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*Original Article*

# The effect of the trendelenburg position on the internal jugular vein's cross-sectional area in overweight and obese children

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**Abstract:** Background: The Trendelenburg position is a common technique used during internal jugular vein (IJV) cannulation in pediatric patients. There has been some speculation as to the correlation between Trendelenburg positioning and increases in the cross-sectional area (CSA) of the IJV in obese child patients. In the present study, we use ultrasound (US) measurements to assess and determine the predictivity of Trendelenburg positioning on the CSA of the right IJV in obese child patients. Methods: The researchers of this studyenrolled 30 cases from the American Society of Anesthesiologists (ASA) II of patients under the age of 18 who underwent ultrasonographic examination between December 2013 and March 2015. US images of the right IJV of each patient were obtained in a transverse orientation at the cricoid level. The CSAs of the right IJVs were measured undert wo different conditions applied in a random orderin a sealed envelope: State 0, in which the table was flat (no tilt) and the patient lay in the supine position; and State T, in which the operating table wastilted 20 degrees to the Trendelenburg position. Results: The change in the CSA of the IJV from the supine to the Trendelenburg position (0.99 $cm^2$ vs 0.96 $cm^2$) was not significant. In contrast, the CSA of the right IJV decreased in 14 of the 30 patients (9 of the 14 were female). Conclusions: The Trendelenburg position does not cause the mean CSA of the right IJV in obese child patients to increase; in fact, the position causes the CSA in some patients to decrease. The researchers of this study do not support the use of the Trendelenburg position for IJV cannulation in obese child patients.

**Keywords:** Cross-sectional area, internal jugular vein's, trendelenburg position, obese children

## Introduction

The percentage of adolescents aged 12-19 years who were obese increased from 5% in 1980 to nearly 21% in 2012 in the United States [1]. Obesity in children is defined by the National Health and Nutrition Examination Survey as a BMI greater than 95th percentile for a respective age. Obesity is associated with various health problems during childhood such as cardiovascular disease, high cholesterol or high blood pressure [2] and with the increasing use of anesthesia and the necessity of central vascular access in children [3]. Hemodynamic monitoring, fluid management, and vasoactive drug therapy typically necessitate central venous cannulation in pediatric cases [4]. Central vascular access is usually enabled through the IJV [4, 5].

On average, it is more difficult to perform IJV cannulation in children than in adults [6]. This difficulty, the high BMI of obese patients presents a risk of complication [7]. Further, achieving central venous access in pediatric patients often requires several attempts to puncture the vein [8]. This may result in an accidental carotid artery (CA) puncture, which can lead to serious complications such as AV fistula and death [9, 10]. Previous studies of obese adults show that the success rate for central venous cannula placement correlates with the CSA of the vein [11-14]. Clinicians should locate the optimum IJV position, including its lower overlap with the

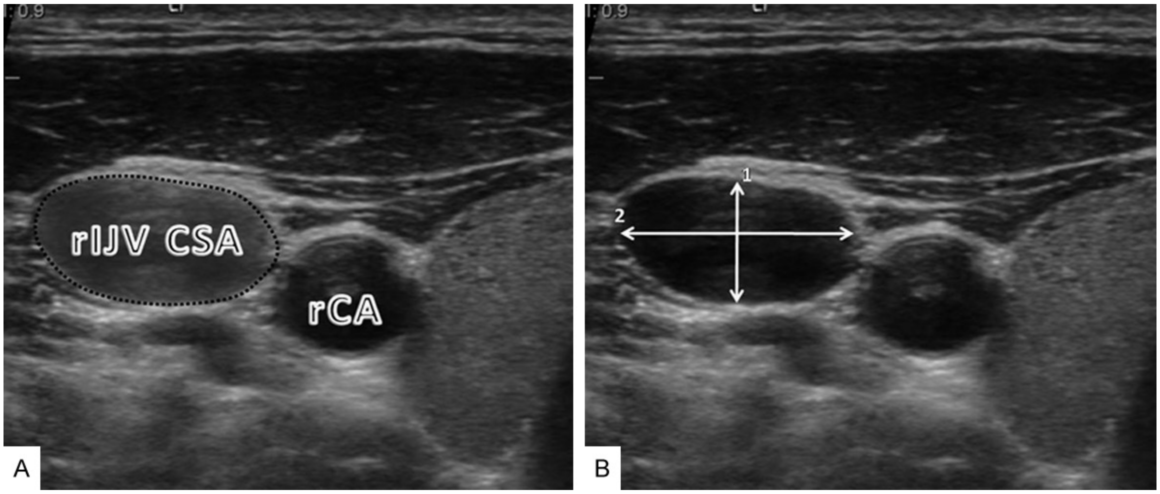


**Figure 1.** (A, B) Ultrasound images of the right IJV and relationship with right CA. (A) CSA of the right IJV (B) 1. A-Pdiameter 2. Transvers diameter of the right IJV. rIJV, right internal jugular vein; rCA, right carotid artery; A-P, anteroposterior; CSA, cross sectional area.

CA and high CSA of the vein, before performing IJV cannulation.

The Trendelenburg position consists of the elevation of the pelvis above the horizontal plane in the supine position [24]. Trendelenburg positioning is a common technique to aid in the puncturing of the IJV [8, 15] and has been recommended on the grounds that it increases vein size, thus reducing the risk of air embolism and improving success rates by Graham et al. [25]. However, a recently published article author Nassar et al. [11] suggests that the Trendelenburg position does not increase the CSA of the IJV predictably in adults. The systematic search of the National Library of Medicine (PubMed) conducted in the present study found that very few studies evaluated the impact of the Trendelenburg position on the CSA of the IJV in non-obese children [15-17]. In addition, the IJV's response to the Trendelenburg maneuver in overweight and obese children has yet to be reported. Thus, the primary aim of the present study is to determine the effectiveness of Trendelenburg positioning in increasing the CSA of the IJV in overweight and obese children. This effectiveness will be assessed and determined using USs.

## Methods

The prospective, controlled study protocol was approved by the Institutional Review Board of the Medical Faculty Hospital of Selcuk University, and written, informed consent was obtained from all participants and parents. We enrolled 30 cases from the American Society of Anesthesiologists (ASA) II of patients under the age of 18 who underwent ultrasonographic examination between December 2013 and March 2015. Patients without any previous trauma or surgery involving the neck, previous right IJV cannulation, or reported limited neck mobility, and patients with coexisting cardiovascular diseases or pulmonary disease were not included the study. Patients who exhibited a stenotic or thrombosed right IJV and hypotension (systolic blood pressure lower than 90 mmHg) during the US measurement were also excluded from the study.

Right IJV diameters in overweight and obese children both at rest and in the Trendelenburg position were assessed and recorded using ultrasonography with a 13.5 MHz linear array transducer (Acuson, Antares, Siemens). The same measurements were repeated upon bringing the patient into a 20 degree Trendelenburg position. The following measurements were collected at each position: (1) the CSA of the right IJV; (2) the degree of overlap between the IJV and the CA; (3) the transverse and anteroposterior diameters of the right IJV; (4) the margin of safety; and (5) the depth of the IJV from the skin. Demographic data of the studied patients were also collected.

The overlap between the IJV and the CA was categorized on the basis of percentage of over-

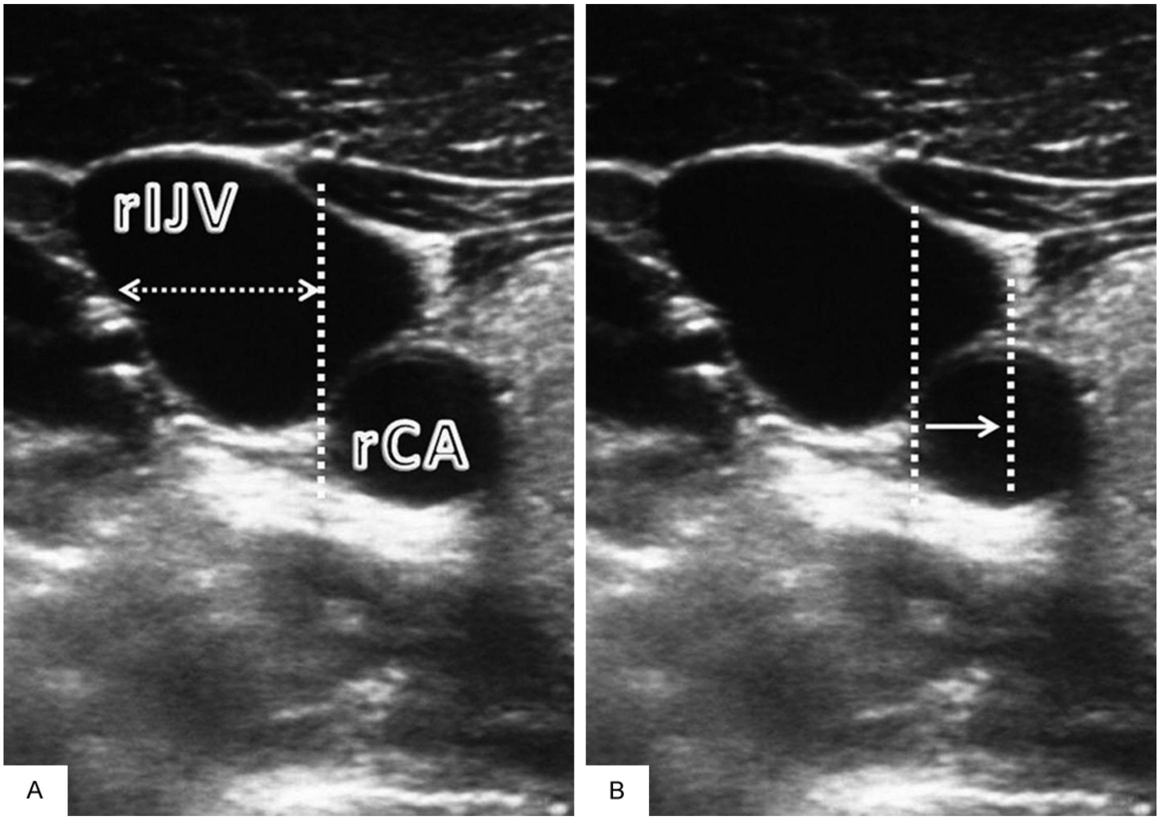


**Figure 2.** (A, B) Ultrasound images of the rIJV and relationship with rCA. (A) Safety margin of the rIJV (arrow) (B) Overlap between rIJV and rCA. White arrow represents the >25% overlap between rCA and rIJV. rIJV, right internal jugular vein; rCA, right carotid artery.

**Table 1.** The characteristics of the patients (n:30)

| Sex (n, %) Male/Female | 17 (56)/13 (44) |
|---|---|
| Mean age (year) (range) | 12.56 (4-17) |
| Weight (mean ± SD) | 75.98 ± 28.41 |
| Height (mean ± SD) | 148.78 ± 32.85 |
| BMI (kg/m$^2$) (mean ± SD) | 31.07 ± 6.82 |

*BMI = Body Mass Index y = year.

lap: (1) 0% (no overlap); (2) the IJV overlapped <25% of the diameter of the CA; (3) the IJV overlapped 25-50% of the diameter of the CA; or (4) the IJV overlapped >50% of the diameter of the CA (8).

The transverse and anteroposterior diameters of the right IJV were measured by drawing a line between the farthest two points of the vein wall in the transverse and anteroposterior planes, respectively. The margin of safety was defined as the distance from the lateral-most border of the IJV to the lateral-most border of the CA at which the IJV could be punctured without touching the CA. The depth of the IJV from the skin was measured by drawing a line between the skin and the closest margin of the vein to the skin's surface (**Figures 1**, **2**).

The study was concluded after all measurements were completed. Demographic data of the patients as well as data on the IJV measurements were recorded during ultrasonography and analyzed statistically using the SPSS version 17.0 (SPSS Inc., Chicago, IL) package program. The data were tested for normality using the Kolmogorov-Smirnov test. A paired sample t-test was used to compare the diameters and the CSA changes between State 0 and State T in all patients. Categorical data were analyzed using the McNemar test. A $P$ value of <0.05 was deemed a statistically significant threshold level.

## Results

Complete data and images suitable for analysis were collected from all patients. Patients' characteristics are shown in **Table 1**. The summa-

**Table 2.** Outcome measurements in the State 0 and State T

| | State 0 (n=30) | State T (n=30) |
|---|---|---|
| CSA (cm$^2$) | 0.99 ± 0.3 | 0.96 ± 0.3 |
| Transvers Diameter (mm) | 13.36 ± 2.8 | 13.12 ± 2.8 |
| A-P Diameter (mm) | 9.69 ± 1.9 | 9.71 ± 2.3 |
| Safety margin (mm) | 10.5 ± 2.4 | 10.5 ± 2.4 |
| Overlap of right IJV n (%) | | |
| <25% or no overlap | 16 (53.3%) | 20 (66.7%) |
| >25% overlap | 14 (46.7%) | 10 (33.3%) |

*JV, internal jugular vein; A-P, anteroposterior; CSA, cross sectional area of the right IJV.

ries of the ultrasonography data are shown in **Table 2**. The sonographic appearance of the right IJV and its relationship with the CA are presented in **Figures 1** and **2**.

The CSA of the right IJV, the degree of overlap between the right IJV and the CA, the transverse and anteroposterior diameters of the right IJV, and the margin of safety from the supine to the Trendelenburg position were not significantly different. The CSA of the right IJV paradoxically decreased in 14 (9 female and 5 male) of the 30 patients.

## Discussion

For many years, clinicians have looked for ways to increase the success rate and reduce the complications associated with central vein catheter placement to improve patient safety [18]. Venous size has a direct impact on the first pass catheterization success rate of the IJV [4]. Several methods of increasing vein size, such as the Trendelenburg position, the Valsalva maneuver, and liver compression have previously been investigated in pediatric patients [15, 16]. The current literature includes studies on US IJV dimensions in normal subjects covering the entire childhood period from birth to 18 years with appropriate grouping according to age [7, 17, 19]. According to the study by Verghese et al., the Trendelenburg position alone resulted in an IJV size increase of 24.3% in non-obese children [15].

Trendelenburg positioning has been acknowledged previously as a means to reduce the risk of air embolism [25]. However, both the present study and that by Nasser et al. [11] find that no CSA increase is observed when a patient is put in the Trendelenburg position. Therefore, particularly in cases involving obese pediatric patients, extra caution should be taken to avoid air embolism even when applying the Trendelenburg position.

Since US is the preferred phlebectasia diagnosis modality and is employed often as a guide for interventions performed via the IJV, IJV US measurements are of primary importance [20, 21]. Compared to other imaging modalities, a US guided approach enables the visualization of the puncture site and surrounding tissue before an attempt for cannulation is made. US imaging enables the visualization of anatomic variations and the IJV in relation to the artery, as the IJV is sometimes partly or fully superficial to the carotid artery [22], increasing accidental arterial puncture risk if the needle traverses the IJV.

Verghese et al. [22] and Hind et al. [23] report significantly lower cannulation time and reduced incidence of carotid artery punctures in infants and children when using the US technique compared to the landmark technique. However, a person experienced in using US for venous cannulation in pediatric cases may not be present in every medical center. In such cases, the use of every maneuver for the insertion of a central catheter by the landmark technique is compulsory. Asheim et al. [7] differentiate arteries and veins easily, as the vein is compressible by gentle pressure from the probe on the skin and pulsations maybe observed from the artery. As an IJV can collapse even if cannulation accompanied by a USG is made, cannulation is to be initiated only after obtaining the image with the least CA overlap and broadest CSA of the IJV. This may lead to failed first attempt rates and CA puncture probabilities. In cases in which a USG device is not present and real cannulation is practiced, this new condition must be clarified.

As stated above, the present study reveals no significant difference in CSA size as a result of the Trendelenburg position. This could be due to increased intra-abdominal pressure that leads to higher pressure levels in both the vena cava inferior and the right atrium, which are also associated with obesity. This could suggest that even when a patient is in supine position, an obese patient will experience pressure on the IJV the same as that produced in the

Valsalva maneuver or the Trendelenburg position. No pediatric report currently exists in English regarding the overlap that includes the Trendelenburg position. The present study did not observe the CSA of the right IJV, the degree of overlap between the right IJV and the CA, the transverse and anteroposterior diameters of the right IJV, and the margin of safety from the supine to the Trendelenburg position to be significantly different. In children and infants, a comparative 80 degree and 40 degree contra lateral head rotation increased the right IJV size, resulting in less carotid artery overlap. Thus, the cannulation success rate increased and the carotid artery puncture risk was reduced [16]. During the USG standardization procedures, all patients' heads were kept at a 30 degree contralateral rotation.

Some limitations of the present study include that the measurements were only obtained in the 20 degree Trendelenburg position for State T. Although the angle of the Trendelenburg position did not affect the CSA of the IJV in non-obese patients, further studies usingdifferent angles should be performed for obese cases [23]. Another limitation is that IJV images were obtained at maximum two minutes after the change in the patient's body position from spine to 20 degree Trendelenburg. Trendelenburg positioning-related hemodynamic effects are known to change within minutes [24]; thus, further studies are needed to determine if greater changes occur following a longer period in the Trendelenburg position. In addition, US measurements are operator-dependent; as such, operator-dependent measurement errors cannot be excluded.

## Conclusion

The researchers of this study examined the impact of the Trendelenburg position on the CSA of the right IJV in overweight and obese children. The results revealed that the increase in CSA when patients were moved from the supine to the Trendelenburg position was not significant. Further, Trendelenburg positioning actually made the vein smaller in 14 of 30 patients.

In conclusion, in cases involving overweight or obese pediatric patients, the Trendelenburg position was not found to yield the desired effect of IJV CSA increase. investigators who would apply this technique should know for and be ready this failure probability.

## Disclosure of conflict of interest

None.

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