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Subclavian Catheterization Procedure Performed by In-plane Technique Guided by Ultrasonography

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ABSTRACT

Objective: Central venous catheterization (CVC) is one of the most commonly performed interventional procedures in intensive care unit (ICU) patients. According to guidelines, it is recommended as the first choice because it is better tolerated by patients, and the infection rate is lower compared to other areas of CVC placement.. However, complications such as pneumothorax, arterial puncture, nerve injury and bleeding may be relatively higher. For these reasons, it has become increasingly common to perform subclavian CVC applications with ultrasonography (USG) to minimize the risks in recent years. Our study aimed to evaluate 53 patients who underwent subclavian CVC with the in-plane technique accompanied by USG.

Method: In this study, the system records of 53 patients with CVC indication, who were hospitalized in the ICU between January 1, 2020, and April 1, 2021, were reviewed retrospectively and subclavian CVC procedures performed using the USG-guided in-plane technique were analyzed.

Results: A total of 53 patients (25 women (47.2%), 28 men (52.8%)) with CVC indication followed in the ICU underwent subclavian CVC with the in-plane technique under USG guidance. The mean age of the patients was 69.98±11.29 years. The mean BMI of the patients was found to be 26,10 kg/m2. Of the 53 patients evaluated, 28 had chronic obstructive pulmonary disease (COPD), 5 had lung malignant neoplasm, 16 had pneumonia, 2 had acute renal failure, and 2 required ICU follow-up after cardiopulmonary resuscitation.. Catheter malposition and other complications were not observed in any of the patients.

Conclusion: Subclavian catheterization applied with an in-plane technique guided by USG is a method that experienced practitioners can safely apply.

Keywords: In-plane technique, Subclavian vein, Ultrasonography, Intensive care

INTRODUCTION

Central venous catheterization (CVC) is an invasive procedure that is frequently used in intensive care with various indications. Central venous catheters are used primarily to safely deliver total parenteral nutrition products, irritating fluids to the vascular wall, and vasoactive and inotropic agents administered in infusion to keep systemic hemodynamics stable (1). Although it provides therapeutic and diagnostic benefits, central venous catheterization can also lead to complications such as arterial puncture, pneumothorax, vascular erosion, airway obstruction, air and thrombus embolism, hemothorax, hydrothorax, chylothorax, arrhythmia, cardiac perforation, cardiac tamponade, adjacent nerve and vascular injuries, and catheter malposition (2). The literature reports that the rate of pneumothorax for subclavian interventions performed with the landmark technique ranges from 1% to 6.6%.. This rate increases as the number of unsuccessful attempts increases (3,4).

Many clinicians do not prefer subclavian CVC application with the classical landmark technique due to pneumothorax, which is an important complication, and many physicians do not even try this method in clinical practice (5). This situation limits the application, especially in patients with emphysematous and COPD diagnosis and in patients with respiratory failure (1,5). This method can be preferred by reducing complications in catheterization performed under the guidance of USG. Studies have shown that USG reduces the rate of pneumothorax, arterial puncture and hematoma development (6,7).

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This retrospective study aims to evaluate 53 patients who routinely underwent USG-guided in-plane subclavian CVC in the intensive care unit in terms of procedural success and complications.

MATERIALS AND METHODS

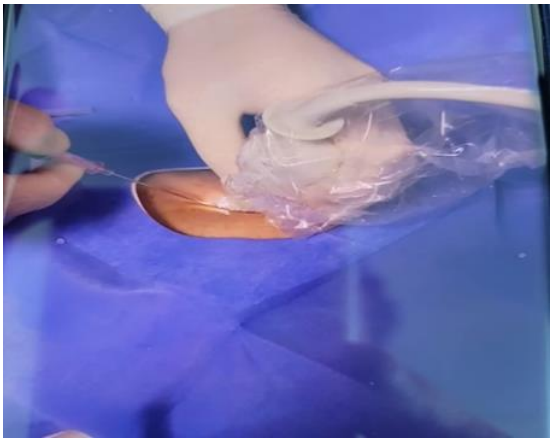
Subclavian catheter was applied to all patients included in the study with the in-plane technique. The right and left subclavian veins and arteries were visualized by ultrasound while the patients were supine. Then, the most appropriate side of the intervention was decided and the practitioner was referred to the department where the patient would be treated. After the necessary sterilization procedures were performed, 5 cc of 2% prilocaine was drawn into the infraclavicular area where the intervention would be performed, diluted with 5 cc of 0.9% isotonic solution, and a 1% concentration was obtained and applied. With the ultrasonography probe, the pleura, subclavian vein and artery were detected by in-plane technique. The procedure was made from the appropriate point. The duration of the procedure, the number, and the complications were recorded in the epicrisis and observations. Chest radiography was observed in all patients for post-procedure catheter malposition. Demographic data, body mass index, diagnosis and comorbidities of the patients were reviewed retrospectively from the records.

Catheterization Technique

All patients who underwent subclavian CVC with the in-plane technique were included in the study. While the patients were in the supine position, the right and left subclavian veins and arteries were visualized by USG and the most appropriate side for the intervention was decided. After performing the necessary sterilization procedures, 3 ml of 2% prilocaine was diluted with 3 ml of 0.9% sodium chloride solution to achieve a 1% concentration. The mixture was then applied to the infraclavicular area where the intervention would be performed (see Picture 1). The pleura, subclavian vein, and artery were detected using the USG probe with the in-plane technique. After sterilization of the skin and USG probe, a 12 MHz linear USG probe (EsaoteMylabsixSpA, Genoa, Italy) was placed in the infraclavicular area. The subclavian vein, subclavian artery, pleura, and lung were imaged in the longitudinal view of the long axis. Puncture was made from the edge of the probe with an 18G 6,5 cm introducer needle (guide wire was inserted into the needle) Picture 2). The needle was visualized with the in-plane technique and moved with ultrasonography (Picture 3). Afterwards, verification was done with out-of-plane and in-plane imaging (Picture 4). A three-port central catheter (Arrow International, Reading, PA, ABD) was inserted into the subclavian vein using the Seldinger technique. In terms of catheter malposition, the jugular vein was examined by ultrasonography during the procedure. After the procedure, the catheter location was confirmed by chest X-ray.

The duration of the catheterization procedure (from skin puncture to insertion of the catheter into the vein), the number of needle attempts, and any complications were recorded at the end of the procedure.

Picture 1: Subclavien vein



Picture 2: needle direction and ultrasound

Picture 3: Real Time needle and subclavien vein

Picture 4: Central venous catheter in subclavien vein

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Statistical analysis

Data analyses were performed by using SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, United States). Whether the distribution of continuous variables was normal or not was determined by the Kolmogorov Smirnov test. Levene test was used for the evaluation of the homogeneity of variances. Unless specified otherwise, continuous data were described as mean ± SD for normal distributions, and median (interquartile range) for skewed distributions. Categorical data were described as a number of cases (%). Statistical analysis differences in normally distributed variables between two independent groups were compared by Student's t-test, Mann Whitney U test was applied for comparisons of the not normally distributed data. It was evaluated degrees of relation between variables with spearman correlation analysis. It was accepted p-value & lt; 0.05 as significant level on all statistical analysis.

RESULTS

Between 1 January 2020 and 1 April 2021, a total of 53 patients (25 women (47.2%), 28 men (52.8%)) with CVC indication followed in the ICU underwent subclavian CVC with the in-plane technique under USG guidance. The mean age of the patients was 69.98±11.29 years. The mean BMI of the patients was found to be 26,10 kg/m2. When patients were classified according to their hospitalization indications, 28 were found to have chronic obstructive pulmonary disease (COPD), 5 had lung malignant neoplasm, 16 had pneumonia, 2 had acute renal failure, and 2 required ICU follow-up after cardiopulmonary resuscitation (see Table 1).

When the patients were evaluated in terms of anticoagulant treatment, 51 (96.2%) received low molecular weight heparin (LMWH), 5 (9.4%) received acetylsalicylic acid, 2 (3.8%) received clopidogrel, and 1 (<2%) was receiving new generation oral anticoagulant therapy (see Table 1)..

According to the bleeding parameters, the mean prothrombin time of the patients was 12.70±2.50, the mean activated partial thromboplastin time was 28.19±6.38, and the mean International Normalized Ratio was 1.19±0.2. The mean platelet count of the patients was found to be 206.640 ±84.680 (Table 1).

Subclavian CVC, which was planned to be opened with an in-plane technique under USG guidance, resulted in success in all patients. The procedure was not terminated in any of the patients due to failure. The procedure was successfully completed in the first attempt for 42 out of 53 patients (79.2%), while catheterization was achieved in the remaining 11 patients (20.8%) after the second attempt. Catheter malposition was not observed in any patient. The mean processing time was 97 ± 42 seconds (Table 1).

In terms of catheter malposition, the jugular vein was evaluated with USG during the procedure and all patients were assessed with postero-anterior chest X-ray after the procedure. Catheter dysfunction and malposition were not observed after catheter detection in all patients.

Table 1: Patients' characteristics

	All Cases (n:53)
Gender, n(%)	
Male	28(52,8%)
Female	25(47,2%)
Age, $\bar{X}$±SD	69,98±11,29
BMI, Med (IQR)	26,10(5,50)
Anticoagulant Therapy, n(%)	
Clexane	51(96,2%)
Aspirin	5(9,4%)
Clopidogrel	2(3,8%)
NOAC	1(1,9%)
PT, Med (IQR)	12,70 (2,50)
aPTT, $\bar{X}$±SD	28,19±6,38
INR, $\bar{X}$±SD	1,19±0,20
PLT, $\bar{X}$±SD	206,64±84,68
Diagnosis, n(%)	
COPD	28(52,8%)
Pneumonia	16(30,2%)
Acute Kidney Failure	2(3,8%)
Post Cardiac Arrest	2(3,8%)
Lung Carcinoma	5(9,4%)
Additional Disease, n(%)	
Hypertension	6(11,3%)
Coronary Artery	2(3,8%)
Heart failure	14(26,4%)
Diabetes	19(35,8%)
Cystic Fibrosis	1(1,9%)
Alzheimer's	3(5,7%)
Bronchiectasis	1(1,9%)
Complication, n(%)	-
Number of Trials, n(%)	
1 time	42(79,2%)
2 times	11(20,8%)
Processing Time, Med (IQR)	97,00(42,00)
Catheter residence time, Med (IQR)	15,00(6,00)

Continuous data were described as mean ± SD for normal distributions, and median (interquartile range) for skewed distributions. Categorical data were described as a number of cases (%). BMI: Body mass index NOAC: New Oral Anti Coagulants PT: Protrombin Time aPTT: Activated Partial Thromboplastin Time INR: International Normalized Ratio, PLT: Platelet number COPD: Chronic Obstructive Pulmonary Disease

The mean stay of the catheter in the patient was found to be 16±8 days.

There was a statistically significant, positive, but weak correlation between the duration of the procedure and the body mass indexes of the patients included in the study group (r=0.388, p=0.004) (see Table 2)..

There is a negative and low-level statistically significant relationship between the duration of catheter stay and PT values of the patients (r: -0,283, p:0,040) (Table 2).

There is a negative and low-level statistically significant relationship between the duration of catheter stay and INR values of the patients (r:-0,325, p:0,018) (Table 2).

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Table 2: Relationship between procedural time and catheterization duration in various situation

		Processing Time	Catheter residence time
Age	**r**	-0,074	0,127
	p	0,597	0,365
BMI	**r**	**0,388***	0,135
	p	**0,004**	0,333
PT	**r**	-0,023	**-0,283***
	p	0,870	**0,040**
aPTT	**r**	-0,125	-0,105
	p	0,372	0,456
INR	**r**	0,057	**-0,325***
	p	0,687	**0,018**
PLT	**r**	0,053	0,202
	p	0,704	0,148

DISCUSSION

In our study, the complication rate was lower in the procedure of subclavian catheter application from the infraclavicular region using real-time USG-guided in-plane technique compared to the literature. Although the reported rate of pneumothorax in the literature for subclavian vein catheterization is approximately 1-3%, none of the patients in our study experienced pneumothorax (1, 2, 8). It should be noted that the use of USG reduces the risk of pneumothorax, but it never resets it (3,9). In addition, malposition was not observed in any of the patients. The orientation of the catheter to the internal jugular vein, which is one of the common malpositions, was excluded using USG during the procedure. In addition, a chest X-ray was taken for each patient after the procedure, and the catheter location was reconfirmed.

It has been shown in different studies that the use of USG facilitates the catheterization procedures (5,10,11). In a study, the use of USG is routinely recommended for the internal jugular vein and femoral vein catheterization (5). The use of USG is also recommended for subclavian catheterization, but the fear of complications and the difficulty of obtaining images lead the practitioner to other methods (10,11).

We believe that this study will give the practitioners a sense of confidence as it shows that the subclavian vein, subclavian artery, and pleura can be seen clearly with the USG-mediated in-plane technique and how much the risk of complications will be reduced by moving the needle live.

In real-time in-plane application, it is performed with the USG beam aligned parallel to the target vein and the needle is held within the plane of the USG beam. The advantage of using the in-plane technique with USG guidance for subclavian CVC placement is that it allows for visualization of the entire needle during insertion into the vein, while the disadvantage is that it requires experience (5, 7)..

In the study, catheterization was performed with real-time in-plane technique under USG guidance for all patients. None of our patients experienced any complications such as bleeding, nerve damage, or arterial puncture. In experienced hands, seeing and moving the needle with the in-plane technique gives the practitioner confidence and reduces the complication rate similar to the literature (5,7).

In a study comparing the Landmark and in-plane technique with real-time USG and subclavian CVC application, it was observed that mechanical complications were quite limited and pneumothorax did not develop in any patient. However, inappropriate placement of the catheter was observed in approximately 10% of patients (6). In our applications, we did not encounter any misplacement since we provided confirmation of the internal jugular vein misplacement by USG during the intervention. We believe that this application allows us to direct the catheter from the inappropriate internal jugular vein placement of the catheter to the superior vena cava with USG-mediated control.

In the literature, a positive relationship has been shown between the number of repetitive attempts and the complication rate. For this reason, it is generally recommended to keep the number of interventions below 3 (3,13). Therefore, we limit the number of attempts in our applications to be less than 3. In experienced hands with the in-plane technique, even 3 attempts were not needed, and the procedure was completed successfully in a maximum of two attempts.

After sterilization and surgical cleaning during the procedure, the time to send the catheter to the Superior Vena Cava from the needle entry was measured and the average was 97 seconds. We have evaluated the duration of subclavian CVC placement with the in-plane technique and found it to be successful. However, further studies are needed to compare its efficacy and safety with the landmark technique or other techniques. In the comparison of out of plane probe position, in-plane probe position and landmark technique for USG guided internal jugular vein cannulation performed by Tammam et al. in 90 intensive care patients, the mean procedure time was found to be 52.30 seconds with the out of plane technique. In the same study, it was found to be 52.70 seconds with the in-plane technique and 116.57 seconds with the landmark technique. They found a significant difference in favor of USG between the USG technique and the landmark technique (4,14).

Our study is retrospective and was carried out with a limited number of cases. These are the limitations of our study.

CONCLUSION

We believe that subclavian catheterization performed with in-plane technique under the guidance of USG will reduce complications, increase the percentage of intervention success and patient comfort. However, studies are needed to compare this method with other methods in terms of success.

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Author Contributions: NCK, AF; designed the study, collected the data and performed the data analysis. All authors revised the data analysis, edited the manuscript and critically revised the final version. **AF;** submitted the manuscript. All authors read and approved the manuscript

Ethical approval: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and/or with the Helsinki Declaration of 1964 and later versions. Informed consent or substitute for it was obtained from all patients for being included in the study. Written consent was obtained from each patient to use their hospital data. Ethics Committee Approval: The study was carried out with the permission of Ankara Atatürk Sanatorium Training and Research Hospital Ethics Committee (Date:08.02.2023, Decision No: 2646).

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