous catheters (CVC) are fundamental among critically ill patients for various medical practices. It is frequently used for hemodynamic monitoring, inadequate peripheral venous access, peripherally incompatible infusion, and extracorporeal therapies [1]. It is estimated that approximately 8% of hospitalized patients require CVC [2]. Every year, more than 5 million CVC procedures are performed in United States hospitals [3]. Overall complication ratios change between 15-33 percent [1, 4]. Most of the complications change associated with an anatomic site, use of ultrasound to guide, and operator inexperience [1]. A variety of complications are related to CVC insertions, divided into mechanical, infectious, and thrombotic complications [1, 5]. While the most common mechanical complications happening during CVC insertion are arterial injury, hematoma, pneumothorax, haemothorax, arrhyth-

mia, and air embolism, thoracic duct injury is a rare serious mechanical complication [3, 4]. Catheter-related infections make up 10-15% of nosocomial infections in intensive care units [6]. Infections are associated with high morbidity and mortality and also increase the treatment costs by prolonging the length of hospital stay [3]. Catheter-related venous thrombosis is a common complication of CVC and the incidence of thrombosis is approximately 15 percent [7]. The clinical significance of catheter-related thrombosis remains uncertain, though all thrombosis has the potential risk of embolization [1].

The first aim of this study was to compare the complications of the internal jugular and femoral central venous catheterization and to determine the complication differences between these two approaches, and the second aim was to evaluate the effectiveness of ultrasound utilization during the insertion of a catheter.

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Materials and Methods

This is a retrospective, observational single-center study that was conducted in a tertiary level institution. Period of study considered from February 2020 to August 2021.

We screened patients aged 1 month to 18 years who were admitted to the pediatric intensive care unit. Patients who undergo jugular or femoral venous catheterization procedures were included in this research. All catheters were placed by the same medical staff. Although all femoral venous catheters were inserted via an original landmark-based technique, jugular catheters were inserted under ultrasound guidance. After anatomical landmarks were visualized, to provide maximal sterile-barrier precautions, the skin was prepared with 10% povidone-iodine-based solutions then covered with sterile draped, and also all vascular access team wore sterile gloves, masks, and caps.

Patients were sedated by intravenous ketamine and for local anesthesia lidocaine (1%) was used. A routine chest radiograph was obtained after all internal jugular catheter insertion to evaluate for catheter position, hemothorax, and pneumothorax. For the avoiding of an inflammatory and infectious situation, antiseptic cure of epithelial tissues located within a radius of 8 cm from the place of placement of the central venous catheter is enforced. Perform a solution of iodine 2% concentration. To apply these medicine, sterile cotton swabs are handled. Bundle care program not performed in our unit The patients were divided into 2 groups based on catheter type (internal jugular and femoral venous catheterization). The following data were collected; gender, age, mechanical, infection, malposition, and thrombotic complications. Catheter-related mechanical complications involved arterial injury, subcutaneous hematoma, haemothorax, pneumothorax, and malposition of the catheter. A central venous catheter-associated infection was accepted as a laboratory-identified infection not related to an infection at a different site that occurs within 48 hours of a CVC insertion and If catheter-related infection documented, all catheter removed [8].

Thrombotic occlusion of the catheter lumen and DVT was defined as a thrombotic complication of CVC and the catheterized vessel. If thrombosis was investigated and examined by Doppler ultrasonography, it was accepted thrombotic complication. For thromboprophylaxis, low dose heparin infusion (0.01 unit/hour for every catheter lumen) was administered to all patients without coagulopathy and/or bleeding risk. Based on previous data, with significance level of $\alpha=0.05$ and $\beta-1=80\%$, a minimum needed sample size of 147 participants was determined for the research [9].

Prior to the research, the necessary approvals were acquired from Research Ethics Committee and adhered to the principles of the Helsinki Declaration (Afyon Karahisar Health Sciences University Clinical Research Ethics Committee, Decision no: 2021/3, date. 03/12/2021). After the Report of the Ethics Committee was numbered, reach to patient registrations was provided and confidentiality of patients was provided, and only medical records were evaluated, all patient information was protected and kept confidential.

Statistical analysis

Continuous variables are expressed as means with standard deviation and discontinuous variables as median, whereas categorical variables are represented as frequency and percentage. Comparison of the baseline properties of the two groups was evaluated by the Mann-Whitney U test for quantitative features and with Fisher's exact test for qualitative variables. The number of complications per patient was compared between both groups using nonparametric Mann-Whitney tests. Student's t-test, χ^2 analysis, or Fisher's exact test was used where appropriate for comparison of categorical variables between the groups. $P < .05$ was considered statistically significant. All calculations were analyzed by SPSS Statistics 22 software (IBM, Armonk, NY, USA).

Results

We identified one hundred seventy-nine consecutive CVC attempts during the study period. Eighteen patients were excluded because they had coagulopathy and the presence of CVC at admission. Catheter-related reinfection or contamination not included. The average age of the internal jugular vein group was 34 months ($p= 0.38$) and an internal jugular venous was catheter applied to seventy-four males ($p= 0.51$). The baseline characteristics of the patients and catheter attempts are presented in Table 1. One hundred thirty-three CVC was inserted into the internal jugular vein and forty-six lines via the femoral vein. Overall complications happened in thirty-seven patients, representing 20.6% of the attempts (Table 2). The subcutaneous hematoma was the most common mechanical complication and it was significantly higher in femoral venous insertion ($p= 0.001$). The arterial injury was the second most common mechanical complication and significantly lower in jugular catheterization ($p= 0.002$). Although hemithorax was not identified, two patients who performed internal jugular venous insertion had a pneumothorax and resolved without chest drainage. Malposition of the catheter was seen in 7 cases, and there was only one case in the femoral vein insertion group and there was no statistically significant difference between the groups ($p= 0.68$). A central venous catheter-related infection was detected in seventeen cases and coagulase-negative staphylococci were the most commonly identified organism. The infection ratio was significantly higher in the femoral venous group ($p= 0.016$). While catheter-related thrombosis was detected by Doppler USG in 3 patients with a femoral venous catheter, thrombosis was detected in only one patient in the internal jugular catheter group ($p= 0.053$).

Table 1. The baseline characteristics of the patients and catheter attempts are presented.

Patient characteristics	Internal jugular	Femoral	p-value
Age (months)*	34 (IQR:55)	32.5 (IQR:31)	0.38
Male	74	23	0.51

*Median (IQR).

Table 2. Complications type by catheter insertion site.

	Internal jugular	Femoral	p-value
Complications	14.3% (n:19)	39.1% (n:18)	<0.001
Arterial injury	3.8% (n:5)	19.6% (n:9)	0.002
Pneumothorax	1.5% (n:2)	-	1
Subcutaneous hematoma	4.5 (n:6)	21.7% (n:10)	0.001
Malposition of catheter	4.5% (n:6)	2.2% (n:1)	0.68
Infection	6% (n:8)	19.6% (n:9)	0.016
Staphylococcus aureus	37.5% (n:3)	25% (n:2)	
Klebsiella pneumonia	25% (n:2)	25% (n:2)	
Acinetobacter baumannii	25% (n:2)	25% (n:2)	
Pseudomonas aeruginosa	12.5% (n:1)	12.5% (n:1)	
Stenotrophomonas maltophilia	-	12.5% (n:1)	
Thrombosis	0.8% (n:1)	6.5% (n:3)	0.053

Catheter-related DVT developed only in one case and deposition of fibrin on the catheter surface was detected other three patients.

Discussion

Central venous catheter insertion is a familiar procedure performed many times each year in intensive care units and also applied in many hospitalized non-intensive care unit patients for the infusion of blood products, antibiotics, and other treatments as well as a sampling of blood. Unfortunately, catheter-related complications are quite common, occurring in approximately 15- 20% of patients [10]. The total percentage of insertion-related complications in our study is consistent with previously published articles. In this current study, the total complication rate was approximately 20%. The important findings of this research are as follows. Firstly, thrombotic complications were less common than in prior studies in the case of thromboprophylaxis usage. Secondly, the use of real-time ultrasound (US) has been shown to decrease complications of CVC. The rate of DVT was detected at 4% in 444 patients with CVC while symptomatic catheter-related DVT developed at only 1% among 3218 critical care patients with experience of thromboprophylaxis [11, 12]. Some approaches were useful to decrease the thrombotic complications such as the preference for subclavian venous catheterization, utilization of thromboprophylaxis convenient for the cases, and placing the end of the catheter just above the cavo-atrial connection [13]. In this research, most of the thrombotic complications were detected in femoral venous catheter procedures. In this current study, the thrombotic occlusion of the catheter lumen occurs in 2.2% of cases with a CVC, and the rate of DVT was lower than 1%. The use of low-dose heparin infusion and preference for the commonly jugular venous catheter were the main factors to reduce the incidence of catheter-related

thrombosis.

Multiple researchers have compared landmark-based methods to US-guided central venous catheterization and showed that the US-guided technique decreased the total complication percentage by 71%, the risk for inadvertent arterial puncture by 72%, subcutaneous hematoma by 74%, access time to successful cannulation by 30.5 s, and the number of attempts needed for successful insertion for jugular venous catheterization [14].

In the current study, US were used to visualize anatomical structures and confirm patency of the vessels and, in this way, helped to successful puncture or effective cannulation for jugular venous catheterization. An ultrasound-guided insertion reduced the mechanical complication rate significantly.

Ergul et al showed that jugular venous catheterization had lower infectious complications than femoral and subclavian venous catheterization. Infectious complications of subclavian venous catheterization had found lower than femoral venous catheterization in a randomized trial [9]. In this current research findings were compatible with prior studies; the higher rate of infectious complications was detected in femoral venous catheterization. In the USA, more than 250,000 vascular catheter-related infections happen each year and these infections cause about 12% to 25% of mortality among critically ill patients [15]. The most common isolated bacteria are coagulase- negative staphylococci which are widespread inhabitants of skin [16]. Our study showed similar findings to previous studies, *Staphylococcus aureus* infections were the most frequently isolated microorganisms.

In literature, the malposition rate is approximately 7% [17]. In addition to the undesirable cardiac effects of catheter malposition, malposition can cause catheter dysfunction. Muhm et al detected malposition of central venous catheterization was so common in the left internal jugular vein than in the right subclavian vein insertion [18]. Malposition of the subclavian vein was observed significantly higher than the internal jugular vein in a systematic review [2]. In this research, malposition was detected in only 3.9% of jugular catheterizations, and only one malposition occurred in femoral catheterization procedures. Arterial injury, hematoma, and pneumothorax are the most common mechanical complications of CVC [1]. Our total mechanical complications rate was 18%. Arterial injury (7%), subcutaneous hematoma (9%), and pneumothorax (1%) ratio of the current study are compatible with the previous studies [4, 9]. In our study, a higher mechanical complication occurred in the femoral approach because the US used for internal jugular venous catheterization reduced the complications. This result was similar to prior studies where the femoral insertion had a higher mechanical complication rate [9, 19].

Conclusion

CVC carries a prominent risk of insertion and utilization of the catheter. Decreasing catheter-related complications in pediatric critically ill cases is a significant goal. Although there were mechanical and thrombotic complications occurred in US-guided internal jugular vein insertion, it was

safer than femoral vein cannulation. The use of thromboprophylaxis may be important to reduce thrombotic complications, but more extensive studies are needed, and it should be used if any contraindications, such as coagulopathy are not present.

Limitations

Our study has some limitations. This study was designed as retrospective single-center research, so prospective multicenter studies are required. While internal jugular venous attempts were enforced under US guidance, the fact that femoral venous insertions were performed with the landmark technique increased the mechanical complications. There was no investigation for thrombophilia in patient with thrombosis and number of insertions attempts not evaluated.

Ethics approval

The study protocol was approved by Medical Faculty Ethical Committee (Afyon Karahisar Health Sciences University Clinical Research Ethics Committee, Decision no. 2021/3, date. 03/12/2021).

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Conflicts of interest

All authors declare no conflict of interest relevant to this study.

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