Original Article

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Impact of positive end expiratory pressure on left internal jugular vein size

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Abstract

Background: Increasing the cross sectional area (CSA) of the left internal jugular vein facilitates cannulation and decreases complications. But, the literature is sparse regarding the methods to increase the cross sectional area of the left internal jugular vein.

Objective: To assess the changes that occur in cross sectional area of left internal jugular vein after application of different levels of positive end expiratory pressure and compare the findings with right internal jugular vein.

Methodology: Sixty-four patients were included. Antero posterior diameter, transverse diameter and cross sectional area of left and right internal jugular vein was measured using two-dimensional ultrasound before the induction of anesthesia and after intubation at positive end expiratory pressure of 0, 5, 10 and 15 cm H_2O.

Result: The increase in positive end expiratory pressure was associated with increase in cross sectional area, antero-posterior and transverse diameter of left internal jugular vein. At 10 cmH_2Opositive end expiratory pressure, left internal jugular vein cross sectional area increased significantly by 22.8% that is 1.34±0.53cm^2(P value< 0.05). The right internal jugular vein is significantly larger than left at baseline and at all levels of studied positive end expiratory pressure. The percentage increase of cross sectional area for both internal jugular veins was similar.

Conclusion: The left internal jugular vein cross sectional area increment has direct relationship with increment of positive end expiratory levels at studied points. However, above 10 cm H_2O of positive end expiratory pressure, there was only non significant increase (P value > 0.05).

Key words: Cross sectional area; Internal jugular vein; Positive end expiratory pressure.

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INTRODUCTION

Internal jugular vein (IJV) catheterization is commonly done for the purpose of fluid resuscitation, vascular access, nutritional support, dialysis or for monitoring of the central venous pressure.[1] The size of internal jugular veins changes due to various physiological factors influenced by the cardiovascular and respiratory system. The respiratory phase alteration in intrathoracic pressure, pleural and intrapulmonary pressure has direct effect on the central venous vascular size. Theoretically increasing the cross sectional area of the vein plummets the most common complication of IJV catheterization, that is, arterial puncture and increases the success rate.[2] For the purpose, Trendelenburg position, and positive end expiratory pressure (PEEP) are the most commonly used methods. These have proved to increase the diameter of right IJV.[1–4]The cross sectional area has increased by 72.5% at 15 cm H_2O PEEP when compared to 0 cm H_2O PEEP in same patient.[4]

Stenosis or thrombosis of right IJV, anatomical changes caused by head and neck surgeries and failure of right IJV catheterization will suggest the catheterization of left IJV be necessary.[5] There is not enough literature to support if the same finding as in right IJV can be applied to the left IJV.

Therefore, we planned to study; the baseline diameters and cross sectional area of left and right IJV before the induction of anesthesia. And after the intubation and mechanical ventilation; the effect of 0, 5, 10 and 15 cm H_2O PEEP levels on the CSA, transverse diameter and anterior posterior diameter of left IJV and compare the findings with the right IJV.

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METHODOLOGY

This analytical prospective study was conducted in the operating theatre of Kathmandu Medical College teaching hospital from June to August 2017. Ethical approval for the study was obtained from the institutional review committee of Kathmandu Medical College. The study included 64 American Society of Anesthesiologists (ASA) physical status Class I and II patients. Patients were enrolled in the study after written informed consent. Patients between the ages 18 to 65 of both genders posted for elective surgery under general anesthesia with endotracheal intubation were included. Patients with history of neck surgery, swelling or tumor, enlarged thyroid, previous IJV catheterization, cardiac diseases, pulmonary diseases and raised intracranial pressure were excluded from the study. Patients were also excluded after enrollment if severe hypotension occurred (persistent fall in mean arterial pressure < 60 for more than 10 minutes) after the induction of anesthesia occurred.

Fasting hours was noted and maintenance fluid with crystalloid was started if it exceeded eight hours. Standard monitors were attached to the patients. All patients received a 500 ml of crystalloid, after being positioned supine in the operating table, before induction of anesthesia. Operating table was placed in neutral position. A 10 MHz linear transducer of ultrasound probe (ExaGoNoveko International Inc.) was placed transversely at the level of the cricoid cartilage first at the left side then at right; both left and right IJV was imaged; the measurements carried out were AP diameter (AD), transverse diameter (TD) and cross sectional area (CSA) using the ellipse tool and caliper incorporated in the ultrasound machine. After baseline measurement (PI), patients were induced with 2mcg/kg of Fentanyl, 2mg/kg of Propofol and 0.1mg/kg of Vecuronium. After endotracheal intubation, patients were kept on volume-controlled ventilation mode. The tidal volume kept at 6-8ml/kg, respiratory rate of 10-12 /minute, inspiration expiration ratio of 1:2 and PEEP at 0 cm H_2O. Anesthesia was maintained with Isoflurane, oxygen and air. A target of MAC (minimum alveolar concentration) 0.8 was attained to prevent hypotension without surgical stimulation. Total fluid received during the procedure was noted.

Images of both left and right IJV with PEEP 0 cm H_2O (P 0), PEEP 5 cm H_2O (P 5), PEEP 10 cm H_20 (P10) and PEEP cm H_20 (P 15) applied in a sequence was obtained and their AD, TD and CSA was recorded. The image was obtained only after 30 seconds of the change in PEEP.

Heart rate, mean arterial blood pressure (MAP), systolic blood pressure and oxygen saturation was recorded every 2 minutes. Fall in MAP less than 60 mmHg or 20% decrease in systolic pressure was defined as hypotension. Heart rate (HR) below 60 beats per minute was defined as bradycardia and haemodynamically significant bradycardia was treated with injection Atropine and hypotension was treated with ephedrine. The primary outcome was to measure CSA, AP and transverse diameter of the left IJV at baseline and at different levels of PEEP. The secondary outcome was to compare the findings with the right IJV.

Sample size was calculated based on a study that compared the CSA of the IJV before and after applying 10 cm H_2O PEEP.[3] A minimum of 68 was calculated for sample size using alpha= 0.05, a power of 80% and 10% dropout.

All statistical analyses were performed using SPSS version 20. The statistical significant change in CSA, AP diameter and Transverse diameter was calculated using Bonferroni's method for multiple comparisons. The comparison between the CSA of left and right IJV was done using paired t-test. P value of <0.05 was considered statistically significant.

RESULTS

Out of 68 patients; 4 were excluded, as these patients did not give consent. Therefore, total analyzed patients were 64. Patient characteristics are given in Table 1.

Table 1: Demographic profile (n= 64)

Variable	Frequency
Age (years)	39.5±12.3*
Sex M/F (n)	35/29
Weight (kg)	63.81± 8.6*
ASA status I/II (n)	54/10
Fluid received during the procedure (milliliter)	143.7± 42.2*
Use of Ephedrine	1
Types of surgery (n)	
General surgery	35
Gynecology	6
ENT	23

*Values expressed as mean ± SD

In comparison to baseline value, the increase in CSA in both right and left IJV at P0, P5, P10 and P15 were statistically significant (Table 2).

Table 2: Measurements of left internal jugular vein along with the findings of right internal jugular vein

PEEP	Left IJV CSA (cm^2)	Left IJV TD (cm)	Left IJV AP diameter (cm)	Right IJV CSA (cm^2)	Right IJV TD (cm)	Right IJV AP diameter (cm)
PI	0.77± 0.2	1.05 ± 0.21	0.84± 0.15	1.47 ± 0.75	1.5 ± 0.3	1.13 ± 0.27
0	0.95±0.24*†	1.22±0.21*†	0.93±0.13*†	1.77±0.7*†	1.66±0.37*†	1.16 ± 0.2
5	1.05±0.29*†	1.29±0.23*	0.98±0.13*†	1.97±0.71*†	1.73±0.36*	1.27±0.2*†
10	1.34±0.53*†	1.41±0.23*†	1.03±0.13*†	2.38 ± 1*†	1.9±0.42*†	1.31±0.22*
15	1.44±0.38*	1.45±0.21*	1.11±0.12*†	2.92±1.1*†	2.06±0.44*†	1.45±0.21*†

Data are given as mean ± standard deviations.*P < 0.05 compared with PI.†P < 0.05 compared with immediate previous PEEP levels. IJV, internal jugular vein; CSA, cross sectional area; TD transverse diameter; AP antero-posterior diameter , PI, preinduction; PEEP, positive end expiratory pressure in cm H_2O

The percentage change after increment of every 5 cm H_2O PEEP is given in Table 3.

Table 3: Comparison of percentage increase from immediate PEEP in cross sectional area of left versus right internal jugular vein

PEEP cm H_2O	Left IJV (%)	Right IJV (%)	P value
5	8.86	9.78	0.75
10	22.8	21.4	0.66
15	31.5	36.6	0.116

Data are given as percentage (%). PEEP= positive end expiratory pressure.

The CSA of the left and the right IJV has been compared with respect to different levels of PEEP (Table 4).

Table 4: CSA of left and right internal jugular vein at pre induction and at different levels of PEEP

PEEP cm H_2O	Left IJVcm^2	Right IJV cm^2	P value
PI	0.77± 0.2	1.47 ± 0.75	0.00
0	0.95±0.24	1.77±0.7	0.00
5	1.05±0.29	1.97±0.71	0.00
10	1.34±0.53	2.38 ± 1	0.00
15	1.44±0.38	2.92±1.1	0.00

Data are given as mean ± standard deviations. PEEP, positive end expiratory pressure; PI, pre induction.

The hemodynamic parameters are given in Figure 1.

Data are given as mean ± standard deviations, HR, heart rate (beat/min); SBP, systolic blood pressure in mmHg; MAP, Mean arterial pressure in mmHg; PEEP, positive end expiratory pressure in cm H_2O.

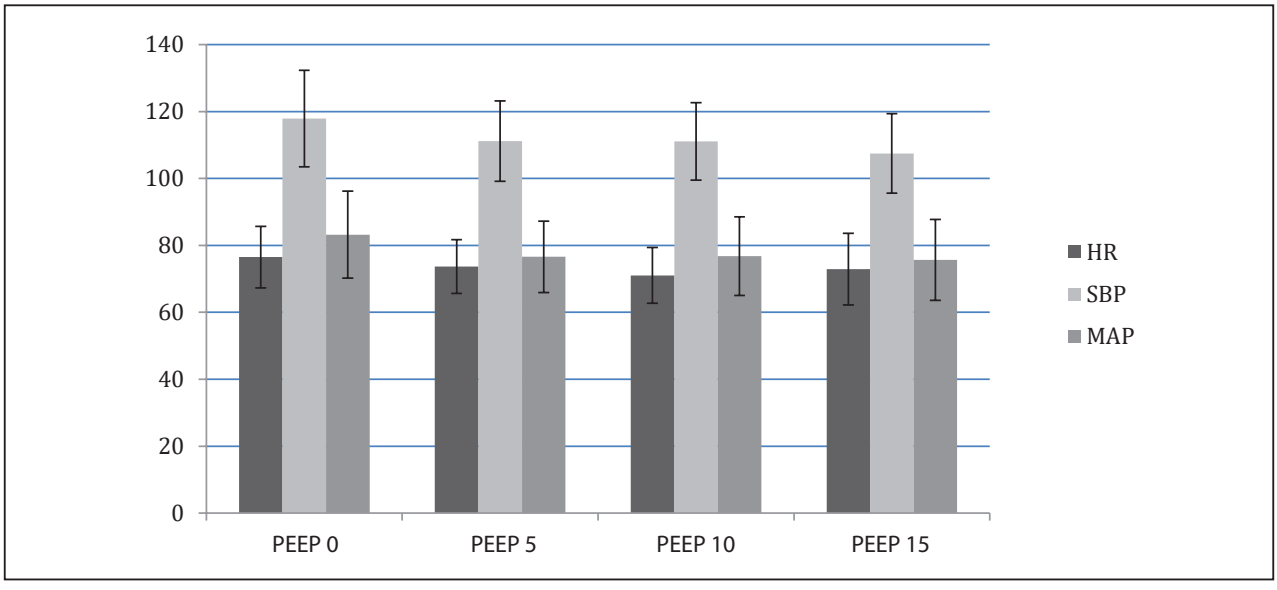

Figure 1: Hemodynamic parameters.

DISCUSSION

Our study shows that there is significant increase in CSA, AP and transverse diameter of left IJV after the patient is intubated and put on intermittent positive pressure ventilation than the baseline values. Furthermore, the increment in AP diameter is significant with each increase in PEEP with respect to the initial pre-intubation value and also to the immediate previous PEEP. The CSA and transverse diameter however increased significantly until 10 cm H_20 PEEP when compared with 5cm H_2O PEEP. Further increase in PEEP only resulted in non-significant increase (P value > 0.05). The right IJV on the other hand, shows a constant increase in CSA with addition of each PEEP value. In contrary to left, the right IJV has statistically significant increase in its CSA when compared to immediate previous PEEP value even at 15 cm H_2O PEEP.

While comparing the effect of different PEEP values on the CSA of left and right IJV, the percentage increase shows a similar trend. Though many studies have focused on the right IJV, our study has made an attempt to find if the same findings on the right can be applied to left as well. Accordingly, since there is no significant difference in percentage increase for both IJV at different levels of PEEP, it can be implied that the effect of increased intra-thoracic pressure is equal for both left and right IJV. Inherently, the larger right IJV has a greater influence with increasing trend of PEEP.

The CSA of both sides has increased in comparison to the baseline values. However, when two are compared, the right IJV is significantly larger than the left at baseline before induction of anaesthesia and after intubation at 0, 5, 10 and 15 cm H_2O PEEP. The right and the left IJV has been compared previously but with change in position from supine to Trendelenburg. They found that in supine position the CSA of right IJV was larger than the left and also the increase in CSA after 10° Trendelenburg position was larger for right.[2]

Increase in CSA is associated with a high success rate of catheterization and less complications. Different maneuvers such as Trendelenburg position, abdominal compression, valsalva, inspiratory hold, PEEP has been used in increase the diameter of the right IJV. Up to 48%, 76% and 45% increase in the CSA by Trendelenburg position[6], Valsalva[7] and inspiratory hold[8] respectively has been claimed and inspiratory hold[8]respectively has been claimed. The Trendelenburg tilt, though has time and again proved to increase the vein diameter, remains unfeasible for obese and hemodynamically unstable patients.[9]In fact, it has been observed that Trendelenburg might further decrease the CSA.[10]

PEEP is a consistent, reproducible and hands free technique to increase the vein diameter. Superior venacaval compression caused by increased intrathoracic pressure is responsible for dilatation of IJV. Different levels of PEEP have been applied to increase the CSA of right IJV. However most of the studies are concerned with just right IJV.[3,4,11]And the level of PEEP, that maximally dilates the left IJV has never been researched. The findings of our study show that the left IJV is dilated significantly at 10 cm H_20 of PEEP without hemodynamic compromise in ASA I and II anesthetized patients.

In a study by Hollenbeck[3] 10cm H_2O PEEP was added to adult patients in supine position and the increase in CSA of right IJV was by 41% and up to 50% in women. Our findings show only around 22% and 21% increase in CSA at 10 PEEP of left and right IJV respectively. Only with addition of 15 PEEP the increment was observed by another 10%. Lee et al[4] demonstrated the increase in right IJV CSA by 37.4,51.9, 66.5 and 72.44% with 3, 6, 9,12 and 15 cm H_2O PEEP respectively applied in a random sequence. But above 12 PEEP significant decrease in mean arterial pressure was seen in 28% of patients. The vasoactive medications were required in 7 patients at 12 cm H_2O PEEP and 12 patients at 15cm H_2O PEEP. The measurements were made after 1 minute of change of PEEP. Our results do not demonstrate such dramatic increase in CSA of both right and left IJV but at the same time, no hemodynamic changes were observed either. Just one patient required vasopressor at 15 cm H_2O PEEP. We had however only waited for 30 seconds after application of new PEEP value. This could have made the percentage increase lesser in comparison.

It has been documented that veins <7 mm in diameter had high incidence of complication rates during catheter placement.[12] Ultrasound guidance for percutaneous puncture of the internal jugular vein provides many advantages over the classic landmark-guided technique, particularly in complicated cases e.g. thrombocytopenia, obesity, dyspnea. In this study the CSA of left IJV in non-anaesthetized patients is 0.77 ± 0.2cm^2. A vein diameter with low failure rate was 1.62 cm according to Gordon et al.[13] In our data even with 15cm H_2O PEEP, the maximum CSA attained was 1.44±0.38 cm^2 for left IJV.

The right IJV is usually the obvious choice for catheterization due to its larger size and favorable

anatomy. Its straighter course into the right atrium and a consistent position in relation to common carotid artery are to name a few.[14] Left IJV is relatively uncommon territory for practitioners due to its anatomical disadvantage. It is smaller in size and there is chance of injury to the thoracic duct.[15] But in some scenarios, left IJV has to be chosen. The maneuvers that decreases the complications and increases the success rate should be employed. With larger CSA, transverse diameter and AP diameter the probability of untoward events, plummets significantly. With increase in AP diameter, the chances of needle puncturing the posterior wall diminish. Furthermore, prevents compression of IJV leading to easy aspiration of venous blood while advancing the needle.[16] Wider transverse diameter, gives a larger target for the needle.[3]

The limitation of our study was that it was performed on healthy patients. Critically ill patients may not tolerate PEEP higher than 8 cm H_2O. Though we did not encounter significant hemodynamic changes, it is possible in dehydrated and critically ill patients. Moreover, in the modern era of ultrasound assisted venous catheterization, the success rate has approached to 98% at first attempt.[11] However, since application of PEEP increases the diameter of left IJV, thereby increasing the target area.

CONCLUSION

The ultrasound imaging of veins reveals that the cross sectional area, antero-posterior and transverse diameters of left IJV increases significantly with increase in PEEP. We advise the application of some level of PEEP for vein dilatation, upto10 cm H_2O PEEP leads to significant increment in size of left IJV.

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