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The effect of contralateral head rotation on the internal jugular vein to carotid artery distance and overlap ratio

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ABSTRACT

Introduction: Carotid artery puncture during central venous catheter (CVC) insertion could lead to serious complication if there were an overlapping of internal jugular vein (IJV) and carotid artery (CA). IJV and CA overlap ratio and distance were determined by contralateral head rotation angle. The optimal angle of contralateral head rotation during CVC insertion can decrease the risk of CA puncture complication. This study was aimed to investigate the optimal angle of contralateral head rotation on IJV to CA distance and overlap ratio at the cricoid level by ultrasound guidance.

Methods: This was a cross-sectional study of 34 patients undergoing elective surgery with CVC insertion. IJV to CA distance and overlap ratio at the cricoid level on each subject in the supine position was measured by using two-dimensional ultrasound (Sonosite® M-Turbo, 6-13 MHz probe) at 0°, 30°, 45°, 60° contralateral head rotation of insertion site. Collected data were analyzed using SPSS 21.0.

Results: There were significant differences on IJV to CA distance and overlap ratio at different contralateral rotation angles (0°, 30°, 45°, 60°, $p<0.001$). Overlapping of IJV and CA started to occur at contralateral head rotation 30° (11.72%) and increased in line with the increasing of contralateral head rotation angle (21.21% at 45°).

Conclusion: There were significant effects of contralateral head rotation to distance and overlapping IJV to CA at the cricoid level. Optimal contralateral head rotation angle for CVC was less than 30° to prevent IJV and CA overlapping.

Keywords: contralateral, head rotation, distance, overlapping, carotid artery, ultrasound

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INTRODUCTION

Central venous catheter (CVC) use increases along with the improvement of quality in critical care, high risk, and also in major surgery patients. Internal jugular vein (IJV) cannulation is a popular option for central venous catheterization.[1-3] Most clinicians use anatomical landmark during IJV cannulation. By rotating the head contralaterally, the Sedillot triangle, which is formed by the sternal head of the sternocleidomastoid, the clavicular head of sternocleidomastoid and the clavicle, will be more visible. The anterior IJV cannulation was done by performing IVJ puncture at the apex of the triangle. However, this method has shown the risk of failure by up to 35%, while the risk of complications was about 19%.[4]

Carotid artery puncture is one complication that should be avoided during IJV cannulation.[5] Anatomically, IJV is located anterolaterally from CA, about 51.4% IJV location is lateral to the carotid artery, and 54% is anterior to CA. This anatomical location might overlap at several different contralateral head rotation angles.[6] The optimal contralateral head rotation could reduce the risk of accidentally carotid artery (CA) puncture by reducing the overlapping of IVJ and CA.[5] Although ultrasonography-guided CVC insertion could increase the safety and quality of the cannulation compared to relying on anatomical landmark alone up to 71%, the optimal anatomical landmark was still needed during CVC insertion.[4,7] This research aimed to investigate the effect of contralateral head rotation on distance and overlap ratio of IJV and CA at the cricoid level and to find the optimal contralateral head rotation angle.

PATIENTS AND METHODS

This research was an analytical observational study with cross-sectional design aiming to investigate the effect of head rotation contralateral on distance and overlap ratio of IJV and CA at the cricoid level. This research took place in Cipto Mangunkusumo Hospital of Jakarta. The study protocol was approved by the institutional review board.

After obtaining informed consents, 34 subjects were enrolled by using consecutive sampling method. The sample size was calculated by using a numeric analytic, comparative, paired formula with repeated measurement. Inclusion criteria include American Society of Anesthesiologists (ASA) physical status 1 and 2, aged 18-60 years old, with no anatomical abnormality in the neck. Exclusion criteria include obesity, a history of previous central

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venous catheter cannulation, and limitation on contralateral head movement. Drop out criteria were abnormalities of anatomical IJV and CA.

Basic demographic data, such as sex, age, body weight and height, body mass index were recorded. Patients were positioned in the Trendelenburg (15°) position. Identification triangle of Sedillot at cricoid level in the right neck with palpation at angle 0°. USG probe was placed upright at the top of the triangle of Sedillot at cricoid level (Figure 1). Identification of IJV and CA was shown in transversal view then the IJV to CA distance and overlap ratio were calculated (Figure 2 and 3). The contralateral head rotation was done with a protractor at angle 30°, 45°, and 60°. The distance and overlap ratio of IJV and CA was calculated in each angle.

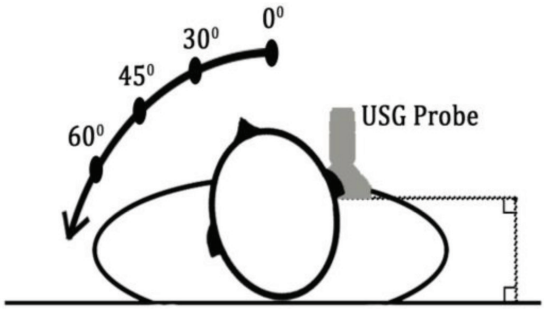

Figure 1 Position of contralateral rotation at certain degrees

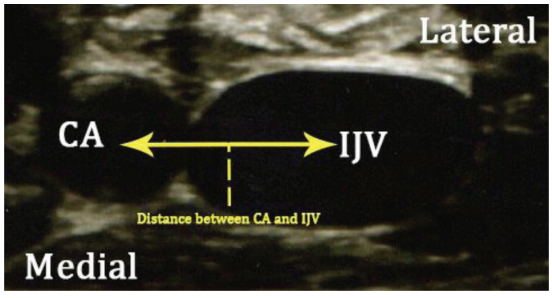

Figure 2 Distance between the internal jugular vein and carotid artery. The picture was taken when contralateral head rotation angle at 30°

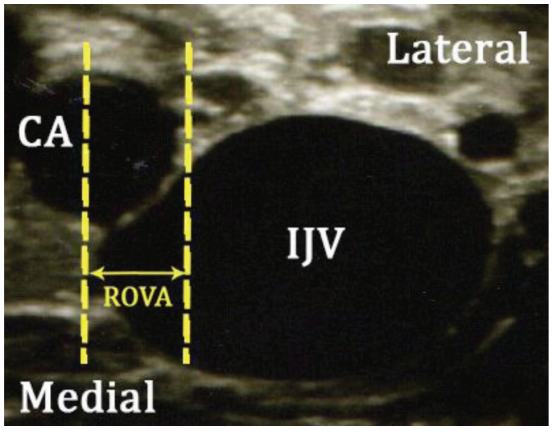

Figure 3 The ratio of the overlapping internal jugular vein and carotid artery (ROVA). The picture was taken when contralateral head rotation angle at 60°

RESULTS

There were 34 subjects enrolled and measured by using the two-dimensional USG Sonosite® M-Turbo with linear probe 6-13 MHz. All subjects have normal BMI (Table 1). The IJV to CA distance was analyzed by one-way ANOVA test for angle 0°, 30°, 45°, 60°. In general, there were significant differences in IJV to CA distance at every angle of contralateral head rotation (Figure 4).

Post hoc Tukey analysis showed a significant difference in IJV to CA distance at rotation angle 0° and 30°, 0° and 45°, and 0° and 60°. Post hoc Tukey analysis showed no significant difference of IJV to CA distance at rotation angle 30° and 45°, 30° and 60°, 45° and 60°. The most distant was 0.234

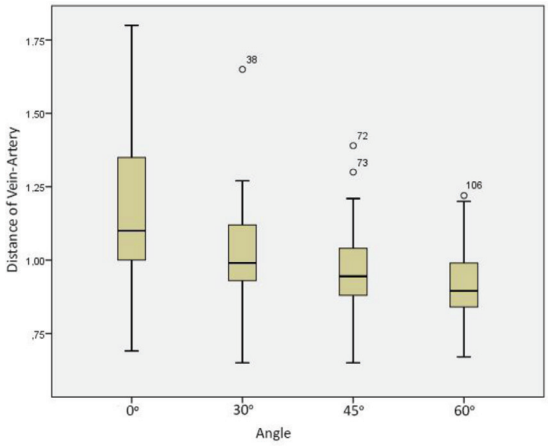

Figure 4 IJV to CA distance at every observed angle of contralateral head rotation

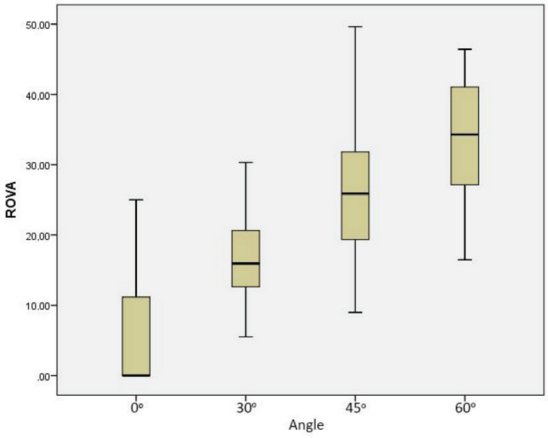

Figure 5 IJV and CA overlap ratio at all observed angle of contralateral head rotation

Table 1 Subjects' characteristics

Parameters	Value
Sex	
Male, n(%)	13 (32.8)
Female, n(%)	21 (61.8)
Age (years), mean±SD	39.6±12.1
Height (cm), mean±SD	159.8±7.5
Weight (kg), mean±SD	60.6±9.6
BMI (kg/m^2), mean±SD	23.6±3.2

BMI: body mass index

Table 2 Post hoc Tukey analysis of IJV to CA distance at every observed angle of contralateral head rotation

Head rotation angle (I)	Head rotation angle (II)	Mean distance difference in cm (I-II)	Confidence interval 95%		p
			Lower	Upper	
Angle 0°	Angle 30°	0.138	0.0201	0.2564	0.015
	Angle 45°	0.193	0.0745	0.3108	<0.001
	Angle 60°	0.234	0.1154	0.3517	<0.001
Angle 30°	Angle 0°	-0.138	-0.2564	-0.0201	0.015
	Angle 45°	0.054	-0.0637	0.1726	0.629
	Angle 60°	0.095	-0.0228	0.2134	0.159
Angle 45°	Angle 0°	-0.193	-0.3108	-0.0745	<0.001
	Angle 30°	-0.054	-0.1726	0.0637	0.629
	Angle 60°	0.041	-0.0773	0.1590	0.805
Angle 60°	Angle 0°	-0.234	-0.3517	-0.1154	<0.001
	Angle 30°	-0.095	-0.2134	0.0228	0.159
	Angle 45°	-0.041	-0.1590	0.0773	0.805

Table 3 Post hoc Tukey analysis of IJV and CA overlap ratio at every observed angle of contralateral head rotation

Head rotation angle (I)	Head rotation angle (II)	Mean distance difference in % (I-II)	Confidence interval 95%		p[a]
			Lower	Upper	
Angle 0°	Angle 30°	-11.729	-16.61	-6.84	<0.001
	Angle 45°	-21.213	-26.10	-16.33	<0.001
	Angle 60°	-28.888	-33.78	-24.00	<0.001
Angle 30°	Angle 0°	11.729	6.84	16.61	<0.001
	Angle 45°	-9.484	-14.37	-4.60	<0.001
	Angle 60°	-17.159	-22.04	-12.27	<0.001
Angle 45°	Angle 0°	21.213	16.33	26.10	<0.001
	Angle 30°	9.484	4.60	14.37	<0.001
	Angle 60°	-7.675	-12.56	-2.79	<0.001
Angle 60°	Angle 0°	28.888	24.00	33.77	<0.001
	Angle 30°	17.159	12.27	22.04	<0.001
	Angle 45°	7.675	2.79	12.56	<0.001

[a]Mann-Whitney test

at angle 0° and 60° (Table 2). Kruskal-Wallis test showed a significant difference in IJV and CA overlap ratio at all angle of head rotation contralateral (p<0.001) as shown in Figure 5. Post hoc analysis showed a significant difference in overlap ratio of IJV and CA for all angle of contralateral head rotation (p<0.001). The largest overlap ratio of IJV and CA was 28.88% between 0° and 60° (Table 3).

DISCUSSION

Mean distance of IJV to CA at angle 0° at cricoid level was 1.15±0.24 cm, shorter than another previous study in the Caucasian population.[1] Puncture of IJV should be done more cautiously to our subjects to avoid CA puncture due to the short distance of IVJ and CA. There was a significant relationship between the angle of contralateral head rotation and distance of IJV to CA (p<0.001). Distance between IJV to CA narrows as the angle of head rotation widens.

This result was different from the previous study by DeAngelis *et al.*[1] which showed that there was no significant relationship between the angle of contralateral head rotation and IJV to CA distance (p = 0.4555). Because of the anatomical differences in our population, variation in placement and angle of linear probe USG might contribute to this result. We measured the distance of IJV to CA at cricoid level in line with the top of Sedillot triangle. Meanwhile, measurement in DeAngelis study was done at the middle of Sedillot triangle.[1]

This study showed that there was a significant relationship between contralateral head rotation with IJV and CA overlap ratio at 0°, 30°, 45°, and 60°. It was consistent with previous studies.[8-10] The ratio increased significantly as the angle of head rotation widened. The smallest IJV and CA overlap ratio (4.96±6.65 %) was found at 0° rotation angle, and the largest (33.8±8.92%) was found at 60° rotation angle. With the most distance of IJV to CA is only 0.234 cm and the most significant overlap ratio was at 60° head rotation. CVC insertion with IJV approach at the cricoid level should be avoided then at 60° head rotation due to a higher risk of CA puncture.

The overlap between IJV and CA started to form when the head was rotated 30° contralaterally (11.72%) and steadily increased to 21.21% at 45°. Head rotation under 30° was recommended since it has smaller IJV and CA overlap ratio than other angles. Woo *et al.*[9] also recommend head rotation <30° in IJV cannulation.

This study limited the age and BMI to diminish anatomical variation of IJV and CA. Studies by Troainos *et al.*[8] and Umana *et al.*[11] showed that

patients who are more than 60 years old have better possibility of overlapped IJV and CA. Another study by Liebermann *et al.*[2] showed that BMI has a significant effect in developing overlaps between IJV and CA along with head rotation. Shoja *et al.*[12] showed that male is a predisposing factor for overlap IJV and CA compared to female.

There was a significant effect of contralateral head rotation to the distance and overlap between the IJV and CA at cricoid level. Contralateral head rotation under 30° was recommended since it has smaller IJV and CA overlap ratio than other angles.

CONCLUSION

There were significant effects of contralateral head rotation to distance and overlapping IJV to CA at the cricoid level. Optimal contralateral head rotation angle for CVC was less than 30° to prevent IJV and CA overlapping.

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