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Optimal Head Rotation for Ultrasound-Guided Internal Jugular Vein Cannulation in Obese Patients: A Prospective Observational Study

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Abstract

Background: Ultrasound-guided internal jugular vein (IJV) cannulation is standard practice, but the risk of accidental common carotid artery (CCA) puncture persists, especially in obese patients. Head rotation manoeuvres aim to improve IJV accessibility but may increase IJV-CCA overlap. The optimal degree of head rotation to minimise this overlap although studied in normal patients remains largely underexplored in obese patients. **Aims:** To determine the head rotation angle (15°–60°) that maximizes IJV diameter while minimizing IJV-CCA overlap in obese patients (BMI ≥25 kg/m^2). **Material and Methods:** Sixty obese patients were stratified by BMI (Group 1: 25–29.9; Group 2: 30–39.9; Group 3: ≥40) in the pre-operative room. In supine position with 15° Trendelenburg tilt, right IJV and CCA were imaged using 5–12 MHz linear probe at cricoid level. Transverse and anteroposterior diameters of the right sided IJV and CCA and their overlap were measured using real time ultrasound at 15°, 30°, 45° and 60° of head rotations. **Results:** IJV-CCA overlap increased significantly with rotation: 34.9% (with15°) to 55.3% (with 60°) (P<0.001). Overlap was highest in Group 3 (BMI ≥40). No significant change in IJV diameter was observed. The safest rotation was ≤45° for BMI 30–39.9 and ≤60° for BMI 25–29.9. **Conclusion:** Head rotation >45° in obese patients significantly increases CCA puncture risk. Ultrasound-guided cannulation at ≤45° is recommended for BMI ≥30 kg/m^2.

Keywords: Internal jugular vein, Obesity, Ultrasound guidance, Head rotation, Common carotid artery

1 Introduction

Internal jugular vein (IJV) cannulation is one of the commonly performed procedures, in both the peri-operative period and in intensive care unit. Use of Real-time Ultrasound guidance during IJV cannulation is considered to be relatively safe and is now recommended as a standard-of-care technique by the American Society of Anaesthesiologists practice guidelines for central venous access[1, 2]. Central venous catheterization is associated with various mechanical complications like accidental common carotid artery (CCA) puncture, haematoma, haemothorax, pneumothorax, etc.[3]. Carotid puncture is considered one of the most severe complication with the reported incidence as high as 10.6% with traditional landmark technique[4]. Although usually benign, accidental carotid artery puncture can sometimes be life-threatening when it results in accidental intra-arterial cannulation, haemothorax, acute cerebro-vascular accident, IJV-carotid artery fistula or airway compromise secondary to a haematoma[5-7]. Real-time ultrasound reduces complications, yet CCA puncture rates remain 5.9%[8].

Although IJV is generally lateral and anterior to the CCA, there may be variations in the position and the degree of overlap of the IJV over CCA. Therefore, the risk of accidental CCA puncture is always there[9]. A safe and successful internal jugular vein cannulation depends on two main factors – larger diameter of IJV and minimum degree of overlap of IJV on CCA[8]. Several maneuvres which increase the size of IJV have been practiced, such as Trendelenburg tilt, head rotation, abdominal compression, passive leg elevation and providing positive end-expiratory pressure[10-12]. Traditionally, there has been a great temptation to rotate the head as far as possible to the opposite side to "open" the neck and visualize the anatomic landmarks. However, this rotation of the head changes the anatomical relationship between the IJV and the CCA. Ultrasound imaging has revealed that when the head is rotated to the contralateral side, the IJV tends to lie more anterior thereby overlapping the CCA. Several researches have studied relation of IJV and CCA with varying degrees of head rotation (0° to 80°), for optimal visualization of the vessels and to minimize the overlap and hence the risk for CCA puncture in normal patients[13]. Obesity exacerbates challenges due to obscured landmarks and deeper IJV placement hence USG guided IJV cannulation is a preferred technique in them. While studies in non-obese patients suggest ≤30° rotation minimizes overlap[14] data for obese populations are limited. This prospective observational study evaluates the optimal head rotation angle for IJV cannulation in obese patients (BMI ≥25 kg/m²) by measuring IJV-CCA overlap and vessel dimensions under US guidance.

2 Methods

This Prospective Observational single centre study was conducted in a tertiary hospital. After obtaining approval from the Institutional Ethics Committee (IEC No: IEC/373/21), 60 consenting patients of age 18 years and above, with BMI ≥ 25 kg/m^2, belonging to ASA physical status I – III were included in the study. Patient with previous history of right IJV cannulation, or with evidence of mass/tumor/scar in the neck area, or with suspected/diagnosed cervical spine injury /disease in whom head rotation was contraindicated, patients with limited neck mobility due any reason and patients refusing to participate in the study were excluded from the study.

The study was carried out in the Pre-operative holding area, Operation theatres and Intensive Care Units. Written informed consent was obtained from all patients. Before the procedure, patients were given supine position with 15° Trendelenburg position. All patients received a head ring of thickness 5 cm and a shoulder roll of thickness 5 cm. Real time ultrasound using standard high frequency (5- 12 MHz) linear probe was performed to visualize Right IJV and CCA, in the short axis view (transverse orientation) at the cricoid level with head in neutral position (0° head rotation). Neutral/0° head rotation was defined as having the patient's sagittal plane perpendicular to the floor. Probe pressure was kept as low as possible to avoid compression of the vein. The head was then rotated to 15° and the diameter of the IJV was measured using calliper by drawing a line using electronic marker between the farthest two points of the vein wall in the Transverse and Anteroposterior (AP) planes, respectively (Fig. 1). The Overlap length - defined as the longest distance between the tangent of the outermost point of the CCA and the innermost point of the IJV (Fig. 2). The percentage of overlap between IJV and CCA as calculated by the formula % Overlap = (Overlap Length x 100) / CCA diameter. Each patient's head was then be rotated in a stepwise manner to 30°, 45° and 60° based on the position of the tip of nose to neutral position (measured using a protractor). Similar sono-anatomical images of IJV and CCA were obtained and corresponding measurements were obtained and recorded for each head position. All sono-anatomical scans were performed under supervision of skilled anaesthesiologist, and all values were measured on the images after the patient is stabilized for at least 30 seconds in each of the measurement position.

The following measurements were noted for each head position:

1. The Transverse and Anteroposterior diameters of the Right IJV (Fig. 1).
2. The Common Carotid Artery (CCA) diameter (Fig. 1).
3. Overlap length of Right IJV on CCA (Fig. 1 & Fig. 2).
4. The degree of overlap between the RIJV and CCA (calculated as percentage).

Optimal Visualization of Right IJV by ultrasound was defined as the maximum diameter of the IJV with least degree of overlap of IJV over CCA. The degree of head rotation which provides optimal visualization of right IJV was noted in each patient. In addition, the operators' perception for the optimal view of IJV and the degree of head rotation was also noted. The patients in whom there was inability to obtain the data in any of the four head rotations, were withdrawn from the study.

Sample size of the study was determined using SAS 9.2 package. Based on the study done by Izumi M *et al.* [9], to get the minimum difference of 20% in the mean overlap of IJV over CCA with the change in head rotation from 15° to 60°, calculated minimum sample size was 53 (Power of study 90% and alpha error of 0.05). Considering 10% dropout we decided to enroll 60 patients for this study.

Data was analysed using SPSS v26. Continuous variables are expressed as mean ± SD, and categorical variables as percentages. ANOVA and paired t-tests compared overlap

across different head rotations ($P<0.05$ is considered as significant).

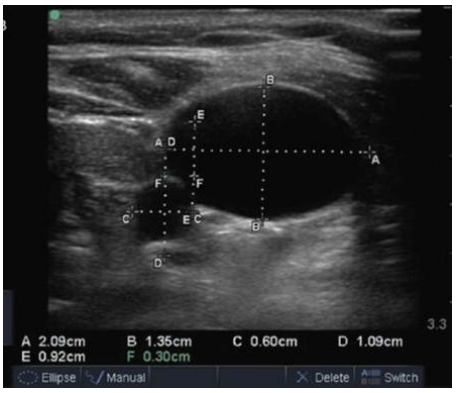


Fig. 1: The Transverse and Anteroposterior (AP) diameter of the IJV (Line segment A, B respectively), and CCA (Line segment C, D respectively)

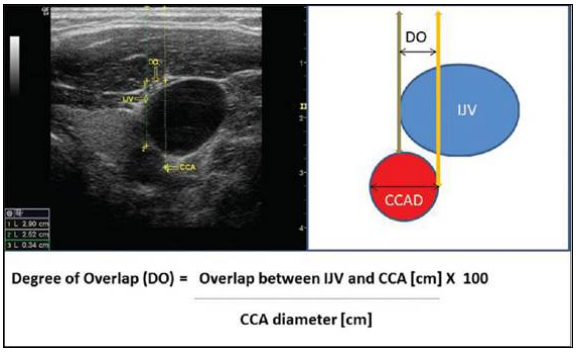


Fig. 2: Degree of Overlap

3 Results

On the basis of body mass index (BMI), all 60 patients with BMI $\geq$ 25 kg/m^2 were divided into 3 groups:

Group 1 - BMI 25 - 29.9 kg/m^2 (n=10)

Group 2 - BMI 30.0 - 39.9 kg/m^2 (n=44)

Group 3 - BMI > 40kg/m^2 (n=6)

None of our cases were withdrawn from the study. The mean age of the study population was 43.40 ± 11.68 years, 33.3 % were male and 66.6% were female subjects with the mean BMI of 34.10 ± 4.18 Kg/m^2 Table. 1.

Table 1: Demographic Parameters

Variables	Mean Value	Standard Deviation (SD)
Age (yrs)	43.40	11.68
Weight	83.33	7.22
Height	159.17	8.34
BMI $\geq$ 25 Kg/m^2	34.10	4.18
Group 1 = 25.0 - 29.9 Kg/m^2	10 (16.7%)	
Group 2 = 30.0 - 39.9 Kg/m^2	44 (73.3%)	
Group 3 = $\geq$ 40 Kg/m^2	06 (10%)	
Male : Female (n) (%)	20 (33.3%) : 40 (66.67%)	

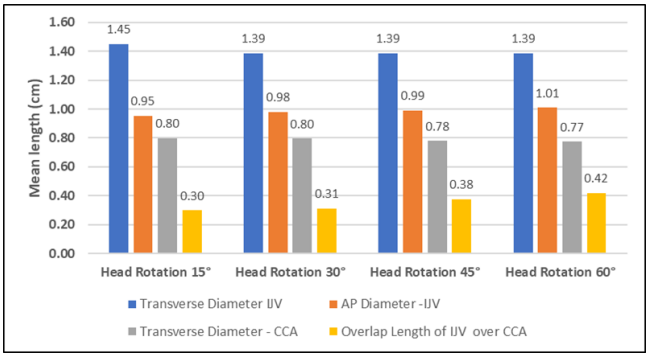
Transverse and Antero-posterior diameters of Internal Jugular Vein (IJV) and transverse diameter of Common Carotid Artery (CCA) and the overlap length of IJV over CCA at different degrees of head rotation are depicted in [**Graph 1**]. As the degree of head rotation was increased the overlap length of IJV over CCA also increased [**Graph 2**]. This overlap of IJV over CCA increased significantly from 34.9% at 15° head rotation to 47.79% at 45° (P=0.032) and to 55.3% at 60° head rotation (P<0.001) Table. 2.

Table 2: Head rotation and percent overlap of IJV over CCA

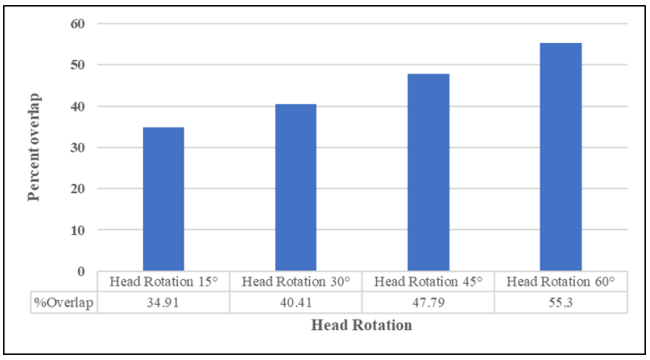
Parameter	15° Head Rotation	30° Head Rotation	45° Head Rotation	60° Head Rotation
overlap – IJV over CCA (percentage)	34.91 %	40.41 %	47.79 %	55.3 %
P value		0.34	**0.032***	**<0.001***

P < 0.05 is considered as statistically significant.

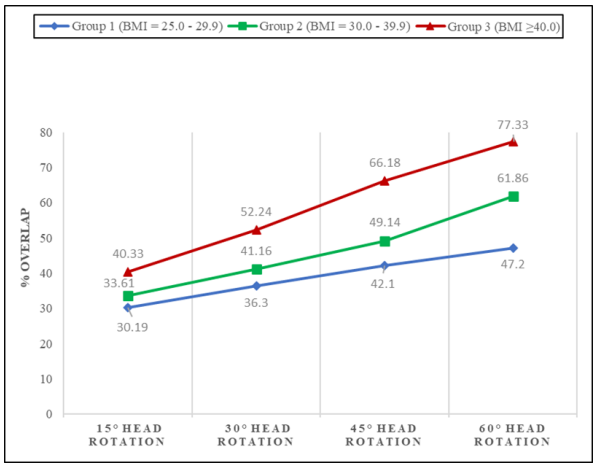
The effect of head rotation on the percentage overlap of IJV over CCA was more pronounced in patients with higher BMI i.e. Group 3 (BMI $\geq$40.0) > Group 2 (BMI = 30.0 - 39.9) > Group 1 (BMI = 25.0 - 29.9). This is depicted by a line diagram in [**Graph 3**].



Graph 1: Effect of Head rotation on measurements of IJV & CCA



Graph 2: Head Rotation and % Overlap of IJV over CCA



Graph 3: % Overlap with Head Rotation in Different BMI Groups

4 Discussion

Venous access is an important issue in the obese patients[1, 2]. A central venous catheter may be needed especially if there is difficulty finding a suitable peripheral venous access for the peri-operative period[2]. The right internal jugular vein (IJV) is the often preferred to place a central venous line. However, IJV catheterization may result in mechanical complications like accidental arterial puncture, haematoma, haemothorax, pneumothorax, arterial-venous fistula, venous air embolism, nerve injury, thoracic duct injury[4].

With landmark-guided IJV cannulation technique, the rate of mechanical complication is 10%–15% and unsuccessful insertion is up to 20%[1]. Although ultrasound guidance improves the insertion success rate upto 93.9%, first-attempt success rate is only 82% and carotid puncture rate is up to 5.9%[16]. Obscured landmarks, short neck and deeply placed IJV in obese patients, pose difficulty in IJV cannulation by landmark technique hence real time US guided IJV cannulation is preferred. Optimum conditions should be carried out before IJV cannulation particularly obese patients. Improving success rate and decreasing complications can be achieved by increasing the cross-sectional area (CSA) of IJV and minimizing the overlap of IJV on CCA respectively.

To increase the success rate, various landmark-based techniques exist and measures such as head rotation and the Trendelenburg position are commonly used[17]. The degree of head rotation to the contra- lateral side is rarely specified[18]. There is a wide variation in the anatomical relationship of the IJV to the Common Carotid Artery (CCA). The IJV usually lies anterior and lateral to the CCA[13, 19]. As the head is rotated away from midline, the IJV becomes more directly anterior to the CCA. Extreme head rotation, to 80° or 90°, frequently causes the CCA to sit directly underneath the IJV, increasing the theoretical risk of CCA puncture[14, 15, 19]. Changes in the relationship between these two structures with head rotation may lead to accidental arterial puncture or failure to locate the IJV[3]. Most of the researchers have studied the effects of various degrees of head rotation on relationship of IJV to CCA in normal patients. Few studies have assessed the changes in relationship of IJV to CCA with head rotation in obese patients. Various degrees of head rotation for optimal IJV positioning have been studied. Woo *et al.*[4] studied at six positions: 0°, 30°, and 60° of head rotation to the contra-lateral side combined with 0° and 10° of Trendelenburg tilt in 102 subjects. Lamperti *et al.*[14] studied with head in neutral position (0°) and 45° head rotation in 932 patients. Purohit *et al.*[19] studied in neutral head position on both sides and also with the head rotated to the contra lateral side by 15° and 45° in 100 patients. Miki *et al.*[9] studied in 30 patients with head rotation at 0°, 15°, 30°, 45°, 60°, and 75° from the midline to the left, 2 and 4 cm above the clavicle. Lieberman *et al.*[18] studied in 49 patients with the head rotated to 0°, 15°, 30°, 45°, and 60°.

In our study, we assessed with head rotated 15°, 30°, 45°, 60° like that of Lieberman *et al.*[18] and Miki *et al.*[9]. However, we did not include 0° (neutral head position) as it is technically difficult to perform IJV cannulation in neutral head position. Clearing the chin is needed for IJV cannulation, which is not possible without giving some degree of head rotation. Also, studies have shown that extreme head rotation, to 80° or 90°, frequently causes the CCA to sit directly underneath the IJV, increasing the theoretical risk of CCA puncture[14, 15]. Hence, head rotation for >60° was not included in our study.

In our study, we observed no significant difference (P>0.05) in the Transverse and AP Diameter of IJV, Transverse Diameter of CCA, during the head rotation at 15°,30°, 45°, 60°. Our findings correlated with Woo *et al.*[4] who observed that IJV diameter did not show any difference regardless of head rotation except for increase in IJV diameter by 10 to 20% with 10° Trendelenburg

tilt. Trendelenburg position was given primarily to all our patients as a standard position for securing IJV, so this difference was not seen.

Significant overlap length (of right IJV and CCA) was observed only during the head rotation from 15° to 60° (p=0.005; 95% CI of 0.06 - 0.18) in our study. Whereas, Miki *et al.*[9] observed this overlap (p<0.01) with head rotation ≥30°, 4 cms above clavicle in non-obese patients. This difference from our study could be attributed to their comparison between 0° to 30° as opposed to our comparison of 15° to 30°. They also observed flattening of IJV (IJV approximately to a perfect circle) ≥30°, 4 cm above the clavicle (P < 0.01) compared to neutral position. Woo *et al.*[4] observed significantly increased (p<0.05) overlap of the IJV and CCA in BMI ≥ 30 kg/m^2 compared to BMI< 25 kg/m^2. They had included subjects with BMI < 25 kg/m^2 whereas our study included subjects only with BMI >25 kg/m^2 which may the reason for this difference observed. Also, in their study, measurements were done with 0°, 30° and 60° head rotation whereas, in our study measurements were done with 15°,30°, 45° and 60° of head rotation (15° difference between the 2 positions). This difference of comparison may be reason for finding increased overlap at 30° between the two studies. Umana *et al.*[20] observed right IJV overlapped the CCA in 30.7% of patients in neutral head position compared to 37.3% with the head rotated to the opposite side. The degree of head rotation was not specified in their study for us to compare.

Percent Overlap on head rotation from 15° to 45° and 15° to 60° was statistically significant (P=0.032;95%CI of 5.32-20.43) and (P<0.001;95% CI of13.13-27.64) respectively. Sulek *et al.*[13] observed that percent overlap of the CCA and IJV increased significantly at 40° head rotation on both right and left side (P < 0.05). Lieberman *et al.*[18] simulated catheter insertion of right IJV observed that the simulated needle did not hit the CCA until the head was rotated at least 30°. The CCA hit rate was higher at 45° compared to 30°(P<0.01). Purohit *et al.*[19] observed increase in overlap of CCA and IJV on both sides with 45° head rotation (99% on right and 97% on left, P<0.05). Miki *et al.*[9] observed that percent overlap at 2 cm and 4 cm above clavicle was significantly higher at 60° and 75° head rotation (p<0.01). Troianos *et al.*[3] observed that 53% of the patients exhibited >75% overlap of the CCA at 90° of head rotation.

On subgroup analysis between different BMI groups, percent overlap increased even with lesser degree of head rotation in higher BMI groups. On head rotation from 15° to 45°, Percent overlap was significant in Group II patients (BMI 30.0-39.9 kg/m^2) (41.16%; P=0.003; 95% CI of 5.75 - 25.3) and Group III patients (BMI > 40kg/m^2) (52.24%; P= 0.05) whereas on head rotation from 15° to 60°, it was significant in patients with BMI 25-29.9 kg/m^2 (P=0.02; 95% CI of 5.29-48.73).

Percent overlap in Group II patients (BMI 30.0-39.9 kg/m^2) was significant on head rotation from 15° to 45° (P=0.003; 95% CI of 5.75 - 25.3). On head rotation from 15° to 60°, it was significant even in patients with BMI 25-29.9 kg/m^2 (P=0.02; 95%CI of 5.29-48.73) BMI 30.0-39.9 kg/m^2 (P=0.003; 95% CI of 9.63 - 26.87). However, subjects with BMI > 40kg/m^2 there was no statistically significant difference (P=0.051) observed with this degree of head rotation. Our findings correlated with Woo *et al.*[4] who observed that the overlap of the IJV and CCA was significantly increased in patients with BMI ≥ 30 kg/m^2 and with higher degrees of head rotation (0°, 30°, 60°) (p<0.05). Lamperti *et al.*[14] reported the risk of overall complications increased in patients with BMI ≥30 Kg/m^2 (OR 3.42, P <0.0001, 95% CI 2.39 – 4.89).

Vessel overlap does not mean it will puncture CCA but there is an increased probability of CCA puncture. With the needle advancement to the IJV, the anterior wall of the IJV is compressed rather than penetrated immediately when the needle reaches the IJV. The IJV may partially or completely compress during needle advancement which could cause puncture of the anterior and posterior walls of IJV almost simultaneously[21]. So, with a smaller diameter of IJV and increasing percentage of overlap, the possibility of puncture of CCA, which positioned directly beneath the IJV, theoretically increases[4].

Based on our findings, we propose the following protocol for US-guided IJV cannulation in obese patients and we recommend that in obese patients, head rotation should be <45° and < 60° with BMI ≥ 30 kg/m^2 and 25-29 kg/m^2 respectively to minimize IJV – CCA overlap and to avoid accidental CCA puncture. Ultrasound is very helpful when the alignment of the IJV and CA is such that there is minimum overlap between the vessels and this can be achieved by optimum head rotation to optimize access and minimizes the risk of accidental CCA puncture.

There are several limitations in our study. First, we did ultrasound examination only at the cricoid level which is routinely used in our practice. Further studies are needed to evaluate the relationship between the IJV and CCA at various levels. Secondly, actual cannulation was not performed in our study which could guide if any altered needle approach angle under real-time ultrasound guidance is needed. Thirdly, the number of patients in our study was small (n=60); particularly patients with higher BMI i.e. > 40 kg/m^2. Therefore, further studies are with larger sample size are necessary to confirm our findings, especially patients with higher BMI > 40 kg/m^2.

5 Conclusion

The effect of head rotation on relation between IJV and CCA placement is variable among patients. Therefore, it is unlikely

to have one standard degree head rotation in all type of patients that would benefit ultrasound guided IJV canulation. Head rotation >45° in obese patients significantly increases CCA puncture risk. For Ultrasound-guided IJV cannulation in obese patients with BMI ≥30 kg/m², head rotation of ≤45° should be optimum to facilitate the ease of canulation and avoid complications.

References

1. Baidya DK, Chandralekha, Darlong V, Pandey R, Goswami D, Maitra S. Comparative Sonoanatomy of Classic "Short Axis" Probe Position with a Novel "Medial-oblique" Probe Position for Ultrasound-guided Internal Jugular Vein Cannulation: A Crossover Study. *The Journal of Emergency Medicine*. 2015;48(5):590-596. Available from: 10.1016/j.jemermed.2014.07.062
2. Ge X, Cavallazzi R, Li C, Pan SM, Wang YW, Wang FL. Central venous access sites for the prevention of venous thrombosis, stenosis and infection. *Cochrane Database of Systematic Reviews*. 2012;2012(3). Available from: 10.1002/14651858.cd004084.pub3
3. Troianos CA, Hartman GS, Glas KE, Skubas NJ, Eberhardt RT, Walker JD, *et al*. Guidelines for Performing Ultrasound Guided Vascular Cannulation. *Anesthesia & Analgesia*. 2012;114(1):46-72. Available from: 10.1213/ane.0b013e3182407cd8
4. Woo JH, Kim Yj, Kim DY, Baik HJ, Kim JH, Han JI. Is Head Rotation Preferred During Right Internal Jugular Vein Cannulation in Obese Asians?. *Journal of Anesthesia & Clinical Research*. 2012;03(10). Available from: 10.4172/2155-6148.1000245
5. Pathak R, Karmacharya P, Aryal MR, Alweis R. Iatrogenesis Imperfecta: Stroke caused by Accidental Carotid Artery Catheterization. *The Journal of Vascular Access*. 2014;15(6):537-540. Available from: 10.5301/jva.5000246
6. Guilbert MC, Elkouri S, Bracco D, Corriveau MM, Beaudoin N, Dubois MJ, *et al*. Arterial trauma during central venous catheter insertion: Case series, review and proposed algorithm. *Journal of Vascular Surgery*. 2008;48(4):918-925. Available from: 10.1016/j.jvs.2008.04.046
7. Rajinikanth J, Stephen E, Agarwal S. Complication of central venous cannulation. *Canadian Journal of Surgery*.2008 Oct;51(5):E113–E114
8. Machanalli G, Bhalla AP, Baidya DK, Goswami D, Talawar P, Anand RK. Sono-anatomical analysis of right internal jugular vein and carotid artery at different levels of positive end-expiratory pressure in anaesthetised paralysed patients. *Indian Journal of Anaesthesia*. 2018;62(4):303-309. Available from: 10.4103/ija.ija_716_17
9. Izumi M, Satoru M, Shinichiro K. Anatomical relationship between the common carotid artery and the internal jugular vein during head rotation. *Ultrasound*. 2014;22(2):99-103. Available from: 10.1177/1742271x14524571
10. Marcus HE, Bonkat E, Dagtekin O, Schier R, Petzke F, Wippermann J, *et al*. The Impact of Trendelenburg Position and Positive End-Expiratory Pressure on the Internal Jugular Cross-Sectional Area. *Anesthesia & Analgesia*. 2010;111(2):432-436. Available from: 10.1213/ane.0b013e3181e2fe41
11. Verghese ST, Nath A, Zenger D, Patel RI, Kaplan RF, Patel KM, *et al*. The Effects of the Simulated Valsalva Maneuver, Liver Compression, and/or Trendelenburg Position on the Cross-Sectional Area of the Internal Jugular Vein in Infants and Young Children. *Anesthesia & Analgesia*. 2002;94(2):250-254. Available from: 10.1213/00000539-200202000-00004
12. Zhou Q, Xiao W, An E, Zhou H, Yan M. Effects of four different positive airway pressures on right internal jugular vein catheterisation. *European Journal of Anaesthesiology*. 2012;29(5):223-228. Available from: 10.1097/eja.0b013e32834f23a3
13. Sulek CA, Nikolaus G, Blackshear RH, Weiss L. Head Rotation During Internal Jugular Vein Cannulation and the Risk of Carotid Artery Puncture. *Anesthesia & Analgesia*. 1996;82(1):125-128. Available from: 10.1097/00000539-199601000-00022
14. Massimo L, Matteo S, Cortellazi P, Vailati D, Borrelli P, Montomoli C, *et al*. Is a Neutral Head Position Safer than 45-Degree Neck Rotation During Ultrasound-Guided Internal Jugular Vein Cannulation? Results of a Randomized Controlled Clinical Trial. *Anesthesia & Analgesia*. 2012;114(4):777-784. Available from: 10.1213/ane.0b013e3182459917
15. Ozkan O, Seza A, Alaaddin N. The Effectiveness Of Trendelenburg Positioning On The Cross-Sectional Area Of The Right Internal Jugular Vein In Obese Patients. *Pakistan Journal of Medical Sciences*. 1969;31(4). Available from: 10.12669/pjms.314.7326
16. Sibai AN, Loutfi E, Itani M, Baraka A. Ultrasound evaluation of the anatomical characteristics of the internal jugular vein and carotid artery – facilitation of internal jugular vein cannulation. *Middle East Journal of Anesthesiology*. 2008;19:1305-20.
17. Kunhahamed MO, Abraham SV, Palatty BU, Krishnan SV, Rajeev PC, Gopinathan V. A comparison of internal jugular vein cannulation by ultrasound-guided and anatomical landmark technique in resource-limited emergency department setting. *Journal of Medical Ultrasound*. 2019;27(4):187-191. Available from: 10.4103/jmu.jmu_2_19
18. Lieberman JA, Williams KA, Rosenberg AL. Optimal Head Rotation for Internal Jugular Vein Cannulation When Relying on External Landmarks. *Anesthesia & Analgesia*. 2004;99(4):982-988. Available from: 10.1213/01.ane.0000132908.77111.ca
19. Purohit G, Setlur R, Dhar M, Bhasin S. Assessment of head and neck position for optimal ultrasonographic visualisation of the internal jugular vein and its relation to the common carotid artery: a prospective observational study. *Journal of Anaesthesiology Clinical Pharmacology*. 2020;36(1):62-65. Available from: 10.4103/joacp.joacp_330_18
20. Umaña M, García A, Bustamante L, Castillo JL, Sebastián Martínez J. Variations in the anatomical relationship between the common carotid artery and the internal jugular vein: an ultrasonographic study. *Colombia Médica*. 2015;46(2):54–9.
21. Blaivas M, Adhikari S. An unseen danger: Frequency of posterior vessel wall penetration by needles during attempts to place internal jugular vein central catheters using ultrasound guidance*. *Critical Care Medicine*. 2009;37(8):2345-2349. Available from: 10.1097/ccm.0b013e3181a067d4

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