

## Original Article

# Comparison of the effect of the Trendelenburg and passive leg raising positions on internal jugular vein size in critically ill patients

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**Abstract:** Central vein catheterization is a common procedure performed on patients under intensive care. The safe and successful placement of the central venous catheter depends on vein size. Although used for this purpose, the Trendelenburg position can be hazardous in some patients. The aim of this study was to compare the effects of the Trendelenburg and passive leg raising (PLR) positions on the size of the right internal jugular vein (IJV) in mechanically ventilated patients under intensive care. Seventy-eight mechanically ventilated patients under intensive care were included into the study. Sonographic images of the right IJV were recorded in supine (control), 10° Trendelenburg and 40° PLR positions. Anterior-posterior and transverse diameter, cross-sectional area (CSA), and depth were calculated from the recorded images. The size of the right IJV (CSA, transverse and vertical diameters) was significantly larger in the Trendelenburg and PLR positions than in supine position. An increase of 26% in the IJV CSA was obtained in the Trendelenburg position and 23% in the PLR position, compared to the supine position. There was no significant difference between the measurements obtained from the Trendelenburg and PLR positions. The study shows that the Trendelenburg and PLR positions increase the size of the IJV to a similar extent in mechanically ventilated patients under intensive care.

**Keywords:** Internal jugular vein size, Trendelenburg position, passive leg raising position, ultrasonography, critically ill patient

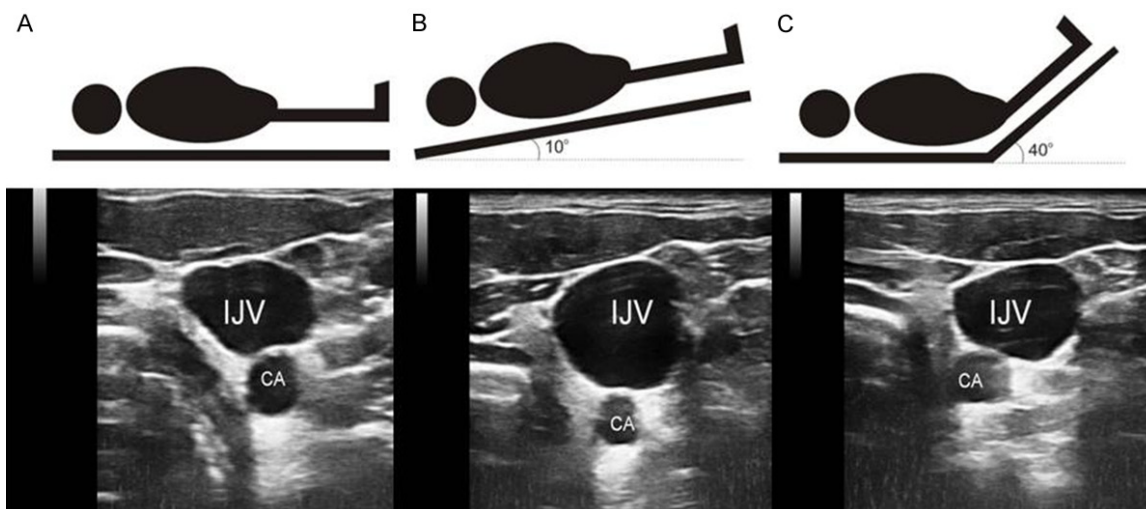
## Introduction

Central vein catheterization is a common procedure performed on intensive care patients to monitor cardiac filling pressures, to administer nutrition and medications [1]. The increase in mechanical complications due to the increased number of catheterization attempts and its correlation with infection may lead to adverse outcomes in critically ill patients [1, 2]. Since ultrasonography (USG) increases the success rate of intervention and reduces the chances of complications, these procedures have recently been recommended to be performed with the guidance of USG [3]. Additionally, an increase in the vein size enhances the chances of success during the intervention [4, 5]. The vein size was shown to increase with the use of the Trendelenburg position, hepatic compression, Valsalva maneuver, leg elevation and positive

end-expiratory pressure (PEEP) [6-11]. The Trendelenburg position is a conventional maneuver commonly used by practitioners to increase the vein size, as well as other advantages, such as the prevention of air embolism [12]. However, the Trendelenburg position was reported to impair gas exchange and cardiac functions [13]. This position may be disadvantageous, especially in obese patients with increased intracranial pressure.

Passive leg raising (PLR) has been suggested to increase the IJV size, especially in cases where the Trendelenburg position cannot be used [8]. However, these positions have yet to be tested sufficiently in mechanically ventilated and critically ill patients. The effects of these positions on the size of the vein may not be predictable due to the effect of mechanical ventilation on increasing the intrathoracic pressure.

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**Figure 1.** Schematic view and sonographic images of the internal jugular vein in different positions. A. Supine position; B. Trendelenburg position; C. Passive leg raising position. IJV: Internal jugular vein, CA: Carotid artery.

In the study, we aimed to evaluate and compare the effects of the Trendelenburg and PLR positions on the size of the right IJV in mechanically ventilated critically ill patients.

### Materials and methods

Approval for this study was obtained from the Clinical Research Ethics Committee of the Meram Medical Faculty in Necmettin Erbakan University. Informed consent was obtained from the relatives of the patients.

This prospective study included 78 adult patients followed-up in a 14-bed intensive care unit (ICU) in 2013 and 2014 years, and scheduled for central vein catheterization. The exclusion criteria consisted of the following: need for immediate catheterization, hemodynamic instability, body mass index (BMI)  $>30$  kg/m<sup>2</sup>, previous catheterization at the same site and presence of a pacemaker, skeletal deformity or lower extremity fractures.

Patients were sedated by a fentanyl-midazolam infusion throughout the procedure. Sedation level was assessed by the Richmond Agitation Sedation Scale (RASS). The target for RASS was -3 or -4. Patients were monitored as to heart rate, mean arterial pressure and pulse oximetry. All patients were mechanically ventilated (Dräger EVITA XL, Dräger AG Lübeck, Germany). To eliminate respiratory effects, the mechanical ventilation settings were temporar-

ily modified. Synchronized Intermittent Mandatory Ventilation (SIMV) mode applied to patients was adjusted so that the tidal volume was 6-8 mL/kg, breathing rate 12-16/minute, inspiration/expiration time 1:2, and positive end-expiratory pressure (PEEP) level was 0 cm H<sub>2</sub>O by the end of the procedure. Additionally, when necessary, FiO<sub>2</sub> was increased. No patient was included into the study if he or she tolerated none of these changes. Age, gender, reasons patients to be admitted into ICU and Acute Physiology and Chronic Health Evaluation Score (APACHE II) were recorded.

In all patients, the right IJV was selected as the initial site of catheterization. A roll appropriate for each patient was placed under the shoulder. Sonographic images of the right IJV were first recorded in the supine (control) position, and then recorded in 10° Trendelenburg position and 40° PLR position (**Figure 1**). After the vein image was recorded in the Trendelenburg position, the supine position was performed again. After waiting a while, the PLR position was applied.

The angles in these positions were adjusted using an anglemeter. An adjustable height was used for PLR. Before recording the images, patients stayed in the selected position for at least 1 min. In this study, USG with a 2-dimensional 8-MHz linear probe (LOGIQ e; GE Healthcare) was used. When the head was in a 15-30° contralateral position, the USG probe

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**Table 1.** Patients' characteristics (n=78)

|                                   |                     |
|-----------------------------------|---------------------|
| Age (years)                       | 49.33±21.03         |
| Gender (male/female) (%)          | 45 (57.6)/33 (42.3) |
| BMI (kg/m <sup>2</sup> )          | 26.26±2.64          |
| APACHE II                         | 17.31±5.67          |
| Diagnosis in ICU                  |                     |
| Pneumonia                         | 11                  |
| Trauma                            | 36                  |
| Malignancy                        | 6                   |
| Intoxication                      | 5                   |
| Cerebrovascular accident          | 7                   |
| Neuromuscular disease             | 4                   |
| Postoperative respiratory failure | 9                   |

Data are expressed as mean±standard deviations or absolute number (%). BMI: Body mass index. ICU: Intensive Care Unit. APACHE: Acute Physiology and Chronic Health Evaluation Score.

was held perpendicular to the skin with minimal pressure without compressing the vein at the apex of the triangle between both sides of the sternocleidomastoid muscle and the clavicle in line with the cricoid cartilage at the transverse axis. The vein was identified based on its large size and association with the artery, and verified by checking its ability to be compressed easily and to create a pulsatile, continuous flow with Doppler. The USG probe was positioned so that the vein image was at the center of the monitor. Additionally, the largest image of the vein was freeze-recorded at the end of the expiration for taking the measurements. All these procedures were performed by the same intensive care physician throughout the study.

Central venous pressure (CVP) value was measured at the end of the procedure. Anterior-posterior and transverse diameter, cross-sectional area (CSA), and depth were calculated from the recorded IJV images. CSA was measured using electronic calipers on the ultrasound screen. For the depth measurement, the distance from the skin surface to the anterior wall of IJV was measured.

### Statistical analysis

The sample size was determined as described in an earlier study [12]. In this study, the average CSA of the right IJV was 1.25 mm<sup>2</sup> in the supine position, 1.47 mm<sup>2</sup> in the Trendelenburg position. Standard deviation (SD) was 0.98 mm ( $\alpha=0.05$ ,  $\beta=0.20$ ). The sample size for repeated

measurements was determined as 72. A total of 78 people were included into the study.

Standards package for the social sciences for Windows 16.0 (SPSS Inc., Chicago IL, USA) was used for the statistical analysis. The data were tested for normality using the Kolmogorov-Smirnov test. Descriptive statistics were presented as mean ± SD, number and percentages. The general linear model was used for age, BMI, APACHE II, mean arterial pressure (MAP) and heart rate (HR). It was expressed as percentage of changes in CSA based on supine position. The Sidak post-hoc analysis was performed.

The ANOVA test was used for repeated measurements to determine the differences occurring in the IJV size (CSA, transverse, vertical diameter and depth) with the positions. Bonferroni post-hoc analysis was performed for multiple comparisons. The Pearson's correlation test was used in order to determine the correlation of CVP and age with CSA. Results with values of  $P<0.05$  were considered significant.

### Results

Seventy-eight patients were analyzed in the study. No patient was excluded from the study. The demographics of patients are presented in **Table 1**.

The MAP was 82.90±10.18 mmHg in the supine position, 86.16±13.65 mmHg in the Trendelenburg position and 85.45±14.68 mmHg in the PLR position. The MAP was found as significantly higher in the Trendelenburg and PLR positions, compared with the supine position ( $P<0.001$ ). There was no significant difference between the Trendelenburg and PLR positions in terms of MAP ( $P=0.12$ ). Mean HR was 97.43±21.90 beats in the supine position, 98.84±22.20 in the Trendelenburg position and 97.76±23.90 per minute in the PLR position, and no significant difference was present ( $P=0.24$ ).

No hemodynamic complications requiring a change in the position or treatment developed. The CVP was measured in all patients at the end of the procedure. A poor correlation was found between the CVP measured in the supine position after the procedure and CSA (Pearson's

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**Table 2.** IJV Sizes (CSA, transverse, vertical diameter and depth) in different positions

|                         | Supine Position | Trendelenburg Position   | Passive Leg Raising Position |
|-------------------------|-----------------|--------------------------|------------------------------|
| CSA (mm <sup>2</sup> )  | 86.7±42.7       | 111.7±45.3* <sup>†</sup> | 107.2±51.4*                  |
| CSA <sub>γ</sub> (%)    | -               | 26                       | 23                           |
| Vertical Diameter (mm)  | 8.28±2.3        | 9.54±2.14* <sup>†</sup>  | 9.29±2.34*                   |
| Transvers Diameter (mm) | 12.71±3.27      | 13.75±3.9* <sup>†</sup>  | 13.43±4.19 <sup>#</sup>      |
| Depth (mm)              | 12.3±3.5        | 11.1±2.9*                | 11.8±2.3                     |

IJV; Internal jugular vein, CSA; Cross-sectional area.  $\gamma$ ; According to supine position shown by the percentage of change CSA occurs, \*P<0.001; Compared with the supine position, <sup>#</sup>P=0.02; Compared with the supine position, <sup>†</sup>P>0.05; Compared with the passive leg raising position.

correlation coefficient,  $r=0.324$ ,  $P<0.001$ ). In our study, no correlation was detected between the CSA in the supine position and age ( $r=0.092$ ,  $P>0.05$ ).

The size of the IJV (CSA, transverse and vertical diameter) increased significantly in the Trendelenburg and PLR positions, compared with the supine position ( $P<0.001$ ) (Table 2). An increase of 26% was achieved in the IJV CSA in the Trendelenburg position and of 23% in the PLR position, compared with the supine position. There was no difference between the measurements obtained from the Trendelenburg and PLR positions ( $p=0.08$ ). The depth measurement significantly decreased in the Trendelenburg position, compared with the supine position ( $P<0.001$ ) (Table 2). No significant difference was found among the other positions in terms of depth.

A decrease occurred in vein size in three patients in the Trendelenburg and PLR positions, compared with the supine position. A minimal increase (<5%) occurred in vein size in both positions in two patients. In four patients, the IJV size measured in the PLR position was found as larger, compared with that found in the Trendelenburg position.

### Discussion

In this study, the effects of the Trendelenburg and PLR positions on the size of IJV in mechanically ventilated critically ill patients were evaluated. The greatest increase in vein size was detected with the Trendelenburg position although it was not statistically significant. The increase caused by the PLR position was found

to be quite similar to that caused by the Trendelenburg position.

The increase in the IJV size seen in the Trendelenburg position is because of the displacement of the blood in the area under the IJV to the central area, the increased distance between the right atrium and right jugular vein, the increased intrathoracic pressure and the prevention of return of the blood to the superior vena cava

(8, 11, 14). In literature, many studies are present where various angles of the Trendelenburg position were studied to obtain an increase in the IJV diameter. These values varied from 10°-30°. Most of these studies in which were investigated the effect of the Trendelenburg position on IJV CSA was conducted on healthy volunteers with spontaneous respiration [8, 10, 15-17]. The increase provided in CSA was reported as 48% in these studies [8]. The pressure gradient between the right atrium and the veins outside the chest cavity increases in spontaneous respiration; hence, an increase takes place in venous return. However, venous return decreases with positive pressure ventilation. Meanwhile, due to the fact that the Trendelenburg position causes the displacement of the diaphragm and abdominal organs towards the cephal, intrathoracic pressure increases and venous return to reduce further [8]. Thus, an increase occurs in the size of the IJV.

In our study, the size of the right IJV increased by 26% with the Trendelenburg position and 23% with the PLR position. The outcomes of the PLR position are similar to those obtained in previous study. In our study, a lesser increase was found in the CSA of the IJV in the Trendelenburg position. It could be caused by the angle used in our more trivial [8]. The most significant difference is that all our patients were mechanically ventilated patients critically ill patients. In two studies composed of patients conducted under general anesthesia, increases of 25% and 39.4% were achieved in the right IJV with 10° and 15° Trendelenburg position, respectively [9, 18]. Although the patient popu-

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lation in the study is different, the results are consistent with this study [9].

A small number of the studies included patients conducted under intensive care [12, 19]. In a study performed with 51 patients, an increase of 17% was achieved in the CSA, when the patients were placed in the Trendelenburg position from the supine position [12]. Although the study was performed in patients under intensive care, the number of mechanically ventilated patients was 11. The population in our study can be considered more homogeneous.

Although the Trendelenburg position increases the vein diameter or the CSA, the increase was reported to be absent, low, or limited in some patients [6, 12, 20]. Nassar et al. [12] reported a decrease in the CSA in nine patients with a 15° Trendelenburg position. In another study, however, a lesser increase was found in the CSA of the IJV in 13 of 50 patients in the Trendelenburg and different PEEP levels [6]. An increase in vein compression in patients with a high BMI has been cited as a reason for this change. Patients with a BMI of more than 30 were not included in our study. A minimal increase (<5%) occurred in vein size in both positions in two patients our study. We also investigated whether these changes observed in the CSA were associated with age. A study shows that the lumen area increases with age [21], while another showed no association between the two [20]. No effect of age on CSA change was detected in our study.

In our study population was composed of critically ill patients under mechanical ventilation. The effect of the position to the IJV size was evaluated in spontaneous breathing patients with chronic diseases [20]. Wu et al. [20] compared the measurements of the right IJV obtained from patients undergoing chronic dialysis and healthy volunteers in the Trendelenburg position and reported that an increase in the CSA was observed in the group composed of healthy individuals; however, no increase was noted in the group consisting of the chronic dialysis patients. They speculated that multifactorial, systolic, and diastolic dysfunction might cause the vein to be fuller in the supine position. They performed transthoracic echocardiography in some of the patients; however, no ventricular systolic dysfunction was detected. Although we did not perform such a proce-

cedure in our patients, we consider that these reasons can also affect the CSA of the right IJV in critically ill patients and might have caused a slight increase or decrease in the CSA of the right IJV.

The Trendelenburg position, together with the functional residual capacity, may cause a reduction in total lung capacity and microatelectasis [22]. This position may be harmful for patients under intensive care, whose pulmonary reserve is limited. In addition, gastroesophageal reflux and malignant cardiac arrhythmia are the other complications of such a position [23, 24]. The angling of the patient during the position requires the practitioner to bend more during the catheterization. Although no complication was observed in our study, various complications are likely to occur during the procedure.

Therefore, the PLR position can be chosen to increase the vein size rather than the Trendelenburg position in many critically ill patients. The PLR is mostly used for fluid challenge in critical ill patients [25-27]. The PLR is a maneuver performed at degrees varying from 10 to 90 [14]. In a study, radioisotopic imaging showed that 300 ml of blood was displaced to the central compartment with PLR [27]. Thus, an increase occurs in the IJV diameter. Normally, no significant change in heart rate is expected in the PLR position. A significant increase in heart rate may occur due to misleading sympathetic stimulations, such as pain, wakefulness and coughing [28]. The level of sedation was standardized in our study, and no change in heart rate was observed in either of the two positions.

The CVP is the static indicator of preload. Although its popularity has decreased, the CVP is still being used in ICUs. As with some studies reporting a correlation between the IJV diameter and the CVP [13], our study also revealed a poor correlation between the CVP and CSA, measured at the end of the supine position.

### Limitations

Turning the head more than 40° causes a decrease in the venous diameter and impairs the relation of the carotid artery with the veins [29]. In the current study, this angle was defined as 15-30°. However, this angle could not be

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precisely measured. The USG probe was used with minimal pressure in the current study to minimize venous collapse by USG; however, the method was not standardized.

To summarize, a similar increase in the size of the IJV was achieved with the Trendelenburg and PLR positions in mechanically ventilated critically ill patients. We believe that leg raising is an easier and practical maneuver, especially in consideration of the harmful effects and challenges of the Trendelenburg position in mechanically ventilated critical ill patients. We consider that the PLR position may also be used to facilitate central catheterization in critical ill patients. Further studies should be conducted to investigate the effect of these results on the success of catheterization.

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### Disclosure of conflict of interest

None.

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