

# The Effect of PEEP on Cross Sectional Area of Right Internal Jugular Vein in Anaesthetised Patients Using Ultrasonography - An Observational Study

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## ABSTRACT

### BACKGROUND

Central Venous Cannulation is a very important technique needed intra operatively and in critical care setting. Most commonly accessed is the right internal jugular vein due to lesser incidence of complications and easy accessibility. Ultrasound guidance improves the successful insertion rate than blind technique. Increasing the cross-sectional area (CSA) of IJV improves the success rate and decreases complications. Several manoeuvres such as Trendelenburg's position, Valsalva's manoeuvre, hepatic compression and positive end-expiratory pressure have been used to increase the diameter of the IJV. Application of PEEP of 10–12 cm H<sub>2</sub>O in supine position has been found to increase the CSA of right IJV in various studies. The aim of the study is to determine the optimal PEEP which increases size of IJV without complications.

### METHODS

This is an observational study conducted in the Government Medical College, Thrissur. The groups were chosen from instances where three different levels of PEEP were used. A total of 90 ASA PS 1 & 2 patients who received general anaesthesia for elective surgeries were assigned to three groups - P0, P5 and P10 with different values of PEEP- 0, 5, and 10 cm of H<sub>2</sub>O respectively. Patients with obesity, raised intracranial pressure, previous neck surgery were excluded from the study. After application of PEEP for 2 minutes, the diameter of Right Internal Jugular was sonologically measured. The increase in cross sectional area of IJV in each group was analysed. Application of PEEP affects heart rate and mean arterial pressure in patients. So, the heart rate and mean arterial pressure readings were taken at the time of measurement of IJV. These were also analysed statistically.

### RESULTS

The three groups P0, P5 and P10 were comparable in demographic parameters like age and weight. Cross-sectional area of three groups was compared. The mean CSA in P0 was 1.3345, P5 was 1.399 and P10 was 1.443 cm<sup>2</sup> (p .001). There was a statistically significant increase in cross-sectional area of IJV when PEEP was applied. Increase in CSA was significantly higher with higher PEEP (p .001).

### CONCLUSIONS

The application of PEEP of 5 to 10 cm of H<sub>2</sub>O is a safe method to increase the area of IJV for successful cannulation. This value of PEEP did not cause clinically significant haemodynamic effects.

### KEYWORDS

PEEP, Cross-Sectional Area of IJV, Sonoanatomy, IJV Cannulation

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**BACKGROUND**

Central Venous Cannulation is a very important skilled technique needed perioperatively and in critical care setting. Most commonly accessed is the Right Internal Jugular due to lesser incidence of complications and easy accessibility. With landmark-guided internal jugular vein (IJV) cannulation technique, the rate of mechanical complication (pneumothorax, haematoma, line misplacement and haemothorax) is 10%–15% and unsuccessful insertion is up to 20%.<sup>1</sup> Although ultrasound guidance improves the successful insertion rate to 93.9%, first-attempt success rate is only 82% and carotid puncture rate is up to 5.9%.<sup>2</sup>

Ideally, a first-pass technique will minimise risk and maximise success.<sup>3</sup> Increasing the cross-sectional area (CSA) of IJV improves the success rate of puncture and decreases complications. Several manoeuvres such as Trendelenburg’s position, Valsalva’s manoeuvre, hepatic compression and positive end-expiratory pressure have been used to increase the diameter of the IJV. Application of PEEP of 10–12 cm H<sub>2</sub>O in supine position has been found to increase the CSA of right IJV in various studies.<sup>4,5</sup>

Clinically application of PEEP and Trendelenburg position increases diameter of IJV. But it also increases the overlap of Carotid artery with IJV, increasing the risk of arterial puncture and haematoma formation. So, the aim of the study is to determine the optimal PEEP which increases size of IJV without complications. The sonoanatomy of IJV (cross-sectional area) with 5-10 cms of PEEP is observed. The hemodynamic variables heart rate and mean blood pressure are also simultaneously observed.

The objective of this study is to evaluate the effect of two different levels of Positive End Expiratory Pressure (PEEP) on cross-sectional area of (R) IJV using ultrasonography.

**METHODS**

This is an observational study conducted among ASA PS 1 & 2 patients undergoing elective surgery under general anaesthesia in the Government Medical College, Thrissur, Kerala, India, over a period of one year.

**Exclusion Criteria**

- 1) history of neck surgery
- 2) morbid obesity
- 3) raised intracranial pressure (ICP)
- 4) haemodynamically unstable patient
- 5) history of previous right IJV cannulation
- 6) short neck

Sample size is calculated using the formula.

$$n = \frac{(z\alpha + z\beta)^2 \times p \times q \times X^2}{d^2}$$

Substituting with a value of 5%, β of 20% (power of study 80%)

$$p = P_1 + P_2/2$$

$$(9.58 + 44.95)/2 = 27.2,$$

$$q = 100 - 27.2 = 72.74,$$

$$d = p_1 - p_2 = 35.37$$

$$\frac{(1.96 + 0.842)^2 \times 27.2 \times 72.4 \times 2}{(35.37)^2} = 24.88 \sim 25 \text{ per group.}$$

Sample Size extended to 30 per group.

**Study Procedure**

The study is designed to have three groups namely P0, P5, and P10. The groups are chosen from different anaesthesia tables which use zero PEEP, 5 PEEP, and 10 PEEP. After induction of General anaesthesia with standard drug protocol and monitoring, observations are made by the investigator. The patient is placed supine with neck turned 30° to left. Before surgical intervention, Ultrasound probe is placed on right side of neck at the level of cricoid cartilage. Probe is placed in short axis view to visualize (R) IJV and screen shots are taken. The readings are taken without PEEP and after 2 minutes of applying, 5 cm PEEP, 10 cm PEEP in each group.

Study tools used was Sonosite M-Turbo ultrasound machine with 6-13 Hz linear probe.

**RESULTS**

Statistical analysis was performed using SPSS 21.0 software (IBM Corporations, Chicago). Data are presented as mean ± standard deviation/median (range). The changes in measured parameters among the three groups are compared using repeated measures and ANOVA. The Cross-sectional area of IJV, patient’s heart rate and mean arterial pressure are compared using ANOVA.

Variable	Group	Minimum	Maximum	Mean	S.D.	95% Confidence Interval for Mean		P Value (ANOVA)
						Lower Bound	Upper Bound	
Age in Years	P <sub>0</sub>	22.00	60.00	38.8000	10.86088	34.7445	42.8555	0.697 <sup>s</sup>
	P <sub>5</sub>	19.00	68.00	41.1000	12.91177	36.2787	45.9213	
	P <sub>10</sub>	20.00	53.00	40.7333	9.72708	37.1012	44.3655	
Weight (kg)	P <sub>0</sub>	40.00	68.00	54.9333	8.46874	51.7711	58.0956	0.728 <sup>ns</sup>
	P <sub>5</sub>	40.00	70.00	55.8667	8.97019	52.5171	59.2162	
	P <sub>10</sub>	38.00	68.00	54.1333	7.76701	51.2331	57.0336	

**Table 1. Demographic data**

	Male	Female
P <sub>0</sub>	14	16
P <sub>5</sub>	16	14
P <sub>10</sub>	18	12

**Table 2. Sex Ratio**

The three groups P0, P5 and P10 were comparable in demographic parameters like age and weight. Mean age

ranged from 38.8 to 41.10. Mean weight ranged from 54.13 to 55.87 Kg.

Variable	Minimum	Maximum	Mean	S.D.	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Age	19.00	68.00	40.2111	11.16324	37.8730	42.5492
Weight	38.00	70.00	54.9778	8.35178	53.2285	56.7270
IJV	1.26	1.50	1.3923	.05533	1.3807	1.4039
HR	54.00	114.00	81.4444	15.08561	78.2848	84.6041
BP	50.00	96.00	67.2111	9.42921	65.2362	69.1860

**Table 3. Comparison of IJV, HR, BP**

The cross-sectional area of three groups were compared. The mean CSA in P0 was 1.3345, P5 was 1.399 and P10 was 1.443 cm<sup>2</sup>. Statistical analysis showed significant increase in CSA (p value = .001).

The application of PEEP affects Heart rate and Mean arterial pressure in patients. So, the heart rate and mean arterial pressure readings were taken at the time of measurement of IJV.

Analysis showed that there was no statistically significant difference in heart rate among three groups. But there was a decrease in mean arterial pressure in the higher PEEP groups.

Variable	Group	Minimum	Maximum	Mean	S.D.	95% Confidence Interval for Mean		P Value (ANOVA)
						Lower Bound	Upper Bound	
Cross-sectional Area of IJV	P <sub>0</sub>	1.26	1.41	1.3345	.04302	1.3184	1.3505	.0001 <sup>s</sup>
	P <sub>5</sub>	1.31	1.46	1.3995	.02766	1.3892	1.4099	
	P <sub>10</sub>	1.40	1.50	1.4429	.02479	1.4337	1.4522	
Heart Rate per Min	P <sub>0</sub>	54.00	110.00	77.0667	15.05377	71.4455	82.6878	0.123 <sup>NS</sup>
	P <sub>5</sub>	54.00	108.00	82.4000	14.62544	76.9388	87.8612	
	P <sub>10</sub>	56.00	114.00	84.8667	15.00054	79.2654	90.4680	
Mean Arterial Pressure (mm of Hg)	P <sub>0</sub>	50.00	96.00	67.6000	8.93501	64.2636	70.9364	0.001 <sup>s</sup>
	P <sub>5</sub>	50.00	88.00	71.5333	10.41793	67.6432	75.4235	
	P <sub>10</sub>	50.00	72.00	62.5000	6.48473	60.0786	64.9214	

**Table 4. Statistical analysis of CSA, MAP, HR in 3 groups**

## DISCUSSION

Cannulation of IJV is an essential requirement in perioperative as well as critical care setting. Conventional technique involves blind approach. The introduction of Ultrasound scan in operating room and ICUs has revolutionised the central venous cannulation. The most common site of central venous cannulation is the Internal Jugular vein. Right jugular is preferred because of it is superficial, straight course. The jugular vein being very superficial is easily visualised in sonography than subclavian vein. In spite of being superficial, the cannulation of Jugular vein is associated with many complications like haematoma, arterial puncture, pneumothorax etc. With landmark-guided internal jugular vein (IJV) cannulation technique, the rate of mechanical complication (pneumothorax, haematoma, line misplacement and haemothorax) is 10%–15% and unsuccessful insertion is up to 20%.<sup>1</sup> Ultrasound guidance improves the successful insertion rate to 93.9%, first-attempt success rate is only 82% and carotid puncture

rate is up to 5.9%.<sup>2</sup> The successful puncture depends on many factors. One of important factors being the size of Jugular vein at the time of cannulation. The increased CSA may provide a larger target for needle entry. Literature shows that many methods including performing a Valsalva manoeuvre, applying abdominal compression, placing the patient in the Trendelenburg position, increasing positive airway pressure and applying PEEP have been shown to increase the success rate.<sup>3,6,5,7,8</sup>

Considering the previous studies application of PEEP was selected as a tool to increase the cross-sectional area of IJV. It was chosen as it was routinely administered in general anaesthesia by most practitioners, easily applied with ventilators. The levels chosen were 0, 5, 10 cm of H<sub>2</sub>O PEEP which were routinely given in our institution.

In our study we recorded the CSA of IJV using sonography after giving PEEP for a time period of 2 minutes. The PEEP was restricted to a maximum of 10 cm of H<sub>2</sub>O to assess whether it was sufficient to increase size of IJV without any side effects. There was an increase in cross sectional area in groups with PEEP 5 and 10. The mean values were statistically significant.

But, Marcus et al. did not find any significant increase in CSA after adding PEEP 5–10 in Trendelenburg position.<sup>3</sup> However in this study application of PEEP was for a very brief time of 30 seconds. Zhou et al. Found that CA overlapping with IJV increased with positive airway pressure (PAP) from 15 to 25 cm H<sub>2</sub>O.<sup>6</sup> Hollenbeck et al and Lee et al. similarly observed an increase in AP diameter with the application of PEEP.<sup>4,5</sup> However, Valsalva manoeuvre requires an assistant for application in mechanically ventilated patients.<sup>9</sup> Zhou et al. observed an increase in CSA in Trendelenburg position only after application of positive airway pressure above 20 cm H<sub>2</sub>O for 30 s, and there was no significant increase in CSA at PAP15 cm H<sub>2</sub>O.<sup>6</sup> A study by Suzuki et al. found that application of the Valsalva manoeuvre decreases the overlapping with the common CA.<sup>9</sup> Kitagawa et al. similarly found a decrease in percent overlap between IJV and CA after the Valsalva manoeuvre (mean value 22.4% vs. 15.2% P < 0.05).<sup>10</sup> Bllobato et al. found that a 10° Trendelenburg position increased the RIJV CSA by 25% and a 20° Trendelenburg position increased it by 32% in anaesthetised adults.<sup>7</sup> A study by Sulek et al. found that with increasing head rotation, CA overlap increases and they recommended head rotation <40°.<sup>11</sup> Primary focus of the study was on increasing the area of IJV by application of PEEP. Since the application of PEEP is associated with hemodynamic instability in the form of bradycardia and hypotension, we included the measurement of heart rate and mean arterial pressure at the time of sonography of the vein. There was no significant change in heart rate values amongst the three groups. The mean blood pressure analysis showed a statistically significant decrease in the groups with 5 and 10 PEEP. But no groups showed clinically significant hypotension during the study. The size of IJV was significantly increased by applying a PEEP of 5 to 10 cm. This may be beneficial in cannulation of IJV successfully without hemodynamic instability.

### CONCLUSIONS

Our study shows that application of PEEP of 5 to 10 cms of H<sub>2</sub>O is an effective method for increasing cross sectional area of right internal jugular vein when using sonography for central venous cannulation. Higher levels of PEEP are not required for this purpose. Use of PEEP up to 10 cm of H<sub>2</sub>O is sufficient to increase area of IJV without clinically significant hemodynamic changes.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.

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