

## Original Articles

# EFFECTS OF THE VALSALVA MANEUVER AND HEAD ROTATION ON INTERNAL JUGULAR VEIN DIAMETER AND LOCATION BY ULTRASONOGRAPHY

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### ABSTRACT

In order to determine the effect of Valsalva maneuver and head rotation on the internal jugular vein (IJV) diameter and cross-sectional area and overlap with the carotid artery (CA) and find the best technique for safe cannulation of the IJV and decrease the risk of CA puncture, the diameter of both the IJV and the CA and percentage of overlap between the two vessels and cross-sectional area of the IJV were measured by ultrasonography on the right side of the neck in the supine, head down position, at three different degrees of head rotation with and without the Valsalva maneuver in 30 subjects. The results were analyzed by two-way repeated-measures analysis of variance followed by least significant difference (LSD).

Head rotation increased the overlap between the two vessels ( $p < 0.001$ ). Valsalva's maneuver also increased overlap between the two vessels ( $p < 0.02$ ) and increased IJV diameter and cross-sectional area ( $p < 0.001$ ). Head rotation did not change IJV diameter and cross-sectional area significantly ( $p > 0.05$ ). Valsalva's maneuver and head rotation did not change CA diameter significantly ( $p > 0.05$ ).

We therefore advocate the neutral head position with Valsalva's maneuver as a safe and reliable method for IJV cannulation.

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**Keywords:** Valsalva's maneuver; Jugular vein, internal; Catheterization, central venous; Head movements

### INTRODUCTION

Cannulation of the central circulation is essential for the management of patients who require major surgery, and for patients who are critically ill. Compared to the subclavian approach, percutaneous cannulation of the IJV has a lower incidence of complications.<sup>1</sup> The IJV

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approach, however, has a potential risk of accidental CA puncture. In order to recommend a suitable position and a reliable method for IJV cannulation, we must choose the method with the least overlap and the greatest IJV diameter. We studied the effects of Valsalva's maneuver on the overlap between the IJV and the CA, IJV diameter, and cross-sectional area of this vessel and the effects of head rotation on the overlap between the two vessels. We tried to find a suitable technique for decreasing the risk of CA puncture.

## MATERIAL AND METHODS

This study was performed on 30 individuals that had never undergone neck surgery or IJV cannulation. After explaining the procedure, informed consent was obtained and subjects were examined by a single ultrasound unit (Ultra mark, Aloka SSD-1700) with a 5-MHZ linear array transducer. For testing, each subject was placed supine in a 15° Trendelenburg position with the transducer perpendicular to the long axis of the body at the mid-point of the imaginary line connecting the tip of the mastoid process to the notch of the sternum. The transducer was applied gently, so as not to distend the underlying low-pressure venous structure. The transverse and perpendicular diameters of the IJV and common carotid artery were measured at three different degrees of head rotation, i.e. 0°, (30-45)° and (60-80)° from the midline with and without Valsalva's maneuver. Cross-sectional area of the IJV was calculated using the two above-mentioned diameters and the following formula:  $(1/4a \times b \times \pi)$ .

The percentage of overlap between the IJV and the CA was calculated at rest and with Valsalva's maneuver at three different degrees of head rotation by measuring the percentage of transverse overlap between the two vessels as shown in Fig. 1.

A- Overlap 0%: No horizontal overlapping of the CA by the IJV (Fig. 1. A).

B- Overlap 25%: The IJV overlaps about 25% of the transverse diameter of CA (Fig. 1.B).

C- Overlap 50%: The IJV overlaps about 50% of the transverse diameter of CA (Fig. 1.C).

D- Overlap 75%: The IJV overlaps about 75% of the transverse diameter of CA (Fig. 1.D).

E- Overlap 100%: The IJV overlaps about 100% of the transverse diameter of CA (Fig. 1.E).

Ultrasound images showing the percentage of overlap between the two vessels are shown in Fig. 2.

The difference between the percentage of overlap between the two vessels, the IJV and the CA diameter, and the cross-sectional area of IJV at three different degrees of head rotation at rest and with Valsalva's maneuver were analyzed statistically by two-way repeated-measures analysis of variance followed by least significant differ-

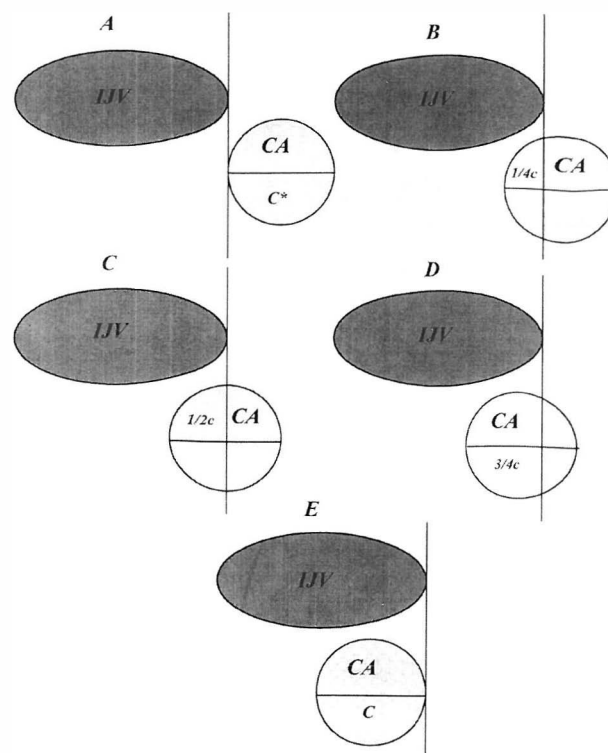


Fig. 1. A schematic diagram depicting the different percentage of overlap between the IJV & CA. (A) Overlap 0%, (B) Overlap 25%, (C) Overlap 50%, (D) Overlap 75%, (E) Overlap 100%. \*Carotid artery diameter

ence (LSD) testing.  $p < 0.05$  was considered significant.

## RESULTS

Thirteen males and seventeen females were studied in the initial investigation.

Valsalva's maneuver increased the overlap between the IJV and the CA from 15% ( $\pm 19\%$ ) to 28% ( $\pm 27\%$ ) in neutral position ( $p < 0.003$ ), from 27% ( $\pm 26\%$ ) to 37% ( $\pm 29\%$ ) in (30-45)° rotation ( $p < 0.017$ ), and from 39% ( $\pm 33\%$ ) to 56% ( $\pm 32\%$ ) in (60-80)° rotation ( $p < 0.003$ ).

Head rotation without Valsalva's maneuver increased the overlap between the IJV and the CA from 15% ( $\pm 19\%$ ) in neutral position to 27% ( $\pm 26\%$ ) in (30-45)° rotation, and to 39% ( $\pm 33\%$ ) in (60-80)° rotation ( $p < 0.001$ ).

Head rotation with Valsalva's maneuver increased the overlap between the IJV and the CA from 28% ( $\pm 27\%$ ) in neutral position to 37% ( $\pm 29\%$ ) in (30-45)°, and to 56% ( $\pm 32\%$ ) in (60-80)° rotation ( $p < 0.001$ ).

Valsalva's maneuver increased the IJV diameter from 13.57 ( $\pm 4.56$ ) to 17.88 ( $\pm 5.74$ ) mm in neutral position,

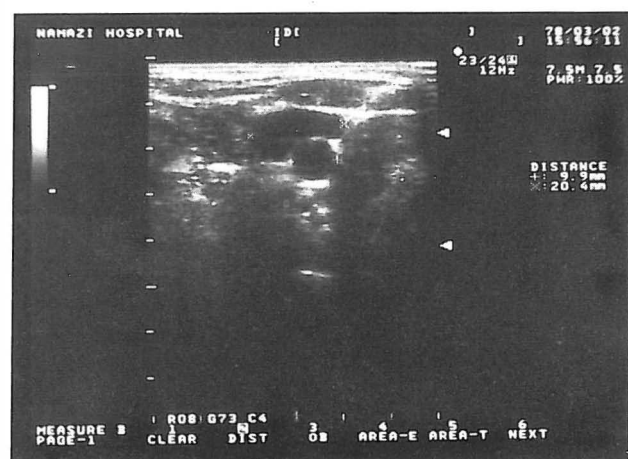
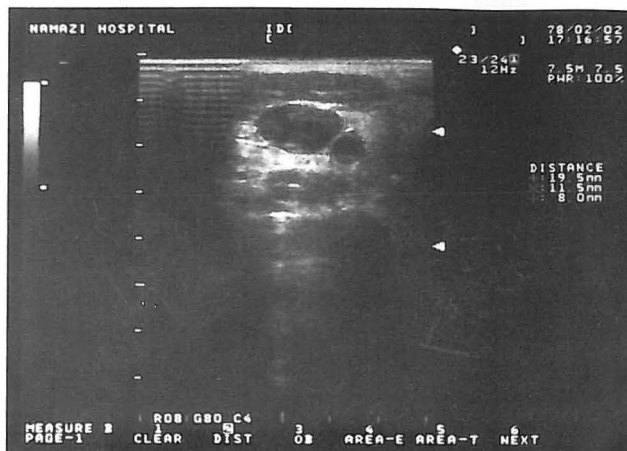
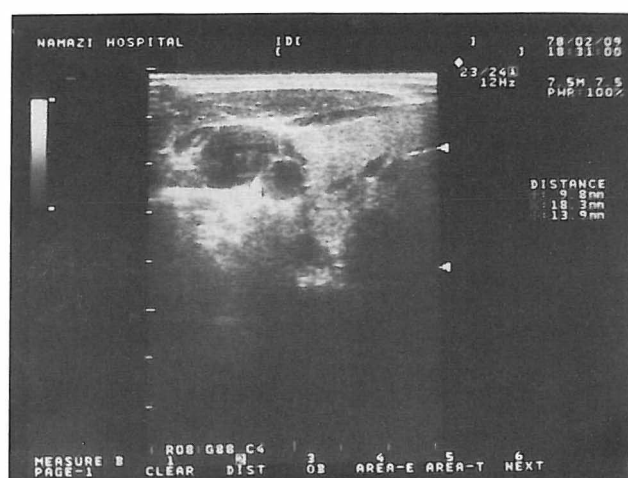
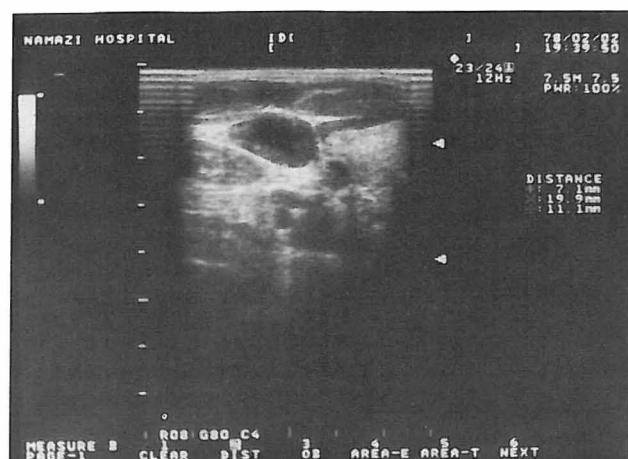


Fig. 2. Ultrasound images of the IJV and CA to show the percentage of overlap between the two vessels. (A) Overlap 0%, (B) Overlap 50%, (C) Overlap 100%.

from 13.66 ( $\pm 4.15$ ) to 17.88 (5.84) mm in (30-45) $^{\circ}$  rotation, and from 13.80 ( $\pm 4.06$ ) to 18.23 ( $\pm 5.34$ ) mm in

Fig. 3. (A) Neutral position with Valsalva's maneuver. (B) Rotation (30-45) $^{\circ}$  with Valsalva's maneuver.

(60-80) $^{\circ}$  rotation ( $p < 0.001$ ).

Head rotation did not change the IJV diameter significantly ( $p > 0.05$ ).

Valsalva's maneuver increased the cross-sectional area of IJV from 72.62 from and from 82.93 ( $p < 0.001$ ).

Head rotation did not change the cross-sectional area of the IJV significantly ( $p > 0.05$ ).

Valsalva's maneuver and head rotation did not change CA diameter significantly ( $p > 0.05$ ) (Table I).

## DISCUSSION

Internal jugular vein catheterization is a common route for central venous access of critically ill patients in emergency departments, intensive care units and operating theatres.<sup>2</sup> A possible complication of IJV cannu-

## Effect of Valsalva Maneuver on IJV Diameter

**Table I.** The mean difference between internal jugular vein diameter, cross-sectional area of internal jugular vein and percentage of overlap at three different degrees of head rotation with and without Valsalva's maneuver.

Position		A	B	C	D
		Mean±SD	Mean±SD	Mean±SD	Mean±SD
Without Maneuver	1-Neutral	15% (±19%)	13.57 (±4.56)	72.62 (±37.34)	8.29 (±1.25)
	2-Rotation (30-45)°	27% (±26%)	13.66 (±4.15)	73.31 (±37.52)	7.92 (±0.84)
	3-Rotation (60-80)°	39% (±33%)	13.80 (±4.06)	82.93 (±37.29)	7.68 (±1.01)
With Maneuver	4- Neutral	28% (±27%)	17.88 (±5.74)	135.69 (±78.56)	8.07 (±0.85)
	5- Rotation (30-45)°	37% (±29%)	17.88 (±5.84)	147.51 (±94.42)	8.05 (±1.19)
	6-Rotation (60-80)°	56% (±32%)	18.23 (±5.34)	153.50 (±83.11)	7.86 (±0.93)

A- Percentage of overlap between internal jugular vein and carotid artery (%).

B- Diameter of internal jugular vein (mm).

C- Cross-sectional area of internal jugular vein (mm<sup>2</sup>).

D- Diameter of carotid artery (mm).

lation is CA puncture.<sup>3</sup> To decrease this complication, we must determine a situation in which overlap between IJV and CA is the least and the IJV is at its greatest diameter.

Our results demonstrated that Valsalva's maneuver increased the percentage of overlap between the two vessels significantly.

This is in contrast to a previous study by Kitagawa et al. who demonstrated that Valsalva's maneuver decreases the overlap between the two vessels.<sup>4</sup> This difference may be related to the technical factor, because Kitagawa et al. did not use the Trendelenburg position while we performed the technique in the 15° Trendelenburg position which is the standard position for IJV cannulation.<sup>2</sup>

In the present study, when head rotation was increased, the percentage of overlap between the CA and IJV increased significantly. This is in contrast to standard techniques which recommend that head rotation is better for IJV cannulation<sup>1,5</sup> and in accord to other studies showing that head rotation increases the overlap between the CA and the IJV.<sup>6</sup>

Standard techniques have reported high success rates. However, this may be attributed to the care and attention given to the procedure rather than to any inherent anatomical advantage.<sup>1</sup>

Accidental carotid artery puncture is usually benign, but can result in serious complications.<sup>7-9</sup> Therefore, we advocate neutral or near neutral head position during IJV cannulation to reduce the overlap and risk of carotid artery puncture. In spite of the greater difficulty associated with the change in mandible position, and the more acute needle insertion angle required with a neutral head position, this method has been highly successful in patients with cervical spine injury, in whom maintenance

of neutral head and neck positions is mandatory.<sup>1</sup>

The right IJV is preferred for cannulation because this approach is associated with less overlap of CA and IJV and fewer cannula malpositions than cannulation on the left.<sup>10</sup>

Our results demonstrated that IJV was dilated by the Valsalva maneuver significantly. This shows that Valsalva's maneuver makes IJV cannulation easier and decreases the risk of accidental CA puncture. This finding is similar to other studies that have demonstrated an increase in IJV diameter by Valsalva's maneuver.<sup>4</sup>

The Valsalva maneuver not only dilates the IJV but also increases the cross-sectional area of this vessel. There is a direct relationship between the IJV diameter and the cross-sectional area of this vessel.<sup>11</sup>

In order to recommend a suitable position and a reliable method for IJV cannulation, we must choose the least overlap and the greatest IJV diameter. In Table I the states 1, 2 and 3, have less overlap than states 4, 5 and 6 and greater IJV diameter is observed in states 4, 5 and 6. A comparison between these two factors (overlap and diameter of IJV), demonstrated that the neutral position with Valsalva's maneuver (state 4) is the best position for IJV cannulation (Fig. 3, A).

In spite of the increased overlap with Valsalva's maneuver, this is less compared to the effect of head rotation.

In conclusion, in addition to customary guidelines for IJV cannulation, we would add the following based on our data:

1) The Valsalva maneuver not only dilates the IJV but also increases the overlap between the IJV and the CA.

2) Head rotation increases the percentage of overlap between IJV and the CA. Therefore, we advocate neu-

tral or near neutral head position during IJV cannulation in order to reduce the risk of carotid artery puncture.

3) In spite of the increased overlap with Valsalva's maneuver, this is less compared to the effect of head rotation.

4) We propose the neutral head position with Valsalva's maneuver (state 4) as a safe and reliable position for IJV cannulation.

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