Brief Communication

The dynamics of changing internal jugular veins diameter based on increasing head elevation angle

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Abstract

Context: Venous outflow from the cranial cavity occurs mainly through the internal jugular vein (IJV). The increase in venous outflow through IJV is possible by head elevation. IJV collapse may indicate the reduction of blood volume in the vein and show the head elevation effectiveness. **Aims:** The aim of this study is to examine the impact of head elevation on IJV size. **Subjects and Methods:** IJV ultrasound scanning in 31 healthy volunteers was carried after gradual head elevation at 15°, 30°, and 45°. Maximum and minimum IJV diameters were recorded. Mean ± standard deviation, median, range, and collapsibility index were calculated. **Results:** Thirty-one volunteers were involved (19 males), their average age was 37.0 ± 11.5 years. Increasing the head elevation angle by 15°, 30° and 45° resulted in a decrease in IJV diameter in the right and left sides in all patients. The occurrence of the vein walls collapse corresponds to the collapsibility index equal to 100%. The results showed that 100% collapsibility index was recorded in 6 patients (19%) at 15° head elevation, in 12 patients (39%) at 30°, in 11 patients (35%) at 45°. In two volunteers (6%), 100% collapsibility index was not recorded even at maximum 45° head elevation. **Conclusions:** Ultrasound IJV scanning during gradual head elevation together with the collapsibility index calculation could be useful guidance for the venous outflow assessment. In order to prove and extend the study findings, more research is needed.

Keywords: Internal jugular vein, intracranial pressure, ultrasound scanning

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Introduction

Head elevation at 15–45° could reduce intracranial pressure due to increased venous outflow from the cranial cavity and reduction of intracranial venous blood volume.[1,2] However, the common practice of head elevation in patients with traumatic brain injury has been questioned lately, as some studies showed that the elevation >30° could reduce cerebral perfusion pressure and mean pressure in the carotid artery.[3] Since the venous outflow from the cranial cavity is mainly through the internal jugular veins (IJVs), their diameter dynamics may help to determine the minimum angle of an individual patient head elevation providing the maximum outflow of venous blood. A number of studies have examined the impact of passive leg elevation and trendelenburg position on IJV size change.[4,5] The impact of head elevation on IJV size change is not studied yet.

The aim of this study is to examine the impact of head elevation on IJV size.

Subjects and Methods

Ultrasound IJV was scanning and their diameter measurements were carried out in 31 healthy volunteers using Siemens Acuson S2000 ultrasound system (USA) and

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5–14 MHz linear transducer. The study was conducted in a hospital bed Futura Plus by Merivaara Company (Finland).

The IJV scanning was carried out in 2 min after placing the volunteers in a horizontal position on their back, and in 2 min each time after the volunteers had attained the new position due to the gradual lifting the bed back section at the 15°, 30°, and 45°. The ultrasonic sensor was placed on the neck of the patient between the heads of sternocleidomastoid muscle, and veins cross-scanning was carried out on both sides. The maximum and minimum vein diameter sizes were recorded. Quantitative data are presented as mean ± standard deviation, median, range, and collapsibility index. IJV collapsibility index was calculated as: IJV-confidence interval (CI) = ([Dmax – Dmin]/Dmax) × 100%. The IJV-CI was derived via M-mode assessment of the variation in the veins diameter (minimum versus maximum). The research plan was approved by the Ethics Committee of the Izhevsk State Medical Academy based on the principles set in the World Medical Association Declaration of Helsinki.

Results

Ultrasound examination of right and left IJV state was carried out in 31 healthy volunteers [Table 1].

A gradual increase of the head elevation angle from 0° to 45° was followed by IJV diameter decrease [Table 2].

Veins collapse in the human subjects was recorded at different head elevation angles. In 6 volunteers (19%), complete IJV collapse was recorded at 15° head elevation while in two volunteers (6%) vein collapse was not recorded even at 45° head elevation.

Collapsibility index dynamics based on volunteers' head elevation angle is shown in Table 3.

IJV ultrasound scanning allows to define IJV size change due to head elevation and to calculate collapsibility index [Figure 1].

We revealed the correlation between the mean IJV diameter and the collapsibility index. The correlation coefficient (right and left) between D-mean and IJV-CI was −0.72 and −0.75, respectively, which means a strong negative correlation.

Discussion

It is traditionally considered that head elevation results in ICP decrease.[6,7] In particular, it was shown that in severe pediatric traumatic brain injury, the relationship between change in head of the bed and change in intracranial pressure was negative and linear.

Decreased intracranial pressure associated with the head elevation is related to the increased venous outflow from the cranial cavity and decreased intracranial venous blood volume.[1,2,8] The major venous blood outflow from the cranial cavity in a supine human occurs through the IJVs. As it was shown before, the IJVs ultrasound scanning provides accurate records of changes in their diameters due to human body position change, performing

Table 1: Demographic of the study group

Study sample characteristics	Number (%)
General demographics	
Number of volunteers	31
Gender, %female	19/31 (61)
Mean age±SD (years)	37.0±11.5
[median, range]	[36, 19-66]
Total volunteers	31
Total data pairs measured	775
[per patient]	25

SD: Standard deviation

Table 2: Changes in internal jugular vein diameter versus head elevation angle

Head elevation, degrees	Diameter of IJV, mm			
	Right		Left	
	D_{min} Mean±SD Median	D_{max} Mean±SD Median	D_{min} Mean±SD Median	D_{max} Mean±SD Median
0°	6.4±2.6 6.2	8.5±2.6 5.5	6.3±2.7 5.5	7.8±2.8 7.2
15°	2.8±2.6 2.0	4.8±3.4 2.8	3.2±2.3 2.8	5.0±2.7 5.2
30°	1.5±2.2 0.6	2.9±2.6 1.0	1.6±1.9 1.0	3.2±2.4 2.4
45°	0.8±1.5 0	1.9±2.3 0	0.7±1.3 0	1.8±2.0 1.2

IJV: Internal jugular vein; SD: Standard deviation

Table 3: Internal jugular vein collapsibility index versus head elevation angle

Head elevation, degrees	IJV-CI, % Mean±SD Median	
	Right	Left
0°	26.0±16.4 22.5	21.3±11.3 17.9
15°	51.3±25.3 44.6	41.4±22.0 40.0
30°	61.7±37.3 62.2	64.6±29.9 66.7
45°	82.2±30.1 100.0	77.8±34.9 100.0

IJV-CI: Internal jugular vein collapsibility index; SD: Standard deviation

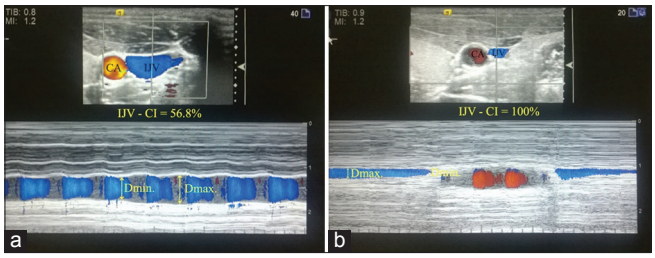

Figure 1: Measuring left internal jugular vein diameter in healthy volunteer using M-mode ultrasonography at 0° (a) and 30° (b) head elevation. Based on the measurements in this example, the confidence interval-internal jugular vein would be 41.7% and 100%, respectively

functional tests, and volume expansion.[4,5] Besides, an inverse correlation between the volume status values and collapsibility index was revealed.[9,10] The increase in collapsibility index value was associated with a reduction of venous blood volume. Thus, IJV collapse and the collapsibility index value equal to 100% may indicate the reduction of local blood volume in IJV to a minimum and show the head elevation effectiveness. Our results suggest that the elevation of the head end is accompanied by a decrease in IJVs diameter up to their collapse. When the image of venous walls collapse appeared on the ultrasound scanner screen, collapsibility index reached 100%.

Thus, in 6 subjects (19%) collapsibility index reached 100% at 15° head elevation and did not change with further head elevation. However, in 6% of volunteers 100% collapsibility index was not recorded even at maximum 45° head elevation.

The results showed the possibility of using IJV ultrasound scanning for collapsibility index evaluation while increasing elevation angle. The image of IJV collapse on the ultrasound scanner screen can be accepted as criterion of head elevation effectiveness in clinical settings. Our findings show that IJVs ultrasound scanning may be recommended to doctors as quick and noninvasive additional method of evaluating the efficacy of therapy aimed at improving venous outflow from the cranial cavity in an individual patient.

However, for better accuracy, we need additional large-scale prospective research to study the relationship between IJVs collapsibility index and intracranial and intravenous pressure characteristics. Nevertheless, this study forms the basis for further related clinical research.

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Conflicts of interest

There are no conflicts of interest.

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