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Effects of Positive End-Expiratory Pressure on Internal Jugular Vein Cross-Sectional Area in Anesthetized Adults

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A B S T R A C T

Introduction: Central vein catheterization is a common procedure performed on critically ill patients to monitor cardiac filling pressures and to administer medications and parenteral nutrition. In the operative setting, the internal jugular vein is the vessel most often used to place a central venous line because of easy access and because, in the majority of cases, it is excluded from the surgical field. Increasing the cross-sectional area (CSA) of the internal jugular vein (IJV) improves the success rate of cannulation and decreases complications.

Objectives: To find out the effects of positive end-expiratory pressure on internal jugular vein cross-sectional area in anesthetized Indian adults.

Methods: This is a prospective observational study comprising of 48 patients satisfying the inclusion criteria and undergoing elective surgery under general anesthesia using an endotracheal tube. The following variables like age, sex, ethnic group, weight, associated diseases and its status, were recorded in all patients before induction. Minimum mandatory monitors attached vitals like HR, BP, SpO2, EtCO2, peak pressure and plateau pressure before and after the application of PEEP (PEEP 8). The operating table was placed in a level position in the transverse and longitudinal planes and the patient was positioned with head in neutral position. Five minutes after initiation of mechanical ventilation, USG assessment of the RIJV CSA at the level of the cricoid cartilage using B-mode duplex sonography with a 8- to the 18-MHz linear transducer (VENUE 40 US Wide-band high frequency linear array.) using a standardized technique applying minimal probe pressure to obtain an adequate sonographic image.

Measurements of transverse and anteroposterior (AP) diameters of the right IJV were obtained at PEEP= 0 (cm H_2O).Then PEEP in increased to 8 cm H2O. After waiting for 2 minutes, the same investigator obtained a second sonographic image of the RIJV at the same location on the neck. And measurements of transverse and anteroposterior (AP) diameters of the right IJV were again obtained. Depending on the ventilation, the right IJV CSA varies in size; the image is frozen, stored and measured (with the internal calipers in USG) when the largest area is obtained.

Results: There was significant increase in AP diameter, CSA and TD with the application of PEEP 8 cmH2O. The TD increases to a 23.58% and APD increases to 17.44% on application of PEEP. TD increases more with application of PEEP than APD. Thus, the CSA of IJV is increased in patients on application of PEEP 8 cm H2O - (P value 0.0001).

Conclusion: The application of PEEP effectively increases the CSA of the IJV.

Keywords: PEEP, Jugular vein, Ultrasonography.

INTRODUCTION

Central vein catheterization is a common procedure performed on critically ill patients to monitor cardiac filling pressures and to administer medications and parenteral nutrition(1). Typical central venous catheter sites include the

internal jugular, femoral, and subclavian veins[2]. In the operative setting, the internal jugular vein is the vessel most often used to place a central venous line because of easy access and because, in the majority of cases, it is excluded from the surgical field[3]. Usually, the right internal jugular vein is larger than the left side because it is aligned better with the major veins and right atrium[4]. Therefore, the right internal jugular vein is used frequently as the site for central venous catheterization[5].

Central venous access under ultrasound guidance is widely supported in current medical practice. Before the advent of Ultrasonography (USG), we used the landmark-guided technique for internal jugular vein (IJV) cannulation. The most dangerous as well as the most common complication associated with the landmark-guided internal jugular vein cannulation was carotid artery puncture, and its incidence ranges from 6% to 25%[6,7] . A hematoma produced by carotid artery puncture could be fatal because it may compress the airway or lead to a cerebrovascular accident [8]. Anatomical variations of the IJV may be seen and in 5.5% of patients, it is medial to the common carotid artery [9]. Therefore, during the landmark-guided technique, it will affect the success rate of cannulation. With Ultrasound guidance, the success rate of internal jugular vein cannulation has increased, with a definite decrease in the complications.

Approximately 18% of the Patient's IJV is less than five mm in diameter, and therefore it is difficult to cannulate that vessel even with USG guidance [10]. Thus, the success rate for IJV cannulation correlates with the cross-sectional area (CSA) of the vein.

Various methods such as head-down tilt of varying extent, the Valsalva maneuver, hepatic compression and positive intrathoracic pressure in ventilated patients have been proposed to increase jugular filling[11]. Thus, the venous diameter of the IJV will be increased, which will facilitate easy cannulation and reduce potential side effects. Among them, an easy way to change the CSA of the internal jugular vein in an anesthetized patient is to change the Positive End-Expiratory Pressure (PEEP) of the patient. Moreover, the application of prophylactic PEEP of 5-8 cm of H2O (in non-hypoxemic ventilated patients) will reduce the number of hypoxemia episodes and the incidence of ventilator-associated pneumonia[12].

Previous studies have already evaluated the effectiveness of application of Positive End-Expiratory Pressure on cross-sectional area of IJV in the American population. Although Indian sub-continent accounts for 25% of world population[13], only very few definitive studies have been done on this ethnic group. The purpose of this study was thus to compare the effectiveness of application of PEEP (PEEP 8), versus no PEEP (PEEP 0) in the Indian population, during IJV cannulation under USG guidance.

MATERIALS AND METHODS

This prospective observational study was conducted to assess the difference in the cross-section area of IJV in baseline PEEP and the last measurement. The study was commenced after obtaining Institutional research committee and ethical committee clearance obtained, No: AIMSIEC/74/2017 and dated on 25/11/2017. 48 patients satisfying the inclusion criteria and scheduled for surgery under general anesthesia with endotracheal intubation were added after taking informed written consent. Standard anesthesia monitoring consisting of ECG, pulse oximetry, capnography, and non-invasive blood pressure measurements. Ultrasound quantification of AP diameter and transverse diameter with **VENUE 40 US Wide-band high frequency linear array.**

After 3 minutes of preoxygenation, anesthesia was induced with an opioid (fentanyl 1.5mcg/kg), induction agent (propofol titrated to loss of verbal communication), Sevoflurane and a muscle relaxant (vecuronium 0.1mg/kg). Laryngoscopy was done with full muscle relaxation. The patient was intubated with appropriately sized cuffed endotracheal tube and set to mechanical ventilation(Volume control mode).Basic settings with tidal volume (7-10ml/kg), RR(10-12 breaths /min.) inspiratory to expiratory ratio 1:2,PEEP= 0 (cm H_2O), Fi$O_2$of 40%-50% was kept and maintained with sevoflurane in a mixture of nitrous oxide and oxygen.

The operating table was placed in a level position in the transverse and longitudinal planes and the patient was positioned with head in neutral position. Five minutes after initiation of mechanical ventilation, USG assessment of the RIJV CSA at the level of the cricoid cartilage using B-mode duplex sonography with a 8-18-MHz linear transducer (VENUE 40 US Wide-band high frequency linear array.) using a standardized technique applying minimal probe pressure to obtain an adequate sonographic image.

Measurements of transverse and anteroposterior (AP) diameters of the right IJV were obtained at PEEP= 0 (cm H_2O). Then PEEP in increased to 8 cm H2O. After waiting for 2 minutes, the same investigator obtained a second sonographic image of the RIJV at the same location on the neck. And measurements of transverse and anteroposterior (AP) diameters of the right IJV were again obtained. Depending on the ventilation, the right IJV CSA varies in size; the image is frozen,

stored and measured (with the internal calipers in USG) when the largest area is obtained. Highly qualified consultants, who have more than 5 years of experience in USG guided technique, do all procedures. They have done at least 100 IJV cannulation.

The data will be entered in to excel worksheet and analysis performed using SPSS 23. Normality of data will be tested using Shapiro wilk test if normal the difference between baseline value and last measurement of PEEP analyzed using ‘’**Paired t-test**’ ’and if not ‘’Sing rank test ‘’. The direction of the PEEP values and the cross-section area if IJV analyzed by Pearson correlation coefficient.

RESULTS AND GRAPH

The study population consisted of males (31.3%) and females (68.8%). The mean age of patients in the study was 42.708 ± 12.7679 years. Our results show that, both TD and APD will be increased with the application of PEEP. The TD and APD both will contribute to the increment of RIJV CSA. Statistical tests were done to identify which will contribute maximum for the increment of RIJV CSA.

Table 1: The application of a PEEP (PEEP - 8) shows a definite positive relationship with an increase in the RIJV diameters.

Variable		Mean	N	Std. Deviation	P Value (Student’ s t test)
T. Diameter	PEEP0	1.4148	48	.29510	0.0001
	PEEP8	1.6506	48	.31809	
AP. Diameter	PEEP0	.9519	48	.19975	0.0001
	PEEP8	1.1263	48	.18793	
CSA	PEEP0	4.3142	48	1.61209	0.0001
	PEEP8	5.9029	48	1.82330	

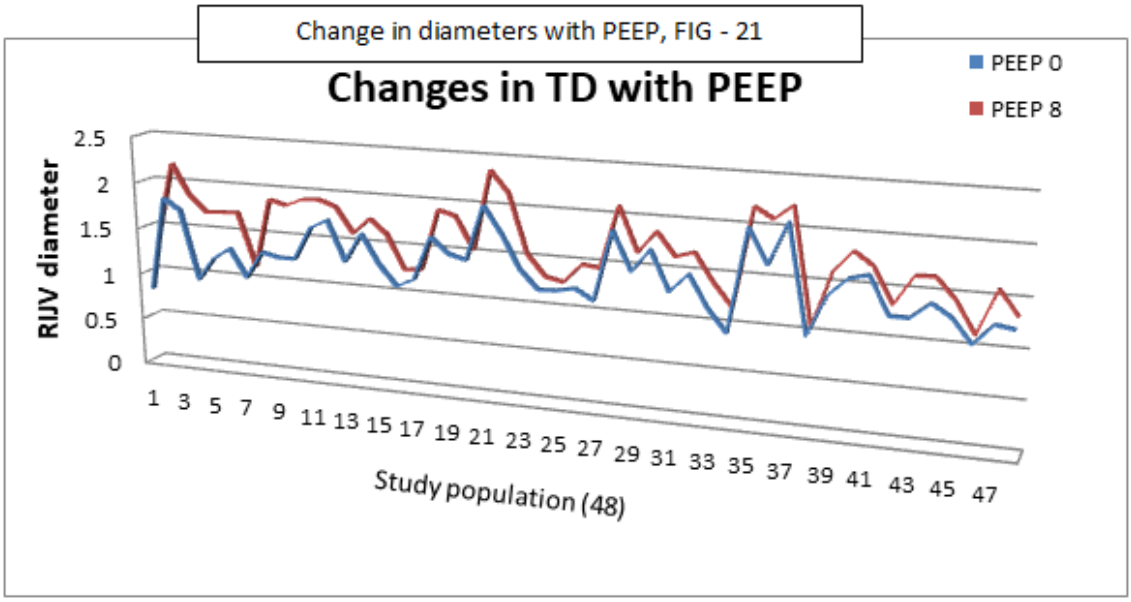

Figure 1: Changes in TD in cm in the study population

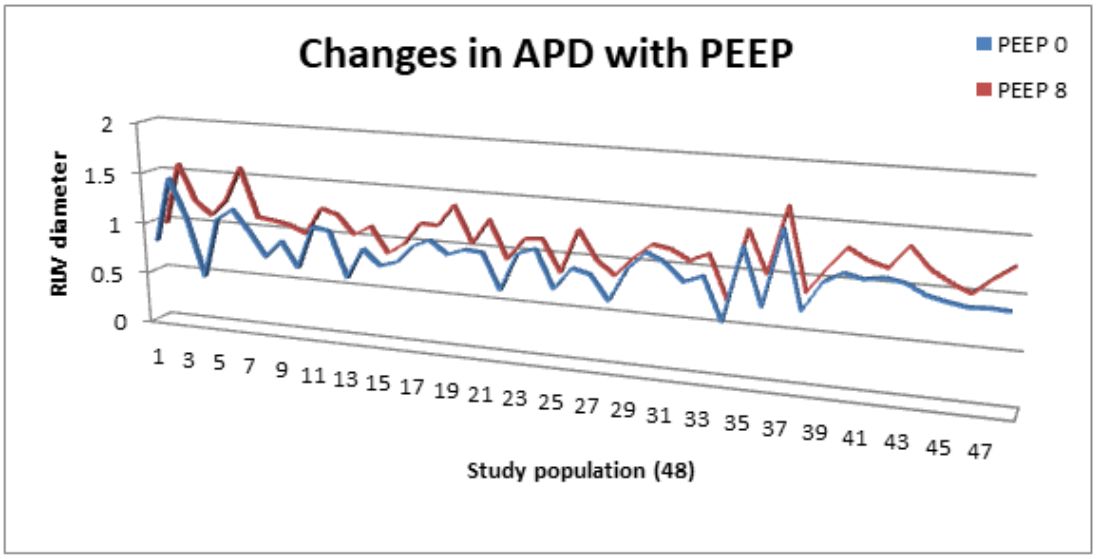

Figure 2: Changes in AP in cm in the study population (48)

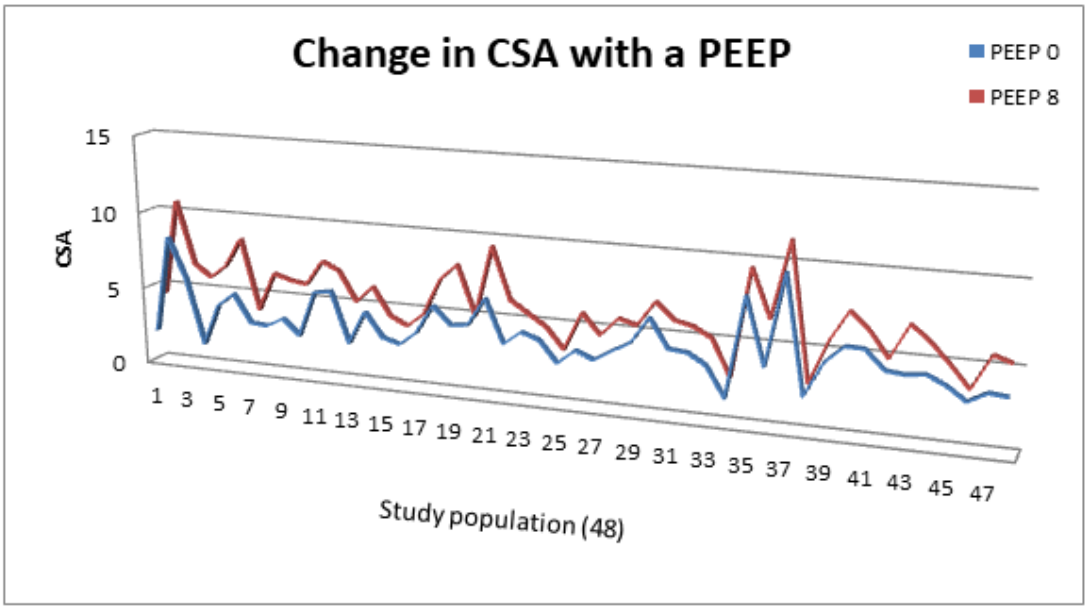

Figure 3: Changes in CSA in cm^2 in the study population (48)

Table 2: Increase in TD and APD with PEEP

Group	N	Mean	Std. Deviation	P Value (Student' s t test)
TD	48	1.4148	.29510	0.0001
APD	48	.9519	.19975	

The mean value of TD of the study population is 1.414 with a SD of .29510, but the change in TD with the application of the PEEP was calculated by subtracting the mean values of PEEP 0 from PEEP 8. Similarly, the APD mean value is .9519 with a SD of .19975. By calculating the change in mean values for both TD (0.2358) – 23.58% and APD (0.1744) – 17.44%, it is evident that the TD is contributing more for the increment of CSA.

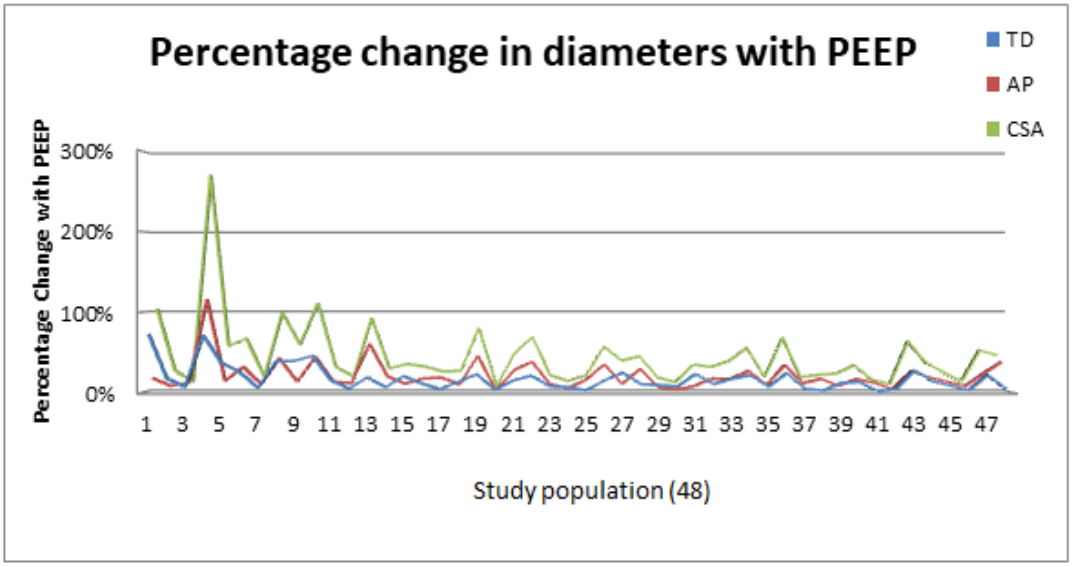

Figure 4: Shows application of PEEP results increment of CSA from 12% to 264%.

DISCUSSION

Our study was designed to compare the effects of positive end-expiratory pressure (PEEP 8) over absent PEEP (PEEP 0) state, on internal jugular vein cross-sectional area in anesthetized adults. Study population was 48 adults, who belong to ASA I & ASA II and age group of above 18 years. As the difference in CSA of RIJV with different PEEP settings were measured in the same patient, both the control and the study group were the same. Thus, the confounding factors between the control and the study group were absent. All patients were given general anesthesia, intubated following a standardized technique and the table was kept in neutral position. In the both settings of PEEP, the maximum CSA of RIJV was obtained after several (3-4) attempts, using B-mode duplex sonography with 8-18-MHz linear transducer (VENUE 40 US Wide-band high frequency linear array). This was to minimize the effect of respiration and compression produced by USG probe. Minimum mandatory monitors were monitored throughout the procedure. The relevant data of each patient was recorded and the results were statistically analyzed.

Our results demonstrate the influence of PEEP on the CSA of the RIJV in anaesthetized adult patients undergoing intermittent positive pressure ventilation. Multiple investigations using ultrasound assessed the effect of dynamic maneuvers on the size of the IJV. Trendelenburg position and Valsalva maneuver are the most common clinical techniques used to promote superior vena cava filling.[14,15]

This study shows that application of PEEP as the sole maneuver increases the size (CSA, transverse, and AP diameters) of the RIJV to an extent similar to other frequently used techniques in the majority of patients. The increased CSA may be associated with more success rate of IJV cannulation. The increased transverse diameter may provide a larger target for needle entry. In addition, the increased AP diameter may prove beneficial in those cases whereby IJV compression prevents aspiration of venous blood during advancement of the needle, possibly preventing injury to a carotid artery positioned posterior to the IJV. There was decrease in CA overlap after adding PEEP 8 cm of H2O compared to baseline value without PEEP in Trendelenburg position.[16]

Physiological PEEP of a normal adult produced by vocal cord is approximately 5cm of H2O. So addition of PEEP 5 cmH2O in a intubated patient did not produce any significant increase in CSA. Therefore, at least PEEP 10 cmH2O is required to significantly increase the CSA of IJV(35). So in our study we took the upper limit of PEEP as PEEP of 8 cm of H2O. Marcus et al. did not find any significant increase in CSA after adding PEEP 5–10 in Trendelenburg position. The difference in the finding can be explained by methodological differences. We allowed 2 min time between application of PEEP and noting the parameters, whereas in a previous study they allowed only 30 s. Addition of PEEP increases intrathoracic pressure and thereby increases CVP and IJV dimension. However, the time required to achieve these changes is not known. Allowing more time perhaps led to better equilibration of pressure transmitted to the venous system in our study.[17,18]

There was decrease in CA overlap after adding PEEP 8 cm of H2O compared to baseline value without PEEP in Trendelenburg position. Previous studies also found that application of the Valsalva maneuver decreases the overlapping with the common CA. [19,20,21]

We have evaluated the other factors like BMI, age, gender, ASA status of the patient , associated diseases like (DM, HTN, CAD, Hypothyroidism) which may have an effect on the increment of CSA of RIJV on application of a PEEP (PEEP 8). And found to be no association between these factors in the increment of CSA of RIJV on application of PEEP.

CSA is the product of Transverse diameter and the Anteroposterior diameter. From the data, we came to know that the increase in the transverse diameter contributes more to the increment of CSA of RIJV than the anteroposterior diameter on application of a PEEP. For all study population the vitals were in acceptable range, with a mild tachycardia and a mild hypotension because of the Valsalva reflux. Peak and plateau pressures where in normal range even with application of 8 cm of H2O PEEP.[22]

From this study we found that application of PEEP may be an acceptable alternative when ultrasound visualization is not optimal or not available or other techniques are inadvisable because of patient comorbidities, equipment, or personnel limitations.

CONCLUSION

From the study, it may be reasonable to conclude that size of the IJV influence the success rate of the cannulation, Application of PEEP is an easy method to achieve the reasonable dilatation and to reduce the complications like carotid artery puncture and through and through passing of needle through posterior wall of IJV. Application of a PEEP within a physiological range will not increase the airway pressures above the safety margin. The increment of CSA of IJV do not varies with age, sex, BMI, ASA status, other co-morbidities of the patient

LIMITATION

1) The sample population size was adequate for the study but still small in number. A still larger study population would have given clearer results.
2) We did our study in Indian population alone. A larger multicenter study involving different ethnic groups would have given clearer and better results.
3) The observer was not blinded and hence might have resulted in bias.
4) The study population could have extrapolated to involve patients, who belong to the all ASA category and all age group.

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