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Is the Trendelenburg position the only way to better visualize internal jugular veins?

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Background. A larger cross-sectional area (CSA) of the internal jugular vein (IJV) makes catheterization easier and the Trendelenburg position is used to achieve this. Unfortunately, it is not comfortable for conscious patients. The aim was to evaluate the impact of alternative manoeuvres on the enlargement of the CSA of the IJV and to compare these manoeuvres with the Trendelenburg position.

Materials and methods. A prospective study of 63 healthy volunteers was conducted. Two-dimensional ultrasound images of right IJV (RIJV) and left IJV (LIJV) were recorded at the level of the cricoid cartilage in the supine position with and without head rotation by 30 degrees during various manoeuvres.

Results. The CSA of the RIJV and the LIJV significantly increased using hold of deep breath (mean size (cm^2) RIJV 1.59 ± 0.82, LIJV 1.07 ± 0.64; both $p < 0.001$) and the Trendelenburg position (mean size (cm^2) RIJV 1.5 ± 0.68, LIJV 0.99 ± 0.54; both $p < 0.001$). The 45-degree passive leg raise increased the CSA of only the RIJV (mean size (cm^2) 1.17 ± 0.61, $p = 0.024$). These manoeuvres were compared with the Trendelenburg position. There was no significant difference in the size of the CSA using hold of deep breath on the LIJV ($p = 0.08$) and the RIJV ($p = 0.203$). The passive leg raise had a significantly weaker impact on the size of the CSA ($p < 0.001$ for both sides).

Conclusions. Hold of deep breath and 45-degree passive leg raise (the latter limited for the right side only) are alternative manoeuvres to improve visualization of internal jugular veins for conscious patients. Hold of deep breath was as effective as the Trendelenburg position.

Keywords: jugular vein, Trendelenburg, ultrasound, manoeuvre, cross-sectional area

INTRODUCTION

Central venous catheterization is an essential part of treatment and diagnostics in intensive care units and surgical wards. It is a routine procedure that is done for patients of intensive care and general wards (1). The internal jugular vein (IJV) is the most common site for central venous access due to lower mechanical complication rates during insertion of a central venous catheter compared to the subclavian vein (2); moreover, there exists a possibility of visualization of the IJV using ultrasound.

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Safety and comfort of the patient during central venous catheterization still remains a relevant issue. A landmark guided technique of catheterization has shown to cause complications such as carotid artery puncture, airway compression, and cerebrovascular neurological problems (2, 3). It has been established that increased cross-sectional area (CSA) of the IJV has a strong impact on cannulation success and lower rates of mechanical complications (4–7). Therefore, knowledge of the safest manoeuvre to increase the CSA of the IJV and to increase the chances of a successful catheterization is needed. Even though the ultrasound guided technique is proven to be safer and has a higher successful cannulation rate (8, 9), it should be kept in mind that in some situations an ultrasound device is not always available or useful (8, 10–13).

The Trendelenburg manoeuvre with head rotation at 30–45 degrees is used to enlarge the CSA of the IJV and is known as a "gold standard" position for cannulation, therefore, widely used in the teaching process and clinical practice (14–18). Unfortunately, the application of the maneuver is unpleasant for conscious patients, causing a subjective distress which interferes with patient operator communication. This position increases work of breathing, intraabdominal and intrathoracic pressures, affects cardiac pump function, causes cerebral venous pooling and is unsafe in cases of disturbed intracranial pressure regulation and respiratory failure (3, 10, 19–21).

Therefore, the purpose of this study is to evaluate other manoeuvres which could be an alternative to the Trendelenburg manoeuvre for the enlargement of the CSA of the IJV.

MATERIALS AND METHODS

Patients

This prospective study included 63 healthy adult volunteers and took place from November of 2014 to January of 2015. A written informed consent was obtained from all subjects prior to the study. Participants with history of IJV cannulation were excluded from the study. Demographic data included age, sex, height, and body weight.

Imaging

Transverse ultrasound images of the right IJV (RIJV) and the left IJV (LIJV) were obtained through a 7.5 MHz two-dimensional linear transducer (LN5-12, MySono6, Samsung, Medison) at the cricoid cartilage level parallel to the clavicle. The probe was placed on the volunteer's neck with minimal force needed to visualize the vein and avoiding IJV compression.

The IJV ultrasound was performed for all the subjects in a standardized manner. The transverse diameters, the anterior-posterior diameter, and the CSA of the RIJV, and the LIJV were measured on the ultrasound image using a built-in calliper. The transverse and anterior-posterior diameters, and the maximal CSA were recorded.

Manoeuvres

While volunteers were in a supine position, the following three positions were achieved: 30-degree bed head elevation, 45-degree passive leg raise, and a 10-degree Trendelenburg position. Afterwards, the four breathing manoeuvres were conducted: resting inspiration hold, hold of deep breath, and resting and forced expiration hold. An abdominal compression of 10 kg was done to imitate raised intra-abdominal pressure. Patients were placed in the supine position for 2 min between manoeuvres. Each manoeuvre was done with and without head rotation of 30 degrees. The mean right and left IJV transverse (T) diameters, anterior-posterior (AP) diameter, and CSA were measured during the stated manoeuvres. The supine position with 30-degree head rotation was the reference manoeuvre for further calculations. All manoeuvres and all measurements were performed in the same manner for all the subjects.

Statistics

Values for all data except sex were presented as mean ± standard deviation (SD). The normality of the distribution of data was tested by the Kolmogorov-Smirnov test. Mean values of T diameters, AP diameters, and CSA of the RIJV and LIJV were compared to one another by one sample t-test. The paired sample t-test was used to compare mean T diameters, AP diameters, and the CSA of the RIJV and LIJV in the supine and rotated head position before the manoeuvres and after them: 30-degree bed head elevation, 45-degree passive leg raise, and 10-degree Trendelenburg position, resting inspiration hold, hold of deep breath, resting and forced expiration hold, and abdominal compression of 10 kg. The manoeuvres with significantly larger CSA were compared with the CSA of the Trendelenburg manoeuvre. A p value of <0.05 was considered statistically significant.

RESULTS

The mean age of the study group was 23 years. The volunteer demographic data is summarized in Table 1. Ultrasound imaging was performed on all volunteers to identify and record the transverse and anterior-posterior diameters, and the CSA of the LIJV and RIJV in supine position and various manoeuvres. The T and AP diameters of both IJV were compared showing significantly larger diameters and CSA of the RIJV than the LIJV in the supine position without head rotation, these results are presented in Table 2. Only 22 (34.9 %) volunteers showed the left as the dominant side.

Table 1. Volunteer demographic data

Variable	N = 63	Range
	Mean ± SD	
Age, y	23.06 ± 1.86	19–28
Weight, kg	69.57 ± 11.67	53–108
Height, cm	178 ± 9.0	160–200
BMI, kg/m^2	21.89 ± 2.62	17.17–32.25
Male, %	29 (46)	

Values are expressed as mean ± SD or numbers of patients

SD – standard deviation, BMI – body mass index

Table 2. Measurements of transverse, anterior-posterior, and cross-sectional areas of the IJV in the supine position without manoeuvres

Measurement	RIJV cm^2 (Mean ± SD)	LIJV cm^2 (Mean ± SD)	p value
T, cm	1.20 ± 0.43	0.98 ± 0.27	0.001
AP, cm	0.72 ± 0.33	0.59 ± 0.24	<0.001
CSA, cm^2	0.76 ± 0.51	0.49 ± 0.31	<0.001

T – transverse, AP – anterior-posterior, CSA – cross-sectional area, RIJV – right internal jugular vein, LIJV – left internal jugular vein, SD – standard deviation.

On its own, head rotation significantly increased the LIJV and the RIJV to 0.70 ± 0.34 cm^2 and 1.02 ± 0.51 cm^2 (both $p < 0.001$), respectively. Further calculations were obtained with head rotation. Values of the CSA of each internal jugular vein before manoeuvre and changes after it are shown in Table 3. The CSA of the RIJV and the LIJV significantly increased using hold of deep breath and the Trendelenburg position in the RIJV and the LIJV. The 45-degree passive leg raise increased only the CSA of the RIJV.

Manoeuvres with the greatest impact on the CSA of the veins were compared with the Trendelenburg position. Changes in vein sizes on both sides – LIJV (p = 0.08) and RIJV (p = 0.203) – were not statistically significant when compared with hold of deep breath. Passive leg raise had a significantly weaker impact on size of CSA ($p < 0.001$ both sides) (Table 4).

DISCUSSION

The Trendelenburg position is achieved by elevating the feet and legs of the patient above the level of the heart in the supine position. This position continues to be used to redirect blood from the lower extremities into the central circulation. Vertical distance between the veins in the neck and the right atrium increases, leading to decreased venous return to the heart from the upper extremities and head. Venous pressure rises, therefore, the IJV dilates.

However, our data confirms the hypothesis that Trendelenburg position is not the only way to increase the CSA of the IJV. According to literature, hold of deep breath, the Valsalva manoeuvre, or positive end-expiratory pressure distend the RIJV mainly by compression of the superior vena cava. (6, 22–24) In our study, hold of deep breath showed the same results with a trend of even larger CSA than the Trendelenburg manoeuvre (22). These results could be useful while performing a jugular vein catheterization on conscious patients without shortness of breath when Trendelenburg position is not comfortable and acceptable. Similar results have been obtained in studies investigating changes in the CSA of the IJV while using positive end-expiratory pressure (5, 22). Increased intra-abdominal pressure

Table 3. Comparisons of cross-sectional area of each internal jugular vein in 30-degree head rotation before manoeuvres and changes after it

	RIJV cm² (Mean ± SD) (change)	*p* value	LIJV cm² (Mean ± SD) (change)	*p* value
Supine position with head rotation without manoeuvres	1.02 ± 0.51		0.70 ± 0.34	
Resting inspiration hold	1.03 ± 0.51 (+1%)	0.853	0.74 ± 0.40 (+5%)	0.193
Hold of deep breath	1.59 ± 0.82 (+55%)	0.000	1.07 ± 0.64 (+52%)	0.000
Resting expiration hold	0.90 ± 0.52 (−12%)	0.004	0.62 ± 0.34 (−11%)	0.018
Forced expiration hold	0.90 ± 0.66 (−12%)	0.030	0.69 ± 0.44 (−1%)	0.840
Abdominal compression of 10 kg	1.00 ± 0.55 (−2%)	0.534	0.71 ± 0.39 (+1%)	0.922
30-degree bed head elevation	0.31 ± 0.30 (−70%)	0.000	0.27 ± 0.24 (−61%)	0.000
45-degree passive leg raise	1.16 ± 0.61 (+14%)	0.024	0.76 ± 0.38 (+8%)	0.063
10-degree Trendelenburg position	1.49 ± 0.68 (+46%)	0.000	0.99 ± 0.54 (+41%)	0.000

A change is an increase or a decrease in percent compared to the supine position with head rotation.

SD – standard deviation, CSA – cross-sectional area, RIJV – right internal jugular vein, LIJV – left internal jugular vein, *p* value compared to supine position with head rotation

Table 4. Comparisons of cross-sectional area of manoeuvres and Trendelenburg position

	RIJV cm² (Mean ± SD)	*p* value	LIJV cm² (Mean ± SD)	*p* value
10-degree Trendelenburg position	1.49 ± 0.68		0.99 ± 0.54	
Hold of deep breath	1.59 ± 0.82	0.203	1.07 ± 0.64	0.089
45-degree passive leg raise	1.16 ± 0.61	0.000	0.76 ± 0.38	0.000

SD – standard deviation, CSA – cross-sectional area, RIJV – right internal jugular vein, LIJV – left internal jugular vein, *p* value compared to Trendelenburg position

shifts the diaphragm upwards and increases intrathoracic and intracardiac pressures in the right side of the heart as well. Therefore we hypothesized that the increased intra-abdominal pressure would be associated with higher CSA. However, the abdominal pressure manoeuver did not increase the CSA. On the contrary, a study by Lobato et al. showed significant increases in CSA, most likely because the patients were mechanically ventilated (20–22, 25). They analysed anesthetized patients differently from ours. Another manoeuvre, which showed an enlargement of the CSA of the IJV was the passive leg raising manoeuvre, a common practice of fluid responsiveness evaluation (26, 27). Although it was not as effective as the Trendelenburg position, this simple manoeuvre should be acknowledged since it is the least inconvenient for the patient and simultaneously could be used as a fluid challenge (28). Moreover, studies suggest passive leg raise as the preferable option for the treatment of initial hypovolemia compared to the Trendelenburg position (29). Possible limitations of our study include general limitations of ultrasound imaging, such as the variability of ultrasound images. The specificity of the studied population also contributes to the limited application of the results. These results may only be applied to young and healthy patients and must be further evaluated in alternative and clinical settings. Patients with hemodynamic derangement or those at the extremes of age were not evaluated. The study did not evaluate the inconvenience or distress caused by each manoeuvre. Further studies are needed to evaluate possible differences in manoeuvre-caused distress.

CONCLUSIONS

In conscious healthy people, either hold of deep breath or 45-degree passive leg raise (the latter limited for the right side only) are alternative manoeuvres to increase the CSA of internal jugular veins. Hold of deep breath is as effective as the Trendelenburg manoeuvre to increase the CSA of both IJVs and therefore may increase the chance of successful catheterization.

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CONFLICT OF INTEREST STATEMENT

We have no conflict of interest to declare.

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AR TRENDELENBURGO PADĖTIS YRA VIENINTELIS BŪDAS PAGERINTI VIDINIŲ JUNGO VENŲ VIZUALIZACIJĄ?

Santrauka

Tikslas. Kuo didesnis vidinės jungo venos (VJV) skerspjūvio plotas, tuo didesnė sėkmingos kateterizacijos tikimybė. Didesniam VJV skerspjūvio plotui pasiekti naudojama Trendelenburgo padėtis, tačiau ji nėra patogi sąmoningiems pacientams. Šio tyrimo tikslas - nustatyti, kuris kvėpavimo ir kūno padėties mėginys labiausiai padidina kairės ir dešinės VJV skerspjūvių plotus ir gautus rezultatus palyginti su išmatuotais Trendelenburgo padėtyje.

Medžiaga ir metodai. Atliktas prospektyvinis tyrimas, kuriame dalyvavo 63 sveiki savanoriai. Jiems ultragarsu išmatuoti kairės ir dešinės VJV skerspjūvių plotai skydinės kremzlės lygyje atliekant kvėpavimo ir kūno padėties mėginius, kai savanoriai buvo horizontalioje padėtyje, laikė galvą tiesiai ir ją pasukę 30 laipsnių kampu.

Rezultatai. Dešinės ir kairės VJV skerspjūvių plotai reikšmingai padidėjo giliai įkvėpus (vidutinis dešinės VJV plotas (cm^2) – 1,59 ± 0,82, kairės VJV – 1,07 ± 0,64 ($p < 0,001$)); Trendelenburgo padėties metu vidutinis dešinės VJV plotas (cm^2) buvo 1,5 ± 0,68, o kairės VJV – 0,99 ± 0,54 ($p < 0,001$). Kojų pakėlimas 45 laipsnių kampu padidino tik dešinės VJV skerspjūvio plotą (vidutinis plotas (cm^2) – 1,17 ± 0,61 ($p = 0,024$). Šių mėginių rezultatai buvo palyginti su duomenimis gautais Trendelenburgo padėtyje. Lyginant Trendelenburgo padėtį su giliu įkvėpimu, reikšmingo skirtumo nepastebėta: kairės VJV skerspjūvio plote – $p = 0,08$, o dešinės – $p = 0,203$. Kojų pakėlimas 45 laipsnių kampu turėjo mažesnę įtaką VJV skerspjūvio plotui ($p < 0,001$), palyginti su Trendelenburgo padėtimi.

Išvados. Gilus įkvėpimas ir kojų pakėlimas 45 laipsnių kampu (pokytis buvo tik dešinės VJV skerspjūvio plotui šio mėginio metu) yra alternatyvūs manevrai norint pagerinti VJV sąmoningų pacientų skerspjūvio ploto mėginių vizualizaciją. Gilus įkvėpimas yra toks pat efektyvus kaip ir Trendelenburgo padėtis.

Raktažodžiai: jungo vena, Trendelenburgo padėtis, ultragarsas, mėginiai, skerspjūvio plotas