

Is Head Rotation Preferred During Right Internal Jugular Vein Cannulation in Obese Asians?

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Abstract

Background: Obese subjects are considered to be a difficult group for central vein cannulation. We investigated the optimal position for right internal jugular vein (IJV) cannulation in relation to BMI in Asians.

Methods: 102 subjects were divided into three groups; 34 with a BMI of less than 25 kg/m² (Group I), 34 with a BMI from 25 to 30 kg/m² (Group II), and 34 with a BMI of 30 kg/m² or above (Group III). Using a 5-12 MHz linear probe of an ultrasound system, the IJV depth, the diameter of the IJV and common carotid artery (CCA) and overlap length between them were measured at six positions: 0°, 30°, and 60° of head rotation to the contralateral side combined with 0° and 10° of Trendelenburg tilt.

Results: The IJV depth was deepest in Group III and significantly shorter at 10° Trendelenburg tilt compared to 0° Trendelenburg tilt. The IJV diameter increased by 10 to 20% with 10° Trendelenburg tilt and there were not significant change by head rotation or BMI. The overlap of the IJV and CCA was significantly increased in Group III compared to Group I and in Group III, there were significant increases of the overlap according to the degree of head rotation, regardless of Trendelenburg tilt.

Conclusion: We recommend head rotation less than 30° with 10° Trendelenburg tilt for right IJV cannulation, especially in obese Asians. In obese subjects, real-time ultrasound should be considered. Further study with actual cannulation is needed for availability of clinical outcome.

Keywords: Cannulation; Body mass index; Common carotid artery; Superior vena cava; Internal jugular vein

Introduction

The right internal jugular vein (IJV) is more direct to the superior vena cava (SVC) and right IJV cannulation is associated with a less incidence of complications [1]. This makes this area among the first attempted by anesthesiologists. The unexpected puncture of the common carotid artery (CCA) during right IJV cannulation is reported at a frequency as 10.6% with external landmark method and 1% with real-time ultrasound [2]. (Figure 1) To mitigate these problems, several methods have been utilized, such as head rotation, Trendelenburg tilt, hepatic compression, the valsalva maneuver, and positive intrathoracic pressure during artificial respiration, which increases the jugular filling [3]. Significant predictive patient's factors of complications such as CCA puncture are obesity, cachexia, previous CVC and local scarring from radiation therapy [4]. Among these, obesity is one of the most common patient management areas encountered during the perioperative period. Obese subjects are especially considered to be a difficult group due to the difficulty in accessing and identifying the anatomical landmarks. However, few studies have suggested an ideal position for CVC for obese subjects on the basis of the body mass index (BMI) in Asians.

This study aims to investigate the optimal position for CVC that is safe and successful while lowering the risk of CCA puncture in relation to the subject's BMI. We use ultrasound to analyze the relationship between the IJV and CCA according to head rotation and Trendelenburg tilt, which is commonly performed to ascertain the location of the central vein in subjects undergoing a procedure.

Subjects and Method

After receiving IRB approval and written informed consent, ASA physical status I or II subjects between the ages of 18 and 80 scheduled for elective surgical procedures under general anesthesia were

recruited. In Asians, the lower cut-off values for obesity are applied than westerners. According to the International Obesity Taskforce, in adults, a BMI greater than 25 is obese I, and greater than 30 is obese II [5]. We studied 34 with a BMI of less than 25 kg/m² (Group I), 34 with a BMI from 25 to 30 kg/m² (Group II), and 34 with a BMI of 30 kg/m² or above (Group III). Those with a previous history of CVC in the right IJV, inflammatory disease or tumor in the neck area or those who had surgery or scar in the neck area were excluded.

NIBP, electrocardiogram and a pulse oximeter were attached to all subjects and vital signs were monitored. After anesthesia was induced, each subject was placed in a supine position with a donut pillow under the head to prevent it from moving. The circumference of the neck was measured at the level of the cricoid cartilage. The neck was extended to its maximum length, and the length of the neck was measured in the linear direction from the sternal notch to the mentum of the mandible.

Using a 5-12 MHz linear probe of an ultrasound system [SonoSite M-turbo (SonoSite®, Bothell, WA, USA)], the IJV depth and the diameter of the IJV and CCA were measured at six positions: 0°, 30°, and 60° of head rotation to the contralateral side combined with 0° and 10° of the Trendelenburg position (Figure 2). The overlap length, which was defined

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as the longest distance between the tangent of the most outer point of the CCA and the most inner point of the IJV, was measured. When the tangent did not cross the IJV, the overlap was considered to be zero. The percentage of overlap between IJV and CCA were calculated as follows: overlap of the right IJV and the CCA (mm)/ the CCA diameter (mm)×100. All images were obtained via ultrasound by one skilled anesthesiologist, and all values were measured after the subject was stabilized for at least one minute in each measurement position (Figure 3). In addition, the maximum IJV diameter during five respiratory cycles was chosen to minimize the influence of breathing.

All variables were expressed in terms of the mean ± standard deviation or the percentile, and SPSS (version 18.0 SPSS Inc. Chicago, USA) was used to process the statistics. A one-way ANOVA was performed for a comparison between groups. A repeated-measures ANOVA test and a paired T-test were also used to analyze within the groups. It was considered statistically significant when the p value was less than 0.05.

Results

The demographic data obtained is shown in table 1. Average BMI in three groups was 22.2 ± 2.0, 27.6 ± 1.5 and 33.5 ± 4.5 kg/m², respectively. Neck circumference was shown to be increase along with BMI. The neck length of Group III was significantly shorter than others.

The IJV was deepest in Group III compared to Groups I and II regardless of the head rotation or Trendelenburg tilt. In a comparison within groups, the IJV depth became significantly shorter at 10° Trendelenburg tilt as compared to 0° Trendelenburg tilt. In all groups except 10° Trendelenburg tilt in group I, the IJV depth decreased significantly when the head rotated to 30°, but there was no more decrease when the head rotated to 60°.

Among three groups, the IJV diameter did not show any difference regardless of head rotation or Trendelenburg tilt. The IJV diameter increased by 10 to 20% when 10° Trendelenburg tilt was done. In a comparison within groups, there were no significant differences of the IJV diameter according to the degree of head rotation. The CCA

diameter showed no difference between and within groups regardless of head rotation or Trendelenburg tilt.

The overlap of the IJV and CCA was significantly increased in Group III compared to Group I (p<0.05). In a comparison within groups, it tended to increase according to the degree of head rotation and particularly in Group III, there were statistically significant increase of the overlap according to the degree of head rotation regardless of Trendelenburg tilt (p<0.05).

In Group I, there was only one subject for whom the IJV was completely above the CCA at 10° Trendelenburg tilt and head rotation of 60° and the overlap percentage between the IJV and CCA was 26%. In Groups II and III, 18 and 24 subjects showed the CCA to sit directly underneath the IJV, respectively. In Group II, the largest mean value of the overlap percentage between the IJV and CCA was 51% at 10° Trendelenburg tilt and head rotation of 60°. In Group III, it was 56% at 0° Trendelenburg tilt and head rotation of 60°.

Discussion

This prospective study provides practical considerations about the optimal position for IJV cannulation in terms of BMI in Asians. We evaluated subjects at 10° Trendelenburg tilt and no greater angles of tilt. It was demonstrated that even 10° Trendelenburg tilt increases the diameter of the IJV effectively and additional effect of further tilt is not significant and may be detrimental because of risk of patient discomfort and raised intracranial pressure in some populations [6]. The IJV diameters increased significantly by 10° Trendelenburg tilt, but head rotation yielded no significant changes in all groups. On the study about the efficacy of ultrasound-guided CVC, Claudia et al. [7] showed that the success of catheter positioning on the first attempt was related to IJV diameter, but not to other anatomical characteristics including BMI, neck circumference, neck height and vein depth.

Our results showed that more noticeable overlap occurred in obese patients compared to non-obese patients according to the head rotation and even in neutral head position. We recommend head rotation less than 30° for CVC, especially in obese Asians. In all groups, Trendelenburg tilt does not result in consistent effects on the overlap between IJV and CCA. Vessel overlap does not mean CCA puncture but the increased possibility of CCA puncture. As the needle advances 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 [8]. Therefore, as the diameter of the vein is smaller and the percentage of overlap increase, the possibility of puncture of CCA, which positioned directly beneath the IJV, theoretically increases. The

	Group I	Group II	Group III
Age (yr)	42.2 ± 2.7	47.2 ± 2.4	40.1 ± 3.0
Sex (M/F)	15/19	16/18	13/21
Height (cm)	165.5 ± 1.62	163.7 ± 1.5	165.4 ± 1.9
Weight (kg)	60.7 ± 1.6	73.4 ± 1.7*	92.4 ± 3.0*†
BMI (kg/m ²)	22.2 ± 2.0	27.6 ± 1.5*	33.5 ± 4.5*†
Neck circ (cm)	37.0 ± 0.7	40.6 ± 0.6*	45.0 ± 0.7*†
Neck length (cm)	12.4 ± 0.3	11.7 ± 0.3	10.8 ± 0.2*†

Table 1: Demographic data

Values are mean ± SD or numbers. Group I, BMI< 25 kg/m²; Group II, 25 kg/m² ≤BMI< 30 kg/m²; Group III, BMI ≥ 30 kg/m²; BMI, body mass index. *: P < 0.05 compared with Group I, †: P < 0.05 compared with Group II.

Degree of HR	0° of Trendelenburg Tilting Position			10° of Trendelenburg Tilting Position		
	0°	30°	60°	0°	30°	60°
Group I	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (2.9%)
Group II	1 (2.9%)	1 (2.9%)	2 (5.9%)	3 (8.8%)	5 (14.7%)	6 (17.6%)
Group III	0 (0%)	7 (20.6%)	7 (20.6%)	3 (8.8%)	2 (5.9%)	6 (17.6%)

Table 2: Number (percentages) of common carotid artery to sit directly underneath the internal jugular vein

Values are numbers (percentages). Group I, BMI< 25 kg/m²; Group II, 25 kg/m² ≤BMI< 30 kg/m²; Group III, BMI ≥ 30 kg/m²; BMI, body mass index; HR, head rotation.

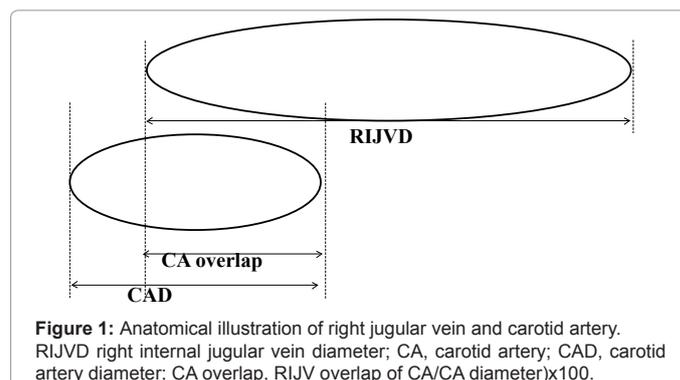


Figure 1: Anatomical illustration of right internal jugular vein and carotid artery. RIJVD right internal jugular vein diameter; CA, carotid artery; CAD, carotid artery diameter; CA overlap, RIJVD overlap of CA/CA diameter×100.

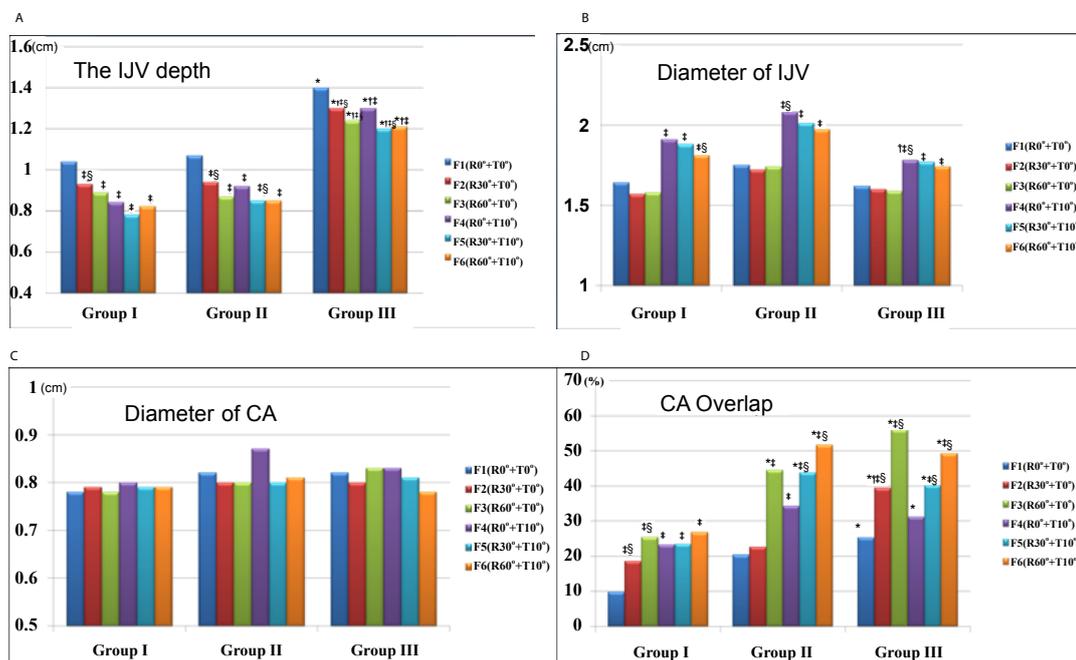


Figure 2: The IJV depth, the diameter of IJV and CA, CA overlap according to Group. Values are mean. *: P < 0.05 compared with Group I, †: P < 0.05 compared with Group II. ‡: P < 0.05 compared with 0° Trendelenburg tilt and 0° of head rotation (among groups) §: P < 0.05 compared with previous values (among groups).

percentage of overlap is the most apparent in the Group III in the supine position with 60° of head rotation (range, 12% to 100%; mean, 56%).

Ultrasound-guided CVC improves first-pass cannulation and success rate and decreases access time and complications by facilitating identification of the IJV and surrounding structure [9,10]. Successful cannulation diminishes by 25% per subsequent attempt if the first attempt by external landmark method are unsuccessful [9]. Many specialties including the American society of echocardiography and the society of cardiovascular anesthesiologists recommend that properly trained clinicians should cannulate IJV using real-time ultrasound as far as possible, which is based on category A, level 1 evidence [11,12]. In particular, ultrasound guidance has a clear advantage when it comes to obese subjects. As shown in our results, obese subjects have short thick necks that may obscure external landmarks and significantly deep IJV. In a study of 55 subjects undergoing bariatric surgery (average BMI; 49 ± 7.4), anatomic variability of IJV was more frequently in morbidly obese subjects than in general population [6]. They concluded the use of ultrasound guidance increased the success rate and decreased the incidence of complications in obese subjects. Lieberman et al. [13] simulated IJV catheter insertion using an ultrasound probe relying only on external landmarks with 15° trendelenburg tilt. The CCA hit was more increased at 45° and 60° compared to 30°. Patients with a BMI of 25 kg/m² or above were independently associated with an increased risk of a simulated needle hitting the CCA when the head was rotated to 45° or 60°. Simulating the needle path using ultrasound cursor supposes that the needle is advanced perpendicular to the ultrasound probe. However, if the CCA and IJV are overlapped, the needle can be advanced away from the CCA with medial or lateral deviation under real-time ultrasound guidance to avoid unintentional CCA puncture.

We did not set a constant angle of the probe positioning. On the study about the effect of scanning at a 45° angle at the level of

the cricoid, Tim et al. [14] reported that right IJV was depicted anteriorly or medio-anteriorly in 48.7% to the CCA and only in the lateral position to a small extent. They pointed out that ultrasound scanning strictly from anterior to posterior was impossible because of the round structure of the human neck and lateral scanning provided the best coupling of the transducer to the skin. Although an angle of the probe positioning could influence variability in the position of the vessel, our purpose was to analyze how the IJV in relation to the CCA change according to combination positions rather than respective informations in each position. Therefore, the transducer was coupled to the skin fit for individual contour of neck and remained constant during the measurements.

There are several limitations in our study. First, we did ultrasound examination only at the cricoid level routinely used in our practice. Further study is needed to evaluate the relationship between the IJV and CCA at various levels. Second, we did not perform actual cannulation because it was unreasonable to cannulate the IJV repeatedly on the same patient at various positions and unethical to attempt cannulation although ultrasound vision presented higher risk of CCA puncture. Further study about actual cannulation based on position proven to be safer in our study is needed with altered needle approach angle under real-time ultrasound guidance. Third, we set the degree of the head rotation; 0°, 30°, and 60°. The overlap of the IJV and CCA may be lower at between 0° and 30°. In practice, there is a difficulty to turn away and maintain the head of the obese patient to a small extent. Neutral head position may interfere the insertion of the needle and obscure the external landmark. Further study about this is needed on the basis of our results. Lastly, all ultrasound examination were done by one anesthesiologist for consistency of measurement, however, investigator was not blinded the head positions and the group that patients belong to (Table 2).

In conclusion, we recommend head rotation less than 30° with

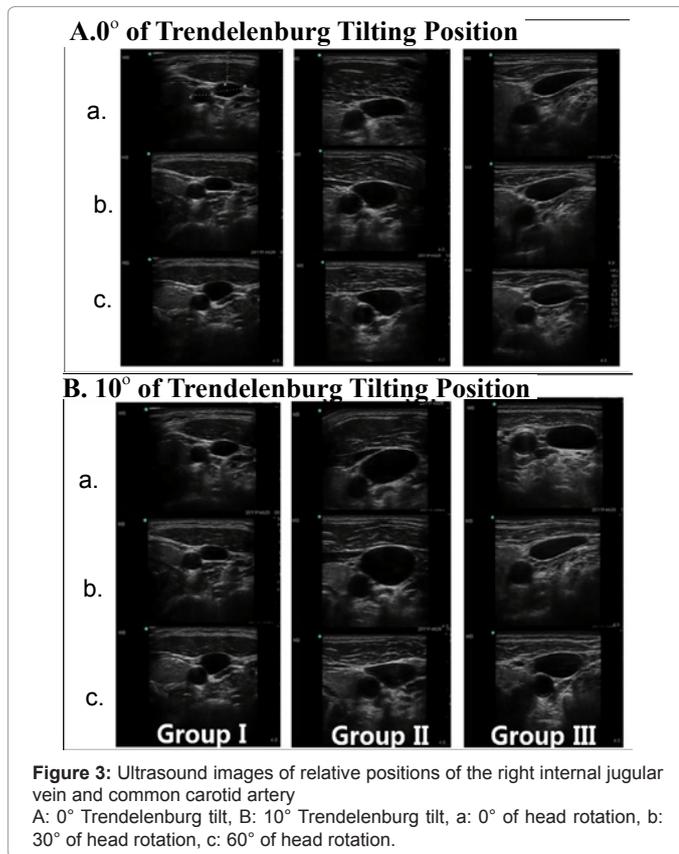


Figure 3: Ultrasound images of relative positions of the right internal jugular vein and common carotid artery
A: 0° Trendelenburg tilt, B: 10° Trendelenburg tilt, a: 0° of head rotation, b: 30° of head rotation, c: 60° of head rotation.

10° trendelenburg tilt for right IJV cannulation. Especially for obese subjects, it is recommended that real-time ultrasound should be considered to identify the relation of vessels and adjust a needle approach angle with head rotation less than 30°.

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