Journal of Applied Pharmaceutical Research
Volume 11 Issue 2, Year of Publication 2023, Page 71 – 75
DOI: 10.18231/j.joapr.2023.11.2.71.75

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Research Article

JOURNAL OF APPLIED PHARMACEUTICAL RESEARCH | JOAPR
www.japtronline.com *ISSN: 2348 – 0335*

EFFECT OF HEAD ROTATION ON VISUALISATION OF CAROTID ARTERY AND JUGULAR VEIN IN IJV CANNULATION: AN OBSERVATIONAL ANALYTICAL STUDY

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Article Information
Received: 9th April 2022
Revised: 27th February 2023
Accepted: 1st April 2023
Published: 30th June 2023

Keywords
Common carotid artery, cannulation, central venous access, internal jugular vein, head rotation, ultrasound guidance

ABSTRACT
Background: The relationship between the common carotid artery (CCA) and the internal jugular vein (IJV) plays a crucial role in the process of internal jugular vein (IJV) cannulation, and this relationship often undergoes changes with head rotation. **Methods:** In this analytical, observational study, we aimed to compare the effect of 15-degree and 45-degree head rotation on the visualization of the IJV and CCA among 30 patients undergoing IJV cannulation for central venous access. Ultrasound guidance was used during the cannulation procedure. **Results:** Our findings revealed that greater overlapping of the IJV, specifically at the 12 o'clock position, was observed in cases with a 45-degree head rotation, whereas a lesser degree of overlapping (IJV at the 10 o'clock position) was observed with head in the neutral position. **Conclusion:** Based on our observations, we conclude that maintaining a head neutral position during IJV central line insertion under ultrasound guidance is safer compared to a 45-degree neck rotation. This information can contribute to improved safety and efficacy during IJV cannulation procedures.

INTRODUCTION

Ultrasound guidance is the recommended approach for cannulating the internal jugular vein (IJV) in both elective and emergency cases involving adult and pediatric patients, as per the guidelines [1,2]. Despite the availability of extensive literature and recommendations, the use of skin surface landmarks for IJV cannulation remains prevalent in clinics. However, ultrasound guidance is employed in complex cases or by inexperienced personnel during central venous cannulation [3]. It is crucial to consider the impact of airway management techniques and head position on the overlap of the internal jugular vein (IJV) with the common carotid artery (CCA) [4]. Numerous studies have demonstrated that incorporating ultrasound guidance into this procedure greatly enhances its effectiveness by improving success rates, reducing access time, and minimizing the occurrence of major complications, particularly carotid artery (CA) puncture, pneumothorax, and haemothorax. However, it is worth noting that despite employing ultrasound guidance with a short-axis approach or in cases involving young patients and children with easily

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collapsible veins, there have been reports of major complications such as arterial cannulation, albeit at a lower incidence [5].

Traditionally, anatomical surface landmarks were used to identify neck blood vessels. In landmark-based internal jugular vein (IJV) central line insertion, the rotation of the head is not consistently specified [6]. Greater head rotation results in increased overlap between the common carotid artery (CCA) and the IJV, potentially raising the risk of CCA puncture. When relying on external landmarks, the optimal degree of neck rotation should generally be below 45 degrees, although in obese patients, optimal landmark visibility may be achieved at a rotation below 30 degrees, while patients with a small BMI may require a rotation closer to 60 degrees. Infants, on the other hand, have shown reduced overlap between the IJV and CA when the neck is positioned at 0 degrees. These recommendations are applicable to patients who cannot or should not rotate their necks (e.g., head trauma, previous cervical fusion), as well as patients with challenging or altered external landmarks due to obesity, the presence of a laryngeal airway mask, or burn injuries [7]. The primary objective of the study was to determine the difference in the proportion of cases with increased overlap between the IJV and CCA on 15 and 45-degree head rotation. Secondary objectives included evaluating the mean anteroposterior and transverse diameter of the IJV and the mean depth of the IJV on 15 and 45-degree head rotation.

MATERIAL AND METHODS

This hospital based analytical, prospective observational study was done on total of 30 patients requiring IJV cannulation for central venous access with due permission from institutional ethics committee vide order no.1099/NC/EC/2021 dated; 01.02.2021. Informed consent for the procedure was obtained.

Inclusion Criteria: All patients of 18-60 years of age both sex and normal neck mobility on both side of neck were included for the study.

Exclusion criteria: Patients with limited neck mobility, neck mass, history of neck surgery, haemodynamic instability, short neck, obesity, SVC syndrome, and refusal to the procedure were excluded from the study.

A sample of 30 cases was required at 95% confidence and 80% power to verify the expected difference of 55% in proportion of cases with increase in overlap on head rotation at 15° and 45° from central position of head. Informed consent was taken from patients. The baseline vitals like heart rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), Peripheral Oxygen Saturation (SpO2) were recorded at the early beginning of the procedure. IV line was secured with 18G iv catheter in upper limb and Ringer Lactate solution was started. The patient was placed in the supine position with 15° Trendelenburg tilt. We used a protractor to assess the rotation of head. A portable ultrasound GE LOGIQ-e machine with a linear probe (vascular) of 5-10 MHz was used. The thin-walled, oval or round shape structure, IJV was identified based on its morphological structure, compressibility and non-pulsatality. The CCA was also identified as per its morphological structure (thick-walled, round shape, pulsatile) and resistance to compression. All images were recorded with a proper transducer orientation in such a way that the medial side of left neck corresponds to the right side of the image and the medial side of right neck corresponds to the left side of the image (figure 1-3)

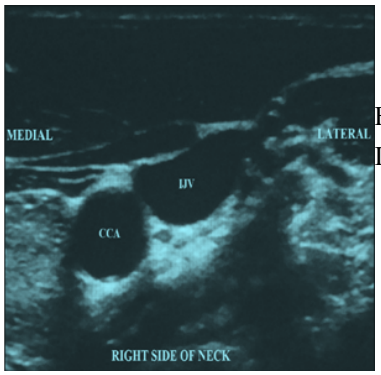

Fig. 1: Anterolateral position of IJV to common carotid artery

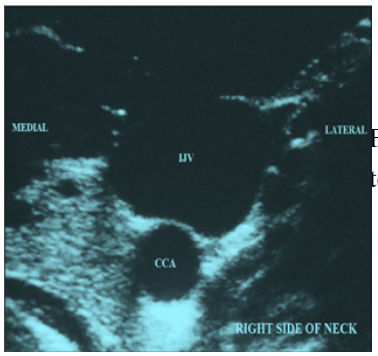

Fig. 2: Anterior position of IJV to common carotid artery

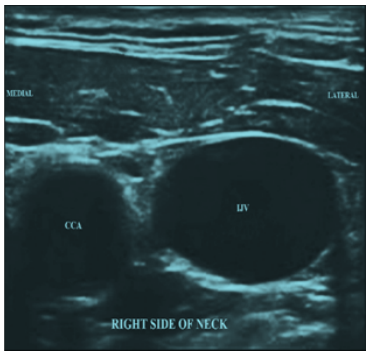

Fig. 3: Lateral position of IJV to common carotid artery

The position of the IJV recorded in one of these segments keeping the CCA in the center.

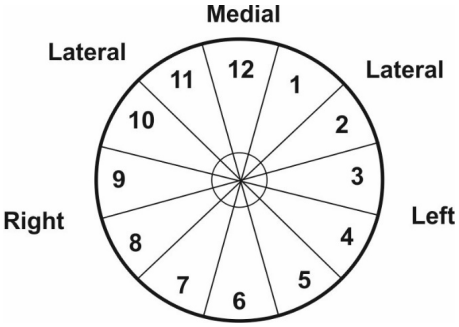

Fig.4: Segments with CCA at centre

The patient's head was rotated to the contralateral side by 15 and 45 degrees. Thus, the effect of rotation on the IJV-CCA anatomical relation was determined on both sides, by noting the change in segment (1-12). The middle of IJV (intersection of anteroposterior and mediolateral diameters) was used to define its position in relation to CCA. The position of IJV described as lateral, anterolateral, medial and posterior. CCA is considered at centre 0 o'clock (medial) and Left IJV positions are defined as 12 o'clock (medial), 1 & 2 o'clock (anterolateral) and 3 o'clock (lateral). Right IJV positions are defined as 12 o'clock (medial), 11 & 10 o'clock (anterolateral) and 9 o'clock (lateral). Anteroposterior (AP) and transverse diameters of IJV was noted in neutral head position and on 15° and 45° head rotations on both side of neck. The depth of IJV (distance from skin to middle of IJV).

Data were entered in excel sheet. Continuous data were summarized in form of mean and standard deviation. Difference in mean of two groups was analyzed using student 't' test. Continuous data were expressed in form of proportions and difference in proportions were analyzed using chi-square test. The level of significance was kept 95% for all statistical analysis.

RESULTS

Mean age of patients was 45.63±14.98 years among 16 male (53.33%) and 14 female patients (46.67%). At neutral position of head, position of left IJV at 12, 1,2 and 3 o'clock in relation to CCA was found in 0, 3, 21 and 6 patients while on 15° head rotation to left leads this number changed to 0,21,8 and 1 which shows that IJV was shifting from lateral to more anterolateral statistically significantly (p value <0.001). At 45° head rotation there was further statistically significant increase in 12 o'clock positioned IJV numbers (14 or 46.67%) which was 0 at neutral and 15° head positions (p value <0.001). So, it was found that No overlapping of IJV over CCA is seen at neutral position and on 15° head rotation (Table 1).

Table 1: Relation of IJV to CCA at neutral, 15° and 45° Head rotation (Left side)

	Neutral		15°		45°		P value	P value
Clock position (CCA-IJV)	No.	%	No.	%	No.	%	(Neutral vs 15°)	(Neutral vs 45°)
0-12	0	0	0	0	14	46.67		0P<0.001 (S)
0-1	3	10.00	21	70.00	15	50.00	P<0.001 (S)	P<0.001 (S)
0-2	21	70.00	8	26.67	1	3.33	P<0.001 (S)	P<0.001 (S)
0-3	6	20.00	1	3.33	0	0.00	P<0.001 (S)	
Total	30	100	30	100	30	100		

Test used Chi-square = 22.899 with 2 degrees of freedom; P<0.001 (S)

Table 2: Relation of IJV to CCA at neutral, 15° and 45° Head rotation (Right side)

	Neutral		15°		45°		P value	P value
Clock position (CCA-IJV)	No.	%	No.	%	No.	%	(Neutral vs 15^0)	(Neutral vs 45^0)
0-12	1	3.33	0	0.00	16	53.33		P<0.001 (S)
0-11	5	16.67	18	60.00	8	26.67	P = 0.006 (S)	P<0.001 (S)
0-10	17	56.67	10	33.33	6	20.00	P = 0.006 (S)	P<0.001 (S)
0-9	7	23.33	2	2.67	0	00.00	P = 0.006 (S)	
Total	30	100	30	100	30	100		

Test used -Chi-square = 12.940 with 3 degrees of freedom; P<0.001 (S)

Table 3: Measurements- Transverse & AP diameter, Skin to IJV Depth.

		Right IJV measurements (cm)			Left IJV measurements (cm)		
		Mean	SD	P value	Mean	SD	P value
Transverse diameter (cm)	Neutral	1.49	0.37	-	1.42	0.35	-
	15°	1.57	0.41	0.029(S)	1.47	0.32	0.104
	45°	1.49	0.46	0.855	1.43	0.39	0.633
AP diameter (cm)	Neutral	0.94	0.21	-	0.97	0.24	-
	15°	1.06	0.25	0.064	1.01	0.22	0.288
	45°	0.95	0.24	0.840	0.91	0.22	0.071
Skin to IJV Depth (cm)	Neutral	1.31	0.14	-	1.32	0.22	-
	15°	1.21	0.16	p<0.001(S)	1.21	0.24	0.015(S)
	45°	1.32	0.19	0.936	1.25	0.21	p<0.001(S)

Test applied- student 't' test, Significant- P<0.05 (S)

On 15° head rotation to Right side there was statistically significant increase in 11 o'clock positioned IJV numbers (18 or 60%) which was 5 (16.67%) at neutral. Maximum overlapping of IJV over CCA seen at 45° head rotation (16 patients, 53.33%). Majority of patients had right IJV at 10 O'clock position when head was at neutral position while on head rotation at 15 degree and 45°, maximum patients were at 11 and 12 o'clock positions respectively which is in favour of overlapping increased with more degree of head rotation. These changes were statistically significant (P<0.001) (Table 2).

In neutral position of head mean transverse diameter of right IJV was 1.49±0.37 cm while on 15° and 45° head rotation it was 1.57±0.41 cm and 1.49±0.46 cm respectively. The difference in transverse diameter between neutral and at 15° was statistically significant (p value-0.029). Transverse diameter of left IJV was 1.42±0.35 cm at neutral position while 1.47±0.32 cm and 1.43±0.39 cm at 15° and 45° head rotation respectively. The differences between these findings were statistically non-significant (p value- 0.104) (Table 3).

AP diameter of IJV on right as well as left side at different position of head rotation are shown in table 3. In neutral position of head mean depth of right IJV was 1.31±0.14 cm while on 15° and 45° head rotation it was 1.21±0.16 cm and 1.32±0.19 cm respectively. The difference in depth between neutral and at 15 degree was statistically significant (p<0.001). Mean depth of left IJV was 1.32±0.22 cm at neutral position while 1.21±0.24 cm and 1.25±0.21 cm at 15° and 45° head rotation respectively. The differences between the above findings were statistically significant (p value<0.05).

DISCUSSION

In tertiary care hospitals, internal jugular vein (IJV) cannulation is a standard procedure typically performed with the head rotated away from the puncture side, although the degree of rotation may vary [8-9]. Our objective was to investigate the impact of head rotation at 15° and 45°, starting from the central position, on the proportion of cases exhibiting increased overlap. We observed that as the degree of rotation increased, the IJV tended to shift more towards the anterolateral or even medial direction. Our findings align with the conclusions of Sulek et al. [10], who conducted a study involving 12 patients and determined that a 40° rotation of the head to the contralateral side increased the overlap between the internal jugular vein (IJV) and the common carotid artery (CCA).

Based on their findings, they recommended that if head rotation is necessary, it should be limited to less than 40 degrees. In a study conducted by Arai et al. [11], involving 51 children and 11 infants, they examined the position of the common carotid artery (CCA) in relation to the internal jugular vein (IJV) and demonstrated a significant increase in IJV overlap due to head rotation. Similarly, Gwak et al. [12] confirmed these findings in their study involving 88 infants and children. On the other hand, Riopelle et al. [13] studied 107 adult patients for IJV access and utilized a circumferential adjustment technique. Their results indicated that, in general, head rotation is not advisable. Augoustides et al. [14] report that, regardless of the technique (landmark or ultrasound guidance), CCA puncture still occurs in 7% of cases if physicians are not well trained in the selected technique.

CONCLUSION

We conclude that head neutral position has the least overlapping to CCA and this overlapping increases with 15° and 45° rotation to opposite side. Ultrasound guidance may help to determine right range of head rotation. There were few limitations, we accessed patients of wide variety from healthy to critically ill, so hydration status of patients may not same for all. We assessed the position of IJV at the apex of the clavicle-sternocleidomastoid triangle only.

FINANCIAL ASSISTANCE

Nil

CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHOR CONTRIBUTION

Poonam Kalra conceptualized whole research and supervised the ultrasound guided IJV cannulation. Gursevak Maan did the research work and statistical analysis along with Poonam Kalra. Satveer Singh Gurjar helped in collecting the information and drafting the manuscript. Manuscript writing and references was also done by Satveer Singh Gurjar.

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