Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 11, 2024

Original research article

Ultrasonographic evaluation of relationship between common carotid artery and internal jugular vein during head rotation

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Abstract

IJV is most commonly used for central venous access as it is superficially located and fewer incidences of serious complications like pneumothorax and haemothorax compared with subclavian approach. The most common complication during IJV cannulation is accidental rupture of CCA. A cross-sectional study was performed on 100 patients coming to hospitals attached to Bangalore Medical College and Research Institute, Bengaluru. USG neck was performed to obtain the images of IJV and CCA on both sides with respect to different head rotations angles (0°, 15°, 30°, 45°, 60°, 75° and 90°) and results were calculated. Most common position of IJV is anterolateral with respect to CCA at any given head rotation angle. On turning head to contralateral position, IJV is noted displaced to anterior position. Percentage overlap of IJV to CCA significantly increases when head rotated >45° at 2 cm above the clavicle and > 30° at 4 cm above the clavicle.

Keywords: Internal jugular vein, common carotid artery, central venous access, ultrasonography

Introduction

Internal jugular vein (IJV) is most commonly used for central venous access as it is superficially located[1]. IJV[1] cannulation is mainly indicated for blood sampling, vascular access for hemodialysis, giving antibiotics, chemotherapy, and monitoring right atrial pressure [2]. Right IJV is also used to create TIPS, inferior vena cava filter placements and trans jugular liver biopsies [2].

IJV cannulation has fewer serious complications like pneumothorax and haemothorax than the subclavian vein approach [3]. However, the most common complication during IJV cannulation is accidental rupture of the common carotid artery (CCA), whose incidence ranges from 6.3-9.3% [4].

The use of ultrasonography during venous cannulation permits the accurate identification of IJV. It also increases the overall success rate of cannulation and reduces complications [5, 6, 7]. But due, to lack of availability of ultrasound machines in all hospital settings and the perception of increased total procedure time leads to the use of basic anatomical knowledge and landmark techniques [8].

Traditional landmarks for IJV cannulation and the anatomical relationship between CCA and IJV are well known. But wide variations in IJV anatomy, specifically its size, location and relationship to CCA with respect to different head rotation angles, may lead to an increase in the accidental puncture of the CCA [8].

Only a few studies have been conducted to determine the amount of overlapping of IJV over CCA during different head rotation angles.

Methodology

Study Design

Cross sectional study.

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 11, 2024

Inclusion Criteria

1. Patients referred to department of radio diagnosis for carotid artery doppler and ultrasonography of neck.
2. **Age:** 18-60 yrs.
3. Patient willing to give informed consent.
4. Patients who has never undergone vascular surgeries in the neck region.

Exclusion Criteria

1. Patient not willing to give informed consent.
2. Patient undergone prior internal jugular vein cannulation.
3. Patient undergone prior vascular surgeries in the neck region.
4. Patients with limited neck mobility and history of cervical spinal cord trauma.
5. Patients with history of head and neck masses or cancer.
6. Patients with superior vena cava syndrome.
7. Patients with hemodynamic instability.

Machine details

Samsung RS80EVO ultrasonography machine equipped with linear array transducer.

Results

Table 1: Representing Position of IJV compared to CCA 2 cm above the clavicle

Position of IJV compared to CCA 2 cm above the clavicle	Right						Left					
	Neutral	15°	30°	45°	60°	75°	Neutral	15°	30°	45°	60°	75°
Lateral	10	9	7	6	4	1	9	10	7	5	4	2
Anterolateral	86	84	79	75	76	77	87	83	77	78	77	77
Anterior	4	7	14	19	21	22	4	7	16	17	19	21
Anteromedial	0	0	0	0	0	0	0	0	0	0	0	0
Medial	0	0	0	0	0	0	0	0	0	0	0	0
Posteromedial	0	0	0	0	0	0	0	0	0	0	0	0
Posterior	0	0	0	0	0	0	0	0	0	0	0	0
Posterolateral	0	0	0	0	0	0	0	0	0	0	0	0

Table 2: Representing Position of IJV compared to CCA 4 cm above the clavicle

Position of IJV compared to CCA 4 cm above the clavicle	Right						Left					
	Neutral	15°	30°	45°	60°	75°	Neutral	15°	30°	45°	60°	75°
Lateral	9	8	5	4	2	1	11	9	4	3	3	2
Anterolateral	88	85	80	78	75	75	85	83	80	78	77	75
Anterior	3	7	15	18	23	24	4	8	16	19	20	23
Anteromedial	0	0	0	0	0	0	0	0	0	0	0	0
Medial	0	0	0	0	0	0	0	0	0	0	0	0
Posteromedial	0	0	0	0	0	0	0	0	0	0	0	0
Posterior	0	0	0	0	0	0	0	0	0	0	0	0
Posterolateral	0	0	0	0	0	0	0	0	0	0	0	0

In our analysis at 2 cm above the clavicle, the most frequent position of IJV with respect to CCA is the anterolateral position at any given head rotation angle. However, on increasing the head rotation angle from neutral to 75°, the IJV position shifted more towards the anterior location from the lateral and anterolateral location. No significant difference was noted between the right and left sides of the neck. None of the study participants had an IJV that was anteromedial, medial, posterior, posteromedial, or posterolateral to the CCA.

The same outcomes were observed at 4 cm above the clavicle.

Table 3: Percentage overlap of right IJV over right CCA

Distance above the clavicle	Neutral	15°	30°	45°	60°	75°
2 cm	17.3±20.6	18.5±19.8	24.7±22.9	29.7±22.1	39.3±23.8	48.4±26.1
4cm	20.8±23.8	24.0±19.8	31.8±26.3	41.3±26.2	55.1±23.8	64.5±22.2

The percentage overlap of right CCA by the IJV gradually increased as the head rotated in the opposite direction, at 2 and 4 cm above the clavicle. The percentage overlap of IJV over CCA in the neutral position at 2 and 4 cm above the clavicle is 17.3% and 20.8%, respectively. As the head rotated to the opposite side, the percentage overlap at 2 and 4 cm above the clavicle was significantly higher when the

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 11, 2024

head was turned >45° and >30°, respectively, compared with that observed in the neutral position.

Table 4: Percentage overlap of left IJV over left CCA

Distance above the clavicle	Neutral	15°	30°	45°	60°	75°
2 cm	16.6±21.1	19.1±20.1	24.4±23.2	28.7±23.3	38.2±29.0	46.3±24.2
4cm	24.0±24.1	25.7±24.0	29.3±23.2	39.4±29.0	52.8±24.9	59.8±21.8

The percentage overlap of left CCA by the IJV gradually increased as the head rotated to opposite direction, at both 2 and 4 cm above the clavicle. The percentage overlap of IJV over CCA in neutral position at 2 and 4 cm above the clavicle is 16.6% and 24.0% respectively. As the head rotated to opposite side the percentage overlap at 2 and 4 cm above the clavicle is significantly higher when the head was rotated >45° and >30° respectively compared with that observed in the neutral position.
On comparison of values between right and left side significant difference noted at 75° head rotation at 4 cm above the clavicle.

Discussion

In our study, we positioned the ultrasound probe perpendicular to the floor to accurately portray the relationship between IJV and CCA.
At 2 cm above the clavicle, the most frequent position of IJV with respect to CCA is anterolateral position at all head rotation angles measured. However, on increasing the head rotation angle from neutral to 75°, the IJV position shifted more towards the anterior location from the lateral and anterolateral location. No significant difference was found between the right and left sides.
The same outcomes were observed at 4 cm above the clavicle.
The percentage overlap of right CCA by the IJV gradually increased as the head rotated to the contra lateral direction at both 2 and 4 cm above the clavicle. The percentage overlap of right IJV over right CCA in the neutral position at 2 and 4 cm above the clavicle is 17.3% and 20.8%, respectively. As the head rotated to the opposite side, the percentage overlap at 2 and 4 cm above the clavicle is significantly higher when the head was rotated >45° and >30°, respectively, compared with that observed in the neutral position.
The percentage overlap of left CCA by the left IJV gradually increased as the head rotated to the contra lateral direction at both 2 and 4 cm above the clavicle. The percentage overlap of IJV over CCA in the neutral position at 2 and 4 cm above the clavicle is 16.6% and 24.0%, respectively. As the head rotated to the opposite side, the percentage overlap at 2 and 4 cm above the clavicle is significantly higher when the head was rotated > 45° and > 30°, respectively, compared with that observed in the neutral position.
On comparison of values between the right and left side, a significant difference was noted at 75° head rotation at 4 cm above the clavicle. According to Macken *et al.* [1] IJV was located anterior and anterio-medial in 48.7% of cases on the right side and 58.7% on the left side, with the lateral position in only 3-3.3% of cases. Atypical positions of the IJV were found in a few of the patients, with the IJV located medially in 0.7-2% of patients. In one patient, the IJV was depicted posteromedially, and in another, it was posterior to the CCA. However, in our study, the anterolateral position was found more frequently than observed by Macken. Moreover, the medial position of IJV was not found in any of the cases in our study. This variation can be explained by the fact that Macken *et al*. placed the probe of the USG perpendicular to the skin rather than perpendicular to the floor, which resulted in the more anterior and anterio-medial position of IJV.
Saya Raghavendra Prasad *et al.* [9] conducted a study on 120 healthy volunteers and found that the commonest position of IJV in relation to CCA was anterolateral, followed by anterior, then lateral. They recommended the use of ultrasonography during IJV cannulation due to wide variations in the IJV anatomy in a significant number of populations.
Purohit *et al.* [10] conducted a study on 200 patients and found that the most common position of IJV with respect to CCA was anterolateral, followed by lateral position. Increasing the head rotation to the opposite side position of IJV changes to the anterior location, thus increasing the overlap of IJV over CCA. They recommended the use of USG during central venous cannulation due to variations in IJV.
According to Sibai *et al.* [11], IJV was found in lateral position in 51% of cases, anterolateral in 33% of cases, posterolateral in 14% of cases and anterior in 2% of the cases on the right side with the USG transducer placed perpendicular to the floor. However, in their study head was rotated to the contra-lateral side at the time of examination. They also studied the effect of placing the transducer perpendicular to the skin, which showed a more anterolateral position of the IJV relative to the CCA.
Hong *et al.* [12] conducted a study on 200 pediatric patients and concluded that the mean percentage overlap of CCA by IJV in the neutral position increased significantly as the head was rotated to the opposite side. The incidence of lateral positioning of IJV to CCA decreased significantly when the head rotated to the opposite side. The right IJV is associated with less overlap of the CCA than the left, regardless of head position.
Miki *et al.* [3] conducted a study on 30 volunteers. According to their study, IJV overlap increases

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 11, 2024

significantly when the head rotates to >45° at 2 cm above the clavicle and >30° at 4 cm above the clavicle.
They concluded that head rotation should be kept to < 45° for procedures occurring 2 cm above the clavicle and to < 30° for procedures occurring 4 cm above the clavicle. However, they conducted the study only on the right side.

Conclusion

- The most common location of IJV is anterolateral with respect to CCA at all given head rotation angles provided.
- IJV displaced to the anterior location as the head rotated contra laterally from neutral position to 75° position.
- No significant difference was made out between the right and left sides.
- The percentage overlap of IJV over CCA increases as the head rotates to the contra lateral side.
- At 2 cm above, the clavicle percentage overlap of IJV over CCA is increased significantly when the head rotated >45°.
  No significant difference was noted between the right and left sides.
- At 4 cm above, the clavicle percentage overlap IJV over CCA is increased significantly when the head rotated >30°.

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