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Lateral oblique approach for internal jugular vein catheterization: Randomized comparison of oblique and short axis view of ultrasound-guided technique

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ABSTRACT

OBJECTIVE: The lateral oblique approach is a novel needle-in-plane technique for ultrasound-guided catheterization of internal jugular vein. We aimed to compare oblique approach with the classical short axis technique for facilitating the procedure and reduction of mechanical complications.

METHODS: The research was planned as a prospective study. 84 open-heart surgery patients requiring a central venous catheter were randomly allocated into two groups: Oblique approach group (n=42), short axis group (n=42). Time to cannulate, number of necessary puncture attempts, and frequency of carotid artery puncture, hematoma, puncture site bleeding, pneumothorax, and hemothorax in each groups were recorded. Visualization of the vein and the needle using ultrasound was also evaluated by a subjective scale.

RESULTS: Patient's characteristics were comparable between two groups. The mean time of catheterization was 52.00±70.18 seconds in oblique approach group and 40.76±49.30 seconds in short axis group. The mean number of needle puncture attempts was 1.21±0.61 in oblique approach and 1.12±0.50 in short axis group. The results did not differ significantly. There was an improved visualization of the needle in the oblique approach group but this was not proved as statistically significant.

CONCLUSION: The results of our study showed that lateral oblique approach is a safe and effective technique, which can be strong alternative to the classical short axis technique for ultrasound-guided catheterization of internal jugular vein.

Keywords: Central venous catheterization; internal jugular vein; lateral oblique approach; ultrasound.

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Ultrasonography is recommended and has been found superior to classic landmark technique for central venous catheterization [1, 2]. Agency for Healthcare Research and Quality report listed ultrasound (US) guidance for placement of central venous catheters (CVC) as one of the top patient safety practices and the use of US during catheterization was recommended by the National Institute of Clinical Excellence since 2002 [3, 4]. Ultrasound-guided central venous catheter placement decreases complications and decreases catheter placement attempts [5]. Real time two dimensional ultrasound guidance was found in association with decreased risks of cannulation failure, arterial puncture, hematoma, and hemothorax, compared to the landmark technique [6].

There are many approaches and techniques of ultrasound-guided central venous catheterization [1, 6]. Catheterization of the internal jugular vein (IJV) is usually

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preferred because of its anatomical position and large diameter in the Trendelenburg position [7]. The puncture may be performed using in-plane approach with a long axis (LA) visualization or out of plane approach with a short axis visualization of IJV. Although the short axis (transverse) visualization is mostly used by practitioners for internal jugular vein catheterization, this technique was found suboptimal considering the lack of prevention of posterior wall puncture [8]. The in-plane (long axis) technique for the needle guidance ensures the view of the entire needle, including tracking of the needle tip [9].

The lateral oblique visualization of the IJV is a novel approach and different from previous techniques, which was primarily offered by Phelan, and Hagerty for ultrasound-guided IJV catheterization [10]. This approach may be alternative to short axis and long axis approaches for US guided IJV catheterization. Oblique visualization provides a longer view of the IJV along with the carotid artery. In this approach, real time visualization of the entire needle, including the tip is possible. Compared to the long axis view of the IJV, the lateral oblique approach ensures a wider lateral space at the neck for needle insertion that may facilitate needle insertion.

Purpose of this study was to evaluate the needle-in-plane technique with oblique visualization of internal jugular vein in comparison to the classical short axis (needle out of plane) technique for catheterization of the internal jugular vein. Our hypothesis was time for catheterization, number of cannulation attempts and complications during catheterization may be reduced when oblique approach is used. We compared these two techniques in terms of catheterization times, number of puncture attempts and frequency of complications.

MATERIALS AND METHODS

The current research was planned as a prospective randomized study. IRB approval (Kocaeli University, KOU KAEK 2015/1) was obtained and written informed consent was provided from all participants before they were included in the study. Patients who were planned open-heart surgery and required a central venous catheter were included in the study. Exclusion criteria were patients requiring an emergency open heart surgery, patients having a history of previous surgical intervention at the catheterization site or with distorted neck anatomy and patients having a body mass index >40.00 kg/m^2. Age <18 years, cervical trauma with present neck immobilization and patients with signs of infection or subcutaneous hematoma at the puncture site were also excluded. A computer generated random number list was used and the patients were randomly assigned into two groups: Oblique approach group (OA) and short axis group (SA).

After monitoring invasive arterial pressure, electrocardiogram and pulse oximetry, induction of general anesthesia was achieved using fentanyl 5 μg/kg intravenous, thiopental 5 mg/kg intravenous and rocuronium 0.6 mg/kg intravenous. Anesthesia was maintained with Sevoflurane 2% and oxygen 50%. The catheterizations were performed under ultrasound guidance using a linear array 12 MHz ultrasound probe (Logic P5, GE Healthcare, Milwaukee WI, USA). Before catheterization, internal jugular vein at both sides of the patients was scanned throughout the neck and abnormalities were recorded. The other side was preferred for cannulation if any abnormality was detected. Patients were placed in supine position with the head rotated slightly (about 30°) to the opposite side of the catheterization site, in neutral position (not Trendelenburg). The skin was prepared with povidone-iodine and the US probe was covered with a sterile cap and sterile gel was used as coupling agent. All catheterizations were performed by the same attending physician (OB.) using a single-performer technique with the same operator handling the US probe and the needle. Catheterizations were performed using Seldinger technique, with an 18-G 6.5 cm introducer needle (Arrow International, Reading, PA, USA).

The oblique view is described as placing the US probe at 45 degrees angle to the vessel to ensure an in plane visualization of the needle while approaching the target vessel which is inserted from lateral to medial [10]. The patients in oblique approach group were cannulated using needle in plane technique. In this group, the ultrasound probe was placed on the jugular vein at mid neck level to capture a transverse cross-sectional image of the carotid artery and IJV together. Once the short-axis view is obtained, the probe is rotated 45 degrees clockwise (or counter clockwise if left IJV is chosen), with the orientation marker medially (or lateral if left IJV is attempted). An oblique view of IJV and carotid artery was visualized which are sonographically seen as oval structures posterior to the sternocleidomastoid muscle. The needle was inserted from the lateral aspect of the probe within the plane of US probe underneath the footprint and advanced medially (Fig. 1). The needle was visualized real time while it was being advanced forward and entering the IJV (Fig. 2). Then the ultrasound probe was removed and a three-port central catheter (Arrow International,

FIGURE 1. The position of the ultrasound probe and the needle during catheterization using oblique approach.

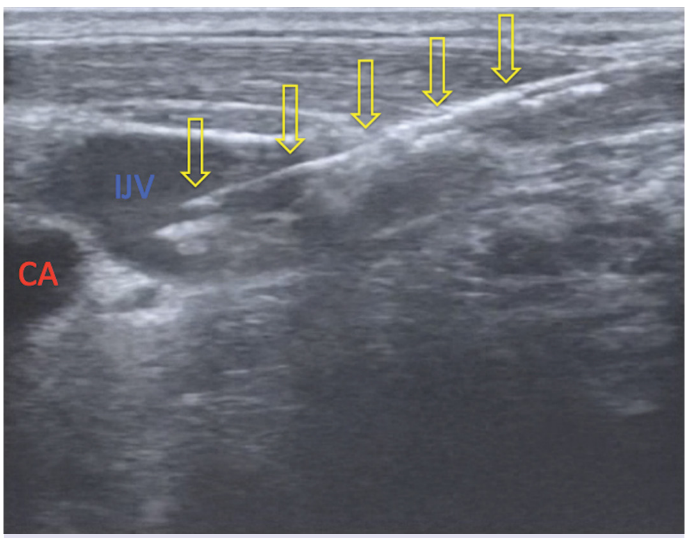

FIGURE 2. Ultrasonographic visualization of the internal jugular vein and the needle using oblique approach. The internal jugular vein (IJV) and the carotid artery (CA) are visualized obliquely. The whole needle (shown by arrows) can be visualized real time during the procedure.

Reading, PA, USA) was placed according to standard Seldinger technique. A syringe free technique was used for insertion of the needle. We did not attach a syringe to the needle and we did not aspirate blood during insertion of the needle. Instead of that, we inserted an open-ended needle and observe the tip of the needle under ultrasound guidance. When the tip of the needle was visualized in the IJV the guide wire was inserted through the needle into the vein. We did not wait to observe blood at the end of the needle. We immediately inserted the guide wire to prevent air embolism.

FIGURE 3. The position of the US probe and the needle during catheterization using short axis technique.

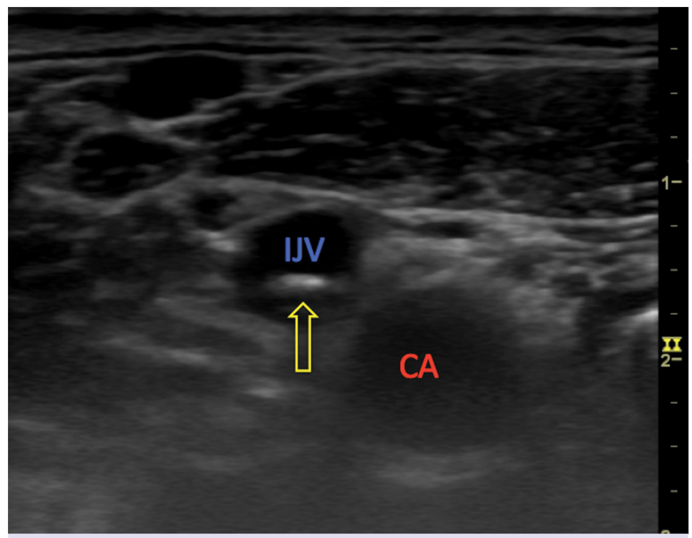

FIGURE 4. Ultrasonographic visualization of the internal jugular vein and the needle using short axis approach. A cross sectional image of the internal jugular vein (IJV) and the carotid artery (CA) is visualized. The needle could be visualized as an echogenic dot in the vein (arrow).

In the short axis group, the US probe was placed transversally over the neck to capture a transverse, short axis view of the IJV and carotid artery. The needle was inserted from the midpoint of the probe towards the center of IJV using out of plane technique (Fig. 3) with a syringe attached at the end. The tip of the needle is visualized as a small hyper-echoic dot when it crossed the wall of the vein (Fig. 4). When blood was aspirated, the guide wire was inserted through the needle into the vein. The insertion of a guide wire is verified by US in the IJV after the procedures.

Demographic characteristics (age, gender, BMI) and type of operation were recorded. The primary outcomes were the catheterization time, the number of puncture attempts for successful placement and potential complications during catheterization. Expected mechanical complications were: carotid artery puncture, local hematoma formation (which was identified by ultrasound), puncture site bleeding, pneumothorax, and hemothorax. Carotid artery puncture was defined as observation of pulsatile blood reflux through the needle. Mechanical complications were diagnosed by ultrasonography and clinical evaluation. Side of catheterization was also recorded.

Catheterization time was defined as the time starting from the first skin puncture until the placement of the guide wire into the vein without resistance and withdrawal of the needle. As all of the catheters were inserted using the Seldinger technique, only cannulation of the vein with a guide wire was determined as time of the procedure, we did not add the remainder of the procedure in the procedure time. The difficulty of US visualization of both the vein and the needle were recorded and classified as: 1. easy to visualize 2. moderate 3. difficult to visualize 4. impossible.

Data were recorded in an electronic spreadsheet (Microsoft Excel, Microsoft Corporation, Redmond, WA). All data were analyzed using SPSS 21 (SPSS Inc., Chicago, IL, USA) package program after transferring to SPSS format. Continuous quantitative data were presented as number, mean±standard deviation. Qualitative variables were expressed as median, 25th and 75th percentiles. Continuous variables consisted of independent measure and normal distribution was analyzed with independent samples T test. Mann-Whitney rank sum test was applied to the data without normal distribution. Chi-square tests were applied to the categorical data. $p<0.05$ was considered as significant.

RESULTS

A total of 84 patients were enrolled in this study. Patient's characteristics are summarized in Table 1. There were no significant differences between two groups in terms of age, weight, height, BMI, gender and side of catheterization.

The mean time of catheterization was 52.00±70.18 seconds in oblique approach group and 40.76±49.30 seconds in short axis group. Median time of catheterization was 33 seconds in oblique approach group and 30 seconds in short axis groups. There was no statistically significant difference between the groups (Table 2).

The mean number of needle puncture attempts for successful catheter placement was 1.21±0.61 in oblique approach and 1.12±0.50 in short axis group. All catheterization attempts were successful. In oblique approach group, 36 patients were successfully cannulated at first attempt, 4 patients were cannulated at second attempt, one patient was cannulated at third attempt and one patient was cannulated at fourth attempt. In short axis group, 39 patients were successfully cannulated at first attempt, 2 patients were cannulated at second attempt and one patient was cannulated at fourth attempt. The results did not differ significantly (Table 2).

Visualization of the IJV was easy in 41 patients and moderate in one patient in the oblique approach group. The IJV was visualized easily in 40 patients and moderately in 2 patients in short axis group. The results were similar between groups (Table 1). Visualization of the needle was classified as easy in 11 patients, moderate in 23 patients, difficult in 7 patients and was impossible in one patient in the oblique approach group. Visualization of the needle was easy in 6 patients, moderate in 19 patients, difficult in 11 patients and was impossible in 6 patients in the short axis group. These results revealed an improved visualization of the needle in using the oblique approach; however, no significant difference was detected (Table 1).

The number mechanical complications were minor. Totally, two mechanical complications occurred in each groups. Bleeding from insertion site was the most frequent complication, which developed in two patients in the short axis group and in one patient in the oblique approach group. One small hematoma occurred in the oblique approach group. None of the patients developed a carotid puncture, pneumothorax or hemothorax. The overall complication rates were similar between groups (Table 2).

DISCUSSION

The results of the current study show that oblique approach with needle in plane technique is a safe and effective technique. This approach may be a strong alternative to the classical short axis technique. Oblique approach (needle in plane) and short axis (needle out of plane) techniques did not differ in terms of catheterization times, number of puncture attempts and frequency of

TABLE 1. Patient characteristics

	Group				p
	Oblique		Short axis		
	n	%	n	%	
Age (year) (Mean±SD)	65.57±10.15		61.62±8.93		0.062*
Weight (kg) (Mean±SD)	84.80±7.36		71.50±16.20		0.052**
Height (m) (Mean±SD)	1.66±0.10		1.69±0.08		0.561**
BMI (kg/m^2) (Mean±SD)	30.88±4.42		25.13±6.64		0.057**
Gender					
Male	22	52.4	28	66.7	0.266***
Female	20	47.6	14	33.3	
Catheterization site					
Right	40	95.2	39	92.9	>0.05***
Left	2	4.8	3	7.1	
Visualization of vein					
Easy	41	97.6	40	96.2	>0.05***
Moderate	1	2.4	2	3.8	
Difficult	0	0	0	0	
Impossible	0	0	0	0	
Visualization of needle					
Easy	11	26.2	6	14.35	
Moderate	23	54.8	19	45.2	0.101***
Difficult	7	16.7	11	26.2	
Impossible	1	2.4	6	14.35	

SD: Standard deviation; *Independent Samples T Test; **Mann-Whitney Rank Sum Test; ***Chi-sqare test; Percantages are expressed as within groups.

complications. Although not proved statistically, oblique approach ensured an improved visibility of the needle during puncture.

The literature is certain that ultrasound guidance is mandatory for central catheterization procedures. Meta-analysis demonstrated that US guidance for IJV puncture clearly reduces the number of complications, failures and time required for insertion [1, 11]. However, there is a controversy which US guided technique is optimal or best for reducing the time for catheterization, number of puncture attempts and mechanical complications. In previous prospective studies, short axis, long axis and oblique techniques have been evaluated for internal jugular vein catheterization.

In the studies that human subject were not evaluated, many of them revealed no significant difference in the number of needle punctures and time for catheterization between the long axis and short axis approach for internal jugular vein catheterization. Long axis view was associated with fewer needle redirections and an improved visibility of the needle [12, 13]. Novice US users among residents completed the procedure more rapidly when using the short-axis approach without a significant difference between the LA and SA views in the number of puncture attempts and needle redirections [14].

In human studies, Chittoodan et al. demonstrated higher first pass success and fewer needle redirections in the short axis group (among experienced) as compared to long axis approach and a comparable procedure time in both groups [15]. Tammam et al. found no significant difference between the short axis and long axis approaches [16].

After introduction of the lateral oblique visualization of the IJV by Phelan and Hagerty [10] for ultrasound-guided IJV catheterization, limited number of prospective studies was conducted. Wilson et al. compared the

Table 2. Comparison of outcomes between groups in terms of catheterization time, puncture attempts and complications during the catheterization procedure

	Group		p
	Oblique		Short axis
Catheterization time (seconds)			
Median (25%–75%)	33.00 (25.75–41.25)	30.00 (25.00–35.50)	0.181**
Mean±SD	52.00±70.18	40.76±49.30	
Number of needle insertion attempts			
Mean±SD	1.21±0.61	1.12±0.50	0.722***
1 (n/%)	36/85.7	39/92.9	
2 (n/%)	4/9.5	2/4.8	
3 (n/%)	1/2.4	0/0	
4 (n/%)	1/2.4	1/2.4	
Complications			
Carotid puncture n (%)	0 (0)	0 (0)	>0.05***
Pneumothorax n (%)	0 (0)	0 (0)	
Hemothorax n (%)	0 (0)	0 (0)	
Hematoma n (%)	1 (2.4)	0 (0)	
Bleeding n (%)	1 (2.4)	2 (4.8)	
Frequency of venous trombosis n (%)	3 (7.2) (1 right, 2 left)	1 (2.4) (right)	0.752***

SD: Standard deviation; **Mann-Whitney Rank Sum Test; ***Chi-sqare test; Percantages are expressed as within groups.

rates of posterior wall puncture and could not demonstrate a difference between the short-axis and oblique-axis approaches in their study [17]. Batllori et al. found that lateral-to medial oblique and short axis techniques had higher first needle pass success and required fewer needle passes and less time when compared with long axis approach [18]. However, they did not found any difference between short axis and long axis approaches in terms of number of puncture attempts catheterization time and first needle pass success rate [18]. A different oblique approach has also been offered by DiLisio and Mittnacht in which needle insertion is performed from medial-cephalad to lateral-caudad direction [19]. However, the oblique position of the probe in medial oblique approach may complicate needle manipulations and redirections because of the mandible. A needle path from lateral to medial can also increase the risk of carotid injury [20].

Oblique approach may be the solution to the anatomical limitation of the needle entry place on the neck imposed by the footprint of the probe. Another advantage of the oblique approach is that it provides visualization of both the carotid artery and the jugular vein. The short-axis approach also allows simultaneous visualization of both artery and vein, but visualization and control of the tip of the needle is difficult and impossible in many cases [18, 19, 21]. We could be able to see the tip of the needle in the vein using the oblique approach, in most of the cases which ensures an excellent protection of posterior wall puncture and also makes blood aspiration during the puncture out of necessity. This can give a lead to the performance of syringe free catheterization technique with no attached syringe. However, this technique may be considered as more difficult procedure due to the difficulty of visualization of the entire needle and need of experience to visualize both the needle and the vein together in the plane of ultrasound beam. Therefore, oblique approach may be preferred after gaining experience in ultrasound-guided procedures.

Complications associated with CVC insertion range from 5% to 19%, which include vascular injury (arterial puncture, pseudoaneurysm, arteriovenous fistula), hematoma, air embolism, pneumothorax and malposition [22]. The overall incidence of mechanical complications was lower in our study than previous ultrasound-guided studies. Our mechanical complications were minor such as minor bleeding from insertion site and a minor hematoma in one patient. Carotid artery puncture may occur in 1.1% to 1.7% and up to 4% of cases despite the use of ultrasound guidance [13, 19]. Improved visualization of the needle tip and real time visualization of both the needle and the carotid artery may reduce these complications and should be investigated in future studies.

Limitations of our study include that the physician performing the punctures was not blinded to the hypotheses of the study. But differences in the ability of different operators performing the two approaches could also be a possible reason of bias. Another limitation is that we did not evaluate posterior wall puncture. This is a relatively difficult complication to diagnose which needs an extra ultrasound.

In conclusion, oblique approach may be considered as an alternative approach when needed which ensures improved visualization and control of the needle. Although short axis approach has been traditionally the classic technique preferred by clinicians for performing and teaching catheterization of the internal jugular vein, we recommend oblique approach as a safe and effective alternative technique. Further studies among inexperienced performers are needed to evaluate if oblique approach is suitable as a first choice.

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