

ULTRASOUND ASSESSMENT OF RIGHT INTERNAL JUGULAR VEIN DIMENSIONS FOLLOWING PASSIVE LEGS ELEVATION VERSUS HEPATIC COMPRESSION

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Abstract

Central venous catheterization has an essential role in the management of patients who are critically ill, and patients who have special operative interventions. In general, the bigger the vein cross sectional area and diameter the easier the catheterization will be. There are different maneuvers to increase internal jugular vein caliber. These include; passive legs elevation, hepatic or abdominal compression, Trendelenburg position, Valsalva maneuver, and positive end-expiratory pressure.

The objective of the study is to evaluate the effect of passive legs elevation and hepatic compression on the diameter and the cross-sectional area of the right internal jugular vein.

This prospective study included 80 adult patients ASA class I and II. Patients who had any contraindication to the passive legs elevation or hepatic compression, or those with disruption of the local neck anatomy; were excluded from the study. Patients were evaluated for their right internal jugular vein cross-sectional area and diameter by the use of linear high frequency two-dimensional ultrasound. Each patient has three stages of measurement; supine, Passive legs elevation at (30o-45o) for one minute, and hepatic compression.

Of the 80 patients, 70% were males, the age range was (19–55 years) with a mean of (37.75±12.16) years, and the majority were overweight. The maximum diameter was achieved during hepatic compression with a stepwise statistically significant increase of about (0.44±0.27 cm) from the baseline in supine position, when compared to only (0.26±0.21 cm) during passive legs elevation. The cross-sectional area is significantly and maximally increased from the baseline of (0.93 ± 0.59 cm²), during hepatic compression. The increase in the diameter and the cross sectional area was more significant in males irrespective to age and weight.

In conclusion, Hepatic compression is significantly superior to the passive legs elevation in achieving more right internal jugular vein diameter and cross-sectional area.

Key words: Internal jugular vein, supine position, passive legs elevation, hepatic compression, maximum diameter and cross sectional area.

Introduction

Utilizing the internal jugular veins (IJV) in central venous catheterization has become a mandatory part of clinical management in a variety of clinical circumstances¹ and it is an integral part in the management of critically ill patients². The anatomical landmark-guided ultrasound technique of the IJV significantly increases the success rate, decreases procedure access time, and reduces complication rate^{1,3}. Technically, the IJV cannulation is more difficult in infants and children than in adults⁴ due to

the smaller veins size and possible variable anatomical relations⁵. The variable position of the IJV and its proximity to the carotid artery may lead to this difficulty^{4,5}.

The anatomical variations in IJV position and unreliability of the external landmarks may be contributed for cannulation complications and failure². The external landmarks may not correlate precisely to the location of the vessel^{1,6}. The possible complications are; puncture of the carotid artery, neck or mediastinal

hematoma, brachial plexus injury, pneumothorax, and injury to the stellate ganglion, phrenic, or recurrent laryngeal nerve¹⁻³.

The right IJV is more preferred over the left IJV because of; its straight course into the superior vena cava, and also the pleural dome is lower on the right side. Cannulation attempts of the left IJV may have the risk for thoracic duct injury^{7,8}. Lobato et al. found that in one-third of adults, the left IJV is significantly smaller compared with the right IJV and, that may increase the level of difficulty for cannulation⁹.

There is a significant relationship between the increase in the diameter of the IJV and the success rate at the first attempt of catheterization, therefore, the bigger the diameter of the IJV the easier the catheterization will be¹⁰.

Large veins have a greater distensibility and compliance within the physiological pressure range compared to arteries. This will help to keep venous pressure within the normal range^{11,12}.

The biomechanical properties of veins depend on age, gender, body mass, and body position which is affected by gravity. In the supine position, the intraluminal pressure of IJV steeply increases, and the distensibility of the venous wall decreases this will form most of the cerebral venous drainage in the majority of healthy subjects^{11,12}.

Changing to a sitting or upright position, IJV distensibility increases as the transmural pressure approaches 0 mmHg; consequently, IJV collapses and blood flow resistance raises. In these positions, a larger part of the cerebral venous drainage is ensured by the vertebral venous system¹¹.

Even with the ultrasound guide, cannulation of the IJV can be challenging in; hypovolemic patients, those with an unstable cervical spine, a short thick neck, increased intracranial pressure, end-stage renal disease, previous IJV cannulations, and/or intraluminal

obstruction¹³. Because IJV cannulation would be easier on a large IJV, it is necessary to look for a maneuver to increase the cross-sectional area (CSA) of IJV in critically ill patients¹⁴.

The CSA of the right IJV increases with the use of the; Trendelenburg (T) position, hepatic compression, Valsalva maneuver, passive leg elevation (PLE), & positive end-expiratory pressure^{4,5,15-17}, thus improving the cannulation success rate. These procedures reduce the time of cannulation and avoids the complications associated with multiple attempts, the incidence of inadvertent arterial puncture and the number of attempts required before successful cannulation^{3,13}.

The T position and hepatic compression are used during IJV cannulation in infants and children [4]. The combination of these maneuvers offer a maximal mean increase in the CSA of the right IJV in patients who needed central venous cannulation^{4,5,15,18,19}, yet, the Valsalva maneuver or abdominal compression may be cumbersome and create discomfort to patients who are awake¹⁵.

The PLE redistributes more blood from the lower limbs into the central veins and can be performed relatively easily thus is commonly used for hypovolemic shock¹⁵. The PLE is an easier and practical maneuver to enhance the IJV congestion^{14,15}, it is as effective as T maneuver¹⁵, and could be used as an alternative to increase the IJV dimensions where the T position cannot be used, or cause a harmful effect^{10,15}, especially in mechanically ventilated patients¹⁸. In infants or small children, PLE can be performed easily so avoids the increase of intracranial pressure and does not require a table tilt for head-down position⁵.

Hepatic compression increases the CSA of the right IJV significantly in supine patients and can be used when the (T) position is not advisable or possible. Performing hepatic compression with patients in the T position may facilitate cannulation, possibly by making the vein

less collapsible due to increased intravascular pressure¹⁷. Bellazzini et al. found that hepatic compression alone would not lead to a statistically significant increase in IJV CSA in comparison with Valsalva maneuver, they also concluded that it would be better to use a combination of these two methods²⁰.

The aim of this study is to evaluate hepatic compression and passive leg raising in increasing the diameter and the cross-sectional area of the right internal jugular vein in Al-Sadr Teaching Hospital in Basrah, Southern of Iraq.

Patients and Methods

This cross sectional study was done in the outpatient clinic in Al-Sadr Teaching Hospital from May to October 2019. Ethical approval of the Iraqi Council of Anesthesia and Critical Care was obtained.

The inclusion criteria included: Patients who have American association of Anesthesia class I and II, awake non-surgical spontaneously breathing patients, and age groups ranged from 19 to 55 years.

The exclusion criteria included: Patients who refused to participate in the study, irritable patient patients with history of neck surgery or trauma, patients with history of previous right IJV cannulation, patients with goiter or any neck swelling, pregnancy, hemodynamically unstable patients, patients with abdominal swelling or distention caused by masses, hepatomegaly, or ascites, and when the maneuver interferes with the original condition, e.g. leg elevation in patients with lower extremity fracture or deep vein thrombosis or hepatic compression in patients with abdominal surgery, trauma, pain, and tenderness.

The final involved patients who fulfill the inclusion criteria were 80 patients, 56 males and 24 females. The maximum diameter and CSA of the right IJV were evaluated in using these two maneuvers

after obtaining a written consent from each patient.

Study Protocol

A GE Logiq P5 ultrasound device with two-dimensional 10 MHz linear probe was used to obtain a real-time ultrasound images. In order to eliminate the respiratory effect, the investigator selected the image showing the largest diameter and CSA which were measured by planimetry. The circumference of the right IJV was delineated using the electronic marker. The same investigator obtained all images in order to achieve consistency in measurements. The probe was applied with the lightest possible pressure and held perpendicular to the skin of the subjects in horizontal supine position. All images of the right IJV were obtained at the level of the cricoid cartilage, with the patient laying down and head rotated 15°-30° to the left side. Each patient underwent three stages of measurement; in each stage we measure the maximum diameter and the CSA of right IJV.

Stage I: First measurement was done in a supine position without applying any maneuver (control).

Stage II: Passive legs elevation was done at 30°-45° and then the second measurement was taken after one minute.

Stage III: The patients returned back to supine position for at least one minute, then hepatic compression was done by hand for one minute and after that, a third measurement was obtained.

All the other demographic characteristics were evaluated for each patient including; Age, gender, body mass index (BMI), and vital signs.

The measurements of blood pressure included systolic, diastolic blood pressure (SBP and DBP respectively), and mean arterial pressure (MAP).

Statistical Evaluation: Statistical Packages for Social Sciences Software (IBM-SPSS-23) was used. The demonstration of different variables in the study was done by using mean ± standard

deviation (SD). The paired sample t test was used to evaluate the maximum diameter and CSA. A P-value less than 0.05 was considered as significant.

Results

Table I demonstrates the different demographic characteristics of all the involved 80 patients. The mean age was

37.75±12.16 years, with an age range of 19–55 years. There were 50% of the patients below the age of 40 years. Males constituted 70% of the cohort. The mean body mass index (BMI) of the patients was in the overweight category. The preliminary readings of the means of systolic blood pressure, diastolic blood pressure, and mean arterial pressure were within normal range.

Table I: General characteristics and the baseline measurements of the enrolled patients (N=80).

Variable	Mean ± Standard deviation	N (%)
Age (years) range (19–55)	37.75 ± 12.16	
Age > 40 years		40 (50%)
Male gender		56 (70%)
Body mass index (kg/m ²)	26.53 ± 2.21	
Body mass index > 25 (kg/m ²)		28 (35%)
Systolic blood pressure (mmHg)	121.75 ± 8.89	
Diastolic bloodpressure (mmHg)	77 ± 7.18	
Mean arterial pressure (mmHg)	91.91 ± 6.86	

The maximum right IJV diameter was achieved during hepatic compression with a stepwise increase from the baseline in supine position (1.32 ± 0.43 cm) to be 1.77 ± 0.39 cm, the amount of increase was about 0.44 ± 0.27 cm, as shown in Table II-A.

Table II (A): Comparison for the right internal jugular vein maximum diameter between supine position versus hepatic compression in different patient groups.

Variables	Mean ± SD for IJV maximum diameter (cm)			Paired t test P value*
	Control	Hepatic compression	Difference Hepatic compress. to Control	
Overall	1.32± 0.43	1.77±0.39	0.44±0.27	< 0.001
Age ≥ 40 years	1.45±0.45	1.90±0.33	0.45±0.25	< 0.001
Age < 40 years	1.19±0.43	1.63 ± 0.41	0.43±0.29	< 0.001
P value**			0.807	
Men	1.39±0.36	1.88±0.32	0.48±0.28	< 0.001
Women	1.17±0.54	1.52±0.45	0.34±0.22	< 0.001
P value**			0.036	
BMI ≥25 (kg/m ²)	1.42±0.48	1.86±0.38	0.45±0.22	< 0.001
BMI <25 (kg/m ²)	1.15±0.24	1.60±0.37	0.44±0.29	< 0.001
P value**			0.791	

*Paired t test P value for horizontal comparison within one group
 **Independent student t test P value for vertical in between groups comparison.
 Abbreviations: BMI: body mass index; IJV: internal jugular vein; SD: standard deviation.

There was only 0.26±0.21 cm increase in the right IJV maximum diameter from the supine position to be 1.59±0.44 cm during passive legs elevation, as demonstrated in Table II B.

Table II (B): Comparison for the right internal jugular vein maximum diameter between supine position versus passive legs elevation in different patient groups.

Variables	Mean ± SD for IJV maximum diameter (cm)			Paired t test pvalue*
	Control	Passive legs elevation	Difference Passive legs elevation to Supine	
Overall	1.32±0.43	1.59±0.44	0.26±0.21	< 0.001
Age ≥ 40	1.45±0.40	1.70± 0.45	0.27±0.25	< 0.001
Age < 40	1.19±0.43	1.47±0.40	0.25±0.16	< 0.001
P value**			0.581	
Men	1.39±0.36	1.70±0.38	0.31±0.21	< 0.001
Women	1.17±0.54	1.31±0.44	0.14±0.17	< 0.001
P value**			< 0.001	
BMI ≥25 (kg/m ²)	1.42±0.48	1.65±0.47	0.32±0.22	< 0.001
BMI <25 (kg/m ²)	1.15±0.24	1.47±0.34	0.23±0.20	< 0.001
P value**			0.079	

*Paired t test P value for horizontal comparison within one group. **Independent student t test P value for vertical in between groups comparison.

Overall, the maximal right IJV diameter was achieved with statistical significant relationship using the hepatic compression in comparison to control, especially in males. Age and BMI show statistically insignificant relationship.

Regarding CSA of the right IJV in the control group, it was 1.34±0.82 cm² which increased by 0.38±0.33 cm² when passive legs elevation is used to be 1.72±0.92 cm² as shown in Table III A, but when the hepatic compression was applied it had increase about (0.93±0.59 cm²) from the baseline supine position to be 2.27±1.15cm², Table III (B).

Table III (A): Comparison of the right internal jugular cross-sectional area between control group versus passive legs elevation in different patient groups.

Variables	Mean ± SD for IJV CSA (cm ²)			Paired t test P value*
	Control	Passive legs elevation	Difference Passive legs elevation to control	
Overall	1.34 ± 0.82	1.72 ± 0.92	0.38 ± 0.33	< 0.001
Age ≥ 40 years	1.66 ± 0.87	2.06 ± 1.05	0.40 ± 0.43	< 0.001
Age < 40 years	1.01 ± 0.64	1.38 ± 0.63	0.36 ± 0.21	< 0.001
P value**			0.584	
Men	1.48 ± 0.84	1.93 ± 0.95	0.45 ± 0.37	< 0.001
Women	1.01 ± 0.68	1.23 ± 0.65	0.22 ± 0.15	< 0.001
P value**			< 0.001	
BMI ≥25 (kg/m ²)	1.54 ± 0.89	1.93 ± 1.01	0.39 ± 0.40	< 0.001
BMI <25 (kg/m ²)	0.96 ± 0.52	1.33 ± 0.57	0.37 ± 0.18	< 0.001
P value**			0.854	

*Paired t test P value for horizontal comparison within one group. **Independent student t test P value for vertical in between groups comparison.

Table III (B): Comparison for the right internal jugular cross-sectional area between control versus Hepatic compression in different patient groups.

Variables	Mean ± SD for IJV CSA (cm ²)			Paired t test P value*
	Control	Hepatic compression	Difference Hepatic compression to control	
Overall	1.34±0.82	2.27±1.15	0.93±0.59	< 0.001
Age ≥ 40 years	1.66±0.87	2.69±1.34	1.03±0.67	< 0.001
Age < 40 years	1.01±0.64	1.85±0.74	0.84±0.50	< 0.001
P value**			0.155	
Men	1.48±0.84	2.57±1.19	1.08±0.63	< 0.001
Women	1.01±0.68	1.58±0.68	0.57±0.28	< 0.001
P value**			< 0.001	
BMI ≥25 (kg/m ²)	1.54±0.89	2.53±1.26	0.99±0.63	< 0.001
BMI <25 (kg/m ²)	0.96±0.52	1.78±0.72	0.82±0.52	< 0.001
P value**			0.171	

*Paired t test P value for horizontal comparison within one group. **Independent student t test P value for vertical in between groups comparison.

Table IV (A) and table IV (B), additionally demonstrated that hepatic compression is significantly superior to the leg elevation in terms of both right IJV diameter and the CSA in males regardless to age and BMI.

Table IV (A): Comparison of the right internal jugular vein maximum diameter between passive legs elevation versus hepatic compression in different patient groups.

Variables	Mean ± SD for IJV maximum diameter (cm)			Paired t test P value*
	Passive legs elevation	Hepatic compression	Difference, Hepatic compression to Passive legs elevation	
Overall	1.59±0.44	1.77±0.39	0.18±0.19	< 0.001
Age ≥ 40 years	1.70±0.40	1.90±0.33	0.20±0.24	< 0.001
Age < 40 years	1.47±0.40	1.63±0.41	0.16±0.13	< 0.001
P value**			0.347	
Men	1.70±0.38	1.88±0.32	0.17±0.21	< 0.001
Women	1.31±0.44	1.52±0.45	0.20±0.13	< 0.001
P value**			0.441	
BMI ≥25 (kg/m ²)	1.65±0.47	1.86±0.38	0.20±0.23	< 0.001
BMI <25 (kg/m ²)	1.47±0.34	1.60±0.37	0.13±0.07	< 0.001
P value**			0.044	

*Paired t test P value for horizontal comparison within one group. **Independent student t test P value for vertical in between groups comparison.

Table IV (B): Comparison of the right internal jugular cross-sectional area between Passive legs elevation versus Hepatic compression in different patient groups.

Variables	Mean ± SD for IJV CSA (cm ²)			Paired t test P value*
	Passive legs elevation	Hepatic compression	Difference Hepatic compression to passive legs elevation	
Overall	1.72±0.92	2.27±1.15	0.55 ± 0.47	< 0.001
Age ≥ 40 years	2.06±1.05	2.69±1.34	0.62 ± 0.53	< 0.001
Age < 40 years	1.38±0.63	1.85±0.74	0.47 ± 0.40	< 0.001
P value**			0.160	
Men	1.93±0.95	2.57 ± 1.19	0.63 ± 0.52	< 0.001
Women	1.23±0.65	1.58 ± 0.68	0.35 ± 0.20	< 0.001
P value**			0.001	
BMI ≥25 (kg/m ²)	1.93±1.01	2.53 ± 1.26	0.60 ± 0.47	< 0.001
BMI <25 (kg/m ²)	1.33±0.57	1.78 ± 0.72	0.45 ± 0.46	< 0.001
P value**			0.168	

*Paired t test P value for horizontal comparison within one group. **Independent student t test P value for vertical in between groups comparison.

The comparison of median, mean and percentage between the groups is demonstrated in table V.

Table V: Comparison of median, mean & percentages of the increase in the internal jugular vein diameter and CSA with control using different methods. (N=80)

Maneuver		Median	25th percentile	75th percentile	Mean ± SD	P value*
Maximum diameter	Hepatic compression	36.61	14.47	55.95	40.21±29.61	< 0.001
	Legs elevation	19.06	10.66	31.21	22.86±18.42	
CSA	Hepatic compression	79.35	34.49	134.47	93.86±73.32	< 0.001
	Legs elevation	25.14	15.23	61.42	38.55±31.88	

*Paired t test P value for the difference between hepatic compression and legs elevations

Discussion

This study dealt with middle aged patients with a mean age of (37.75±12.16) years, that was nearly similar to the mean age of patients who were enrolled by Dhulkhed et al²¹ (35.65±9.69) years with a nearly similar gender distribution. The mean age was

less than the mean age of the three regional studies by Gok et al¹⁴ and Erkan et al²² in Turkey, and Masjedi et al¹⁸ in Iran who gave a mean age of 49.33±21, 47.83±15.07, and 50.5±00 years respectively. The Korean studies of Kim et al¹⁵ and Seong et al²³ dealt with

patients who were younger with a mean age 27.6 ± 1.9 and 28.15 ± 2.85 years respectively, when they compared the diameter of the IJV during supine, PLE, and different (T) maneuvers. The most famous study about the effect of different maneuvers on the IJV diameter and CSA was done on infants with a mean age of 5.8 ± 2.9 months by Verghese et al when they use Valsalva, liver compression, and different (T) positions⁴.

The majority of the involved patients were in the overweight category. The result was similar to the mean BMI of patients who were enrolled by both Magnano et al²⁴ and Gok et al¹⁴ which was in the same category around 26 kg/m^2 . Other studies were done on patients with a lower BMI like Yoon et al²⁵ and Tarnoki et al¹¹, which was around 24 kg/m^2 , and Judickas et al²⁶ which was around 22 kg/m^2 . Although there was a significant statistical relationship between the BMI of the patients and achieving the maximal CSA of the right IJV and diameter, its effect on choosing different maneuvers in different studies is minimal, because this study and the aforementioned studies were performed on normal and overweight adult patients, and it was not a restriction to any of the procedures done^{11,14,15,19,24-26}.

The mean DBP, SBP, and MAP of the patients were in the normal ranges, in concordance with other regional studies by Karaaslan et al²⁷ and Gok et al¹⁴.

Hepatic compression had achieved the maximal increase in both right IJV diameter and CSA when comparing the two parameters from that in the baseline measurements in the control group. There was statistically significant increase in the IJV diameter about $0.44 \pm 0.27 \text{ cm}$, and the CSA of the right IJV which is about $0.93 \pm 0.59 \text{ cm}^2$ from the baseline measurements during hepatic compression. The increase of CSA of the right IJV during hepatic compression was more than that achieved by Lobato et al which was statistically significant

$1.6 \pm 0.86 \text{ cm}^2$ from the baseline supine position, to be $2.16 \pm 1.20 \text{ cm}^2$, when they examine 15 adult patients undergoing central venous cannulation via the right IJV as part of their anesthetic plan compared to a control group¹⁷.

Verghese et al measured the effect of the combination of different maneuvers (Trendelenburg position, Valsalva maneuver, and hepatic compression) on the CSA of the right IJV in infants and young children, and achieved a significant increase of about 14% from the baseline supine position measurements in young children, compared to only 7% in infants. They attributed this difference to the different collapsibility of the right IJV between the two age groups and to the study characteristics, in addition to the small size and short stature that attributed minimally to the venous return making it an inefficient way to increase the size of the IJV⁴.

There was more increase in the CSA of the IJV in this study than that of Verghese et al, because the CSA of the IJV enlarges with age, a phenomenon which is more pronounced in the right IJV than the left IJV, and in males more than females²⁴.

The result of Bellazzini et al is in contradiction with this study, and the aforementioned two studies, as they concluded that hepatic pressure will not lead to a statistically significant increase in CSA of the IJV as compared with control²⁰.

Maneuvers designed to increase intravascular pressure tend to increase the CSA of the right IJV and, in turn, make the right IJV less prone to collapse when compressed²⁸. The elevation of the intravascular pressure will increase the chances of successful cannulation. Even though, the hepatic compression will not dilate the right IJV further, the progressive increase in intravascular pressure presumably makes the vessel less collapsible, thus may facilitate needle entry during right IJV cannulation^{17,29}.

Of note, the hepatojugular reflux is not commonly exaggerated in healthy subjects. Therefore, hepatic compression may be a reasonable maneuver to try in a patient with elevated right ventricular pressure²⁰.

The increase in the diameter of the right IJV and the CSA that which was achieved during the PLE in this study were less than the corresponding increase achieved by the hepatic compression; although it was significant statistically.

The passive legs elevation redistributes blood from the lower extremities into the central circulation. It is a relatively easy manoeuvre, and is used when the Valsalva manoeuvre, abdominal compression, or the Trendelenburg position may be not applicable or create discomfort to patients¹⁵.

Kim JT et al study achieved a significant increase in the CSA of the right IJV which is comparable to this study when using the PLE alone. They studied the effect of PLE in comparison to the Trendelenburg position, and found the latter to be more effective than the leg elevation in increasing the CSA in awake young adult patients who undergone IJV cannulation. They proposed that the PLE may be an alternative to the Trendelenburg position in patients who had some contraindication to the procedure¹⁵.

Gu et al¹⁹ reported a similar result to the present study and that of Kim JT et al¹⁵ in young adult patients. They also evaluate the effect of different durations of the PLE on the diameter and found that the increase in the IJV diameter is achieved when PLE lasts one minute in comparison to a decrease in diameter after 10 minutes' leg elevation. Interestingly, PLE for 10 min reduced the distended jugular veins to an extent; because the hemodynamic effects of leg elevation would reach their maximum within one min and diminish rapidly thereafter^{30,31}.

Kim WH et al study concluded that PLE was as effective as Trendelenburg

position to increase the CSA of the IJV in infants and young children only⁵.

Generally, the hepatic compression, passive legs elevation, and other maneuvers have been recommended to increase the CSA of the IJV in adults^{15,28,32}. However, studies that have evaluated some of these maneuvers in infants or young children reported few clinically significant increases in the CSA, especially in infants^{4,5}. Because IJV catheterization would be easier on a large IJV, it is necessary for evaluating the maneuver to increase in the CSA of IJV in infants and small children. The PLE can be performed easily in infants or small children, avoids increase of intracranial pressure, and does not require a tilt table to place the head in the down position⁵. Armstrong et al reported that PLE and abdominal compression achieved significant mean increase of the IJV diameter in healthy young adults (12.6 and 12.2 mm) respectively from the baseline diameter which was (11.5 mm), with similar confidence intervals²⁸.

In conclusion, the hepatic compression is significantly superior to the passive legs elevation in achieving more right IJV diameter and the CSA in the male, irrespective to age and BMI.

The main limitations of this study were: Two maneuvers only were used to increase the CSA of the right IJV.

No comparison to patients who had combination of any two maneuvers.

The study did not involve infants, neonatas, children, or adolescent age group to be compared the enrolled adult patients of 19–55 years age range.

The study recommends the following:

The use of hepatic compression as a procedure of effective right IJV cannulation whenever is applicable to achieve maximal IJV diameter and CSA for better access, especially in young adults. The use of passive leg elevation as an alternative procedure when the hepatic compression is contraindicated or not applicable.

Additional studies are needed to compare leg elevation and the hepatic compression to other procedures to achieve maximal benefits during the IJV cannulation.

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