

# Differential Responsiveness of Internal Jugular Veins in the Trendelenburg Position Beyond Diameter Measurements: A Cross-sectional Study in Neonates

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## ABSTRACT

**Introduction:** To circumvent the challenges faced with neonatal central venous cannulation, variations in position, lateral neck rotation, ultrasound technology are being used with fair success rate. However, there is paucity of data regarding the degree of relative responsiveness between the Right and Left Internal Jugular Veins (RIJV, LIJV) and the physiological effect of patent shunts or Persistent Left Superior Vena Cava (PLSVC) on positioning success in neonates.

**Aim:** To assess the differential response of the RIJV and LIJV to 10° Trendelenburg position in neonates by measuring Cross-Sectional Area (CSA), Anteroposterior Diameter (APD), Mediolateral Diameter (MLD) and Skin-to-Vein Distance (SVD), respectively.

**Materials and Methods:** The present cross-sectional study was conducted at Mahatma Gandhi Medical College and Research Institute, Puducherry, India, from May 2024 to April 2025. A total of 60 neonates between 36 weeks and one month of gestational age born in-hospital were recruited. The RIJV and LIJV were scanned using high-frequency linear-array transducer (L25xp, 13-6 MHz) of the X-Porte Ultrasound system (FUJIFILM

Sonosite, Inc). The CSA, anteroposterior and MLDs and SVD were measured in the supine and 10° Trendelenburg position. Bilateral pre-post changes were analysed using the Wilcoxon-Signed Rank test between supine and Trendelenburg position.

**Results:** The median age and weight of neonates were 268±15 (262-277) days and 2.87±0.5 (2.69-3.20) kg with equal gender distribution. The CSA of RIJV (W=537, p=0.03) and LIJV (W=232, p<0.001) increased significantly from supine to 10° Trendelenburg position. Although, the CSA of RIJV (W=1319.5, p=0.001) was greater than the LIJV (W=1301, p=0.005) in both supine and Trendelenburg position. But the LIJV was found more responsive to the Trendelenburg position with 11.7±27% (4.7-18.7) increase in size compared to 7.2±26% (0.5-14) for RIJV, respectively (W=678, p=0.12). Likewise, there was a significant increase in the anteroposterior and MLDs as well, but the SVD remained unchanged.

**Conclusion:** The responsiveness of LIJV is greater in the 10° Trendelenburg position, but its smaller size necessitates separate ultrasound-guided catheter to avoid disproportionate Catheter-to-Vein Ratio (CVR), thereby reducing thrombosis risk considerably.

**Keywords:** Catheter-to-vein ratio, Positioning, Ultrasound-guided vascular access, Vascular responsiveness, Vena cava abnormalities

## INTRODUCTION

Inserting a percutaneous Central Venous Catheter (CVC) in a newborn poses a challenge, even for an experienced anaesthesiologist [1]. However, advancements in imaging technology, particularly ultrasound, have improved the understanding of complexities involved in such procedures [2,3]. Numerous studies in the literature have analysed the impact of various factors, like limited neck space, SVD, positioning, mode of ventilation and CVR on success rate of IJVs cannulation [4,5]. There has been a shift from catheter selection based on age and weight as per established guidelines towards an ultrasound-guided individualised approach [6]. RIJV is preferred for central venous cannulation compared to the LIJV due to difficult ergonomics, tortuous path and smaller size [7].

Furthermore, the higher likelihood of the presence of a patent foramen ovale and persistent left SVC in neonates can have both anatomical and physiological effects which can affect positioning success [8]. In Trendelenburg position, increase in IJVs CSA is secondary to gravity-assisted flow and pressure augmentation. The LIJV drains via the left innominate vein into the SVC allowing a sustained rise in pressure due to the blood column in the innominate vein [9]. In contrast, the RIJV drains directly into the SVC and then right atrium, which in the presence of patent foramen ovale decompresses the

system negating a rise in pressure, limiting the expected increase in CSA [9]. The novelty of this study lies in assessing and quantifying the differential response of the RIJV and LIJV to 10° Trendelenburg position in neonates by measuring CSA, APD, MLD and SVD; providing objective evidence for an individualised approach.

Various degrees of Trendelenburg position to optimise vessel size have been analysed but there is paucity of data regarding the degree of relative responsiveness between the right and LIJVs in neonates [9]. The RIJVs and LIJVs are asymmetrical due to difference in drainage but almost all studies have found RIJV to be larger in CSA than the LIJV [10,11]. By far in our knowledge, Lee JG et al., have mentioned rate of change in IJV CSA with position change and found it to be greater for the RIJV [12]. Furthermore, the findings of Botero M et al., also concur with the sidedness but did not find Trendelenburg position effective in increasing the CSA of either side [13]. Understanding which IJV is more responsive to position change can guide clinicians in choosing the optimal site of cannulation and appropriate size of catheter, thereby reducing complication like thrombosis and increasing the success rate.

The present study was conducted to analyse the differential response of RIJV and LIJV to 10° Trendelenburg position in neonates by measuring CSA, APD, MLD and SVD, respectively.

## MATERIALS AND METHODS

The present cross-sectional study was conducted at Mahatma Gandhi Medical College and Research Institute, Puducherry, India; from May 2024 to April 2025. After Institutional human ethics committee approval (MGMCRI/Res/01/2021/8/IHEC/56), written informed consent was obtained from the parent before enrollment.

**Inclusion criteria:** All healthy neonates between 36 weeks and one month of gestational age born in-hospital were screened for inclusion in the present study.

**Exclusion criteria:** Neonates with congenital deformities involving the neck, lesions over and around the neck, suspected chromosomal abnormalities, birth injury like clavicle fracture and any upper limb nerve palsy were excluded.

**Sample size calculation:** The sample size calculation was based on a prospective randomised controlled study conducted by Lee JG et al., [12]. Assuming an alpha level of 0.05, a power of 80%, and a precision of 10% for the MLD of the RIJV in the supine position  $1.62 \pm 0.38$  cm versus the  $10^\circ$  Trendelenburg position  $1.85 \pm 0.4$  cm, the calculated sample size was 60. The effect size was determined as 0.6 and the sampling method used was convenience sampling. The sample size was calculated using the below mentioned formula:

$$N = 2\sigma^2 (Z_{1-\alpha/2} + Z_{1-\beta})^2 / d^2$$

{ $\sigma^2$ - Variance,  $Z_{1-\alpha/2}$ - critical value for a two-sided test with a significance level of  $\alpha$  as 0.05 (1.96),  $Z_{1-\beta}$ - critical value corresponding to the desired power of 80% (0.84),  $d$ - effect size}.

### Study Procedure

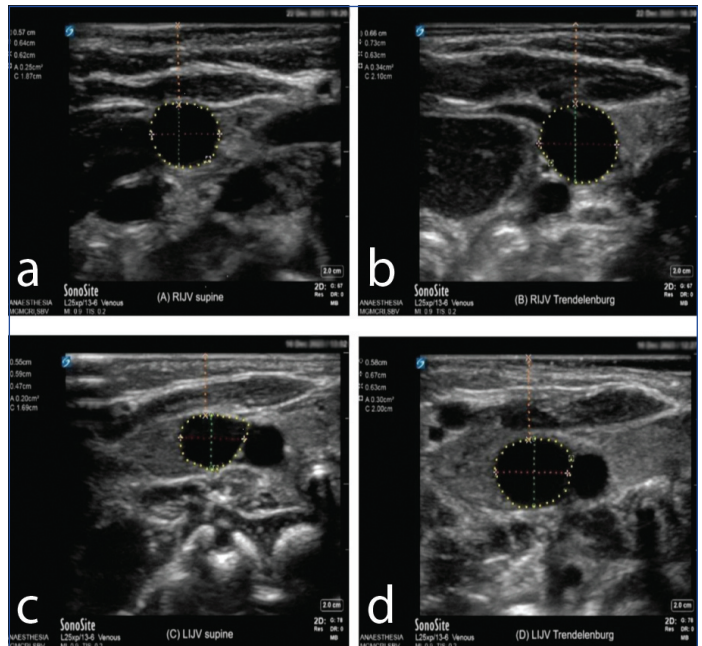
Before imaging, each baby was either breastfed or bottle-fed, and a towel roll measuring 4 cm in diameter was placed under the shoulders. Using a mobile application, called clinometer app (Plaincode on Android/iOS version 3.0) which uses gyroscope sensor, the baby's head was rotated  $45^\circ$  to the contralateral side and a folded towel placed appropriately to rest upon [14,15]. The RIJV and LIJV of study participants were scanned using high-frequency linear-array transducer (L25xp, 13-6 MHz) of the X-Porte Ultrasound system (FUJIFILM Sonosite, Inc). The CSA, APD, MLD and SVD were measured in the supine and  $10^\circ$  Trendelenburg position.

Ultrasound gel was applied to the probe and gently placed in a transverse orientation at the level of the cricoid cartilage. Therein was gently compressed and then decompressed to detect the presence of intraluminal thrombi [5]. When completely decompressed, the largest vein image was captured in short-axis view with ultrasound probe angle at 90 degrees to the vein, and measurements were taken by positioning calipers from near field to far field and noting this as the internal diameter. An average of three measurements was taken as the final value and noted. This comprehensive methodology ensured the accuracy and reliability of the results. Additionally, the SVD was measured from the skin surface to the anterior wall of the IJV, and its CSA [Table/Fig-1] was calculated by tracing the vein circumference. After initial measurements in the supine position, the neonate was placed in a  $10^\circ$  Trendelenburg position for 30 seconds, also using the same mobile application, and all measurements were duplicated [5]. An experienced anaesthesiologist performed all measurements, and the total duration of the assessment was approximately 10 minutes.

### STATISTICAL ANALYSIS

Statistical analysis was performed using Jeffreys's Amazing Statistics Program (JASP) version 0.18.3. The normality of data was assessed using the Shapiro-Wilk test and distribution was found to be skewed. Patient characteristics and continuous data have been expressed as median  $\pm$  Interquartile Range (IQR) and as proportion for gender and percentage change respectively. The pre-post changes from supine to Trendelenburg position and comparison between RIJV and LIJV was done using the Wilcoxon-Signed Rank

test. Although data is skewed in distribution but to express the relative percentage change in dimensions comparing the RIJV and LIJV with Trendelenburg position, mean  $\pm$  Standard Deviation (SD) (95% CI) has been mentioned. This has been done to highlight the average change in percentage. A p-value of less than 0.05 was considered statistically significant.



**[Table/Fig-1]:** Ultrasonographic measurements of Right Internal Jugular Vein (IJV): a) supine; b)  $10^\circ$  Trendelenburg position and Left Internal Jugular Vein (LIJV): c) supine; d)  $10^\circ$  Trendelenburg position.

\*Anteroposterior Diameter (APD) (green-dashes) and Mediolateral diameter (MLD) (red- dashes), CSA (yellow-dashes) and skin-to-vein distance (SVD) (orange-dashes)

## RESULTS

In the present study, the proportion of female (53%) neonates was greater than male (47%) with the median gestational age of  $268 \pm 15$  (262-277) days, weight  $2.87 \pm 0.5$  (2.69-3.2) kg, length  $49 \pm 3$  (48-51) cm [Table/Fig-2].

Parameters	Median $\pm$ IQR (25 <sup>th</sup> -75 <sup>th</sup> percentile)
Gestational age (days)	268 $\pm$ 15 (262-277)
Weight (kg)	2.87 $\pm$ 0.5 (2.69-3.2)
Length (cm)	49 $\pm$ 3 (48-51)
Gender	Female-32 (53%), Male-28 (47%)

**[Table/Fig-2]:** Baseline patient demographics and anthropometric characteristics of the study participants.

\*Values expressed as median  $\pm$  Interquartile range (IQR; 25<sup>th</sup>-75<sup>th</sup> percentile) for gestational age, weight and length; gender is shown as number (%); IQR: Interquartile range

The median CSA of RIJV in the supine position was  $0.28 \pm 0.11$  (0.24-0.35)  $\text{cm}^2$  and  $0.28 \pm 0.10$  (0.26-0.36)  $\text{cm}^2$  in the  $10^\circ$  Trendelenburg position. Compared to this, the median CSA of LIJV was  $0.26 \pm 0.05$  (0.23-0.28)  $\text{cm}^2$  in supine position and it increased to  $0.28 \pm 0.05$  (0.25-0.30)  $\text{cm}^2$  in the  $10^\circ$  Trendelenburg position [Table/Fig-3].

The CSA of RIJV in supine ( $W=1319.5$ ,  $p=0.001$ ) and Trendelenburg ( $W=1301$ ,  $p=0.005$ ) position was significantly larger than LIJV. The increase in CSA with  $10^\circ$  Trendelenburg was found to be significant for both veins (RIJV  $W=537$ ,  $p=0.03$ ; LIJV  $W=232$ ,  $p<0.001$ ) [Table/Fig-4]. The mean percentage change in CSA was greater for the LIJV ( $11.7 \pm 27\%$  (4.7-18.7)) vs RIJV ( $7.2 \pm 26\%$  (0.5-14)) but this difference did not reach statistical significance. Likewise, the percentage changes in APD and MLD were relatively more for LIJV but not statistically significant. There was no change in SVD from supine to  $10^\circ$  Trendelenburg position although it was greater for RIJV compared to LIJV in both positions but not statistically significant [Table/Fig-5-7].

Parameters	RIJV Median (IQR) (25 <sup>th</sup> -75 <sup>th</sup> percentile)	LIJV Median (IQR) (25 <sup>th</sup> -75 <sup>th</sup> percentile)
<b>Cross-sectional Area (CSA) (cm<sup>2</sup>)</b>		
Supine	0.28±0.11 (0.24-0.35)	0.26±0.05 (0.23-0.28)
Trendelenburg	0.28±0.10 (0.26-0.36)	0.28±0.05 (0.25-0.30)
<b>Antero-Posterior Diameter (cm)</b>		
Supine	0.53±0.15 (0.48-0.63)	0.50±0.05 (0.48-0.53)
Trendelenburg	0.56±0.12 (0.52-0.64)	0.54±0.07 (0.50-0.57)
<b>Medio-Lateral Diameter (cm)</b>		
Supine	0.61±0.18 (0.51-0.69)	0.59±0.1 (0.52-0.62)
Trendelenburg	0.62±0.16 (0.53-0.69)	0.59±0.08 (0.56-0.64)
<b>Skin-to-Vein Distance (SVD) (cm)</b>		
Supine	0.77±0.27 (0.66-0.93)	0.76±0.22 (0.66-0.88)
Trendelenburg	0.76±0.26 (0.68-0.93)	0.75±0.25 (0.67-0.92)

**[Table/Fig-3]:** Descriptive statistics of Internal Jugular Vein (IJV) parameters in supine and 10° Trendelenburg positions. \*Values are presented as median±interquartile range (IQR; 25<sup>th</sup>-75<sup>th</sup> percentile); RIJV: Right internal jugular vein; LIJV: Left internal jugular vein; CSA: Cross-sectional area

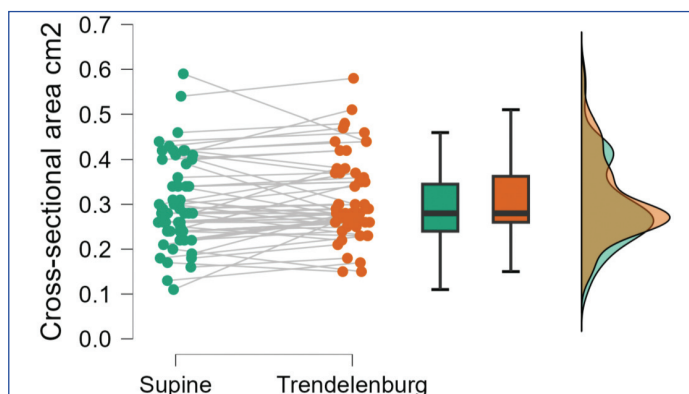
Parameter	Wilcoxon-Signed Rank test (W)	p-value
<b>Cross-sectional Area (cm<sup>2</sup>) (CSA)</b>		
Supine (RIJV vs LIJV)	1319.5	0.001
Trendelenburg (RIJV vs LIJV)	1301	0.005
RIJV (Supine to Trendelenburg)	537	0.03
LIJV (Supine to Trendelenburg)	232	<0.001
Percent change RIJV vs LIJV (Supine to Trendelenburg)	678	0.12
<b>Antero-Posterior Diameter (cm)</b>		
Supine (RIJV vs LIJV)	1148.5	0.002
Trendelenburg (RIJV vs LIJV)	1269	0.004
RIJV (Supine to Trendelenburg)	441.5	0.004
LIJV (Supine to Trendelenburg)	254	<0.001
Percent change RIJV vs LIJV (Supine to Trendelenburg)	760	0.35
<b>Medio-Lateral Diameter (cm)</b>		
Supine (RIJV vs LIJV)	1184	0.01
Trendelenburg (RIJV vs LIJV)	1116	0.08
RIJV (Supine to Trendelenburg)	421.5	0.009
LIJV (Supine to Trendelenburg)	264.5	<0.001
Percent change RIJV vs LIJV (Supine to Trendelenburg)	836.5	0.72
<b>Skin-to-Vein Distance (SVD) (cm)</b>		
Supine (RIJV vs LIJV)	970	0.38
Trendelenburg (RIJV vs LIJV)	1001.5	0.26
RIJV (Supine to Trendelenburg)	694.5	0.18
LIJV (Supine to Trendelenburg)	697	0.16
Percent change RIJV vs LIJV (Supine to Trendelenburg)	770.5	1.00

**[Table/Fig-4]:** Wilcoxon-Signed Rank test results for paired comparisons of Internal Jugular Vein (IJV) parameters between the Right (RIJV) and Left (LIJV) and between supine and Trendelenburg positions. \*Statistical significance is indicated by p<0.05 (Wilcoxon-Signed Rank test); CSA: Cross-sectional area; RIJV: Right internal jugular vein; LIJV: Left internal jugular vein

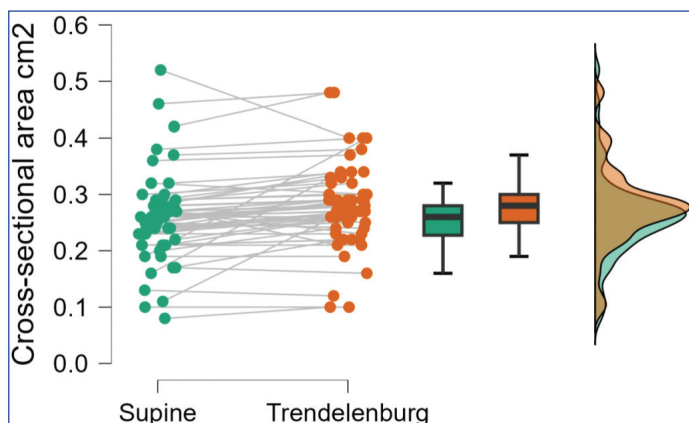
The CSA of RIJV in supine position was found to correlate significantly with gestational age (Spearman's rho=0.35, p=0.006, Effect size=0.37) and weight (Spearman's rho=0.38, p=0.003, Effect size=0.40) of the neonate. Likewise, the correlation of CSA of LIJV in supine position was with gestational age (Spearman's rho=0.51, p<0.001, Effect size=0.57) and weight (Spearman's rho=0.42, p<0.001, Effect size=0.44), respectively. All the other morphometric parameters like APD, MLD and SVD and their correlation with anthropometric measurements have been depicted in [Table/Fig-8].

Parameters	RIJV {Mean±SD (95% CI)}	LIJV {Mean±SD (95% CI)}	p-value
<b>Cross-sectional Area (CSA) (cm<sup>2</sup>)</b>			
Supine- Trendelenburg	7.2±26 (0.5-14)	11.7±27 (4.7-18.7)	0.33
<b>Antero-Posterior Diameter (cm)</b>			
Supine- Trendelenburg	3.87±12 (0.8-7)	7.3±14.6 (3.5-11)	0.18
<b>Medio- Lateral Diameter (cm)</b>			
Supine- Trendelenburg	3.1±9.3 (0.73-5.5)	6.4±17.5 (2-11)	0.15
<b>Skin-to-Vein Distance (SVD) (cm)</b>			
Supine- Trendelenburg	1.9±23 (-4 to 8)	3.3±22 (-2.5 to 9)	0.76

**[Table/Fig-5]:** Comparative percentage change between RIJV and LIJV measurements with positional change. \*RIJV: Right internal jugular vein; LIJV: Left internal jugular vein



**[Table/Fig-6]:** Comparison of mean Cross-sectional Area (CSA) of Right Internal Jugular Vein (RIJV) between two positions.



**[Table/Fig-7]:** Comparison of Mean Cross-sectional Area (CSA) of Left Internal Jugular Vein (LIJV) between two positions.

Parameters	Gestational age (days)			Weight (kg)		
	Spearman's rho	p-value	Effect size	Spearman's rho	p-value	Effect size
RIJV CSA supine	0.35	0.006	0.37	0.38	0.003	0.40
RIJV CSA trendelenburg	0.30	0.02	0.31	0.30	0.02	0.31
LIJV CSA supine	0.51	<0.001	0.57	0.42	<0.001	0.44
LIJV CSA trendelenburg	0.40	0.002	0.42	0.28	0.03	0.30
% RIJV CSA Supine-trendelenburg	-0.11	0.38	-0.11	-0.20	0.13	-0.20
% LIJV CSA Supine-trendelenburg	-0.11	0.40	-0.11	-0.11	0.42	-0.11
RIJV APD supine	0.28	0.03	0.28	0.36	0.005	0.38
RIJV APD Trendelenburg	0.33	0.01	0.34	0.37	0.004	0.38
LIJV APD supine	0.21	0.10	0.22	0.03	0.83	0.03

LIJV APD Trendelenburg	0.13	0.33	0.13	-0.0004	0.99	-0.0004
% RIJV APD Supine-Trendelenburg	0.04	0.79	0.03	-0.06	0.65	-0.06
% LIJV APD Supine-Trendelenburg	-0.19	0.15	-0.20	-0.04	0.74	-0.04
RIJV MLD supine	0.33	0.01	0.34	0.41	0.001	0.44
RIJV MLD trendelenburg	0.21	0.11	0.21	0.30	0.02	0.31
LIJV MLD supine	0.44	<0.001	0.47	0.43	<0.001	0.45
LIJV MLD trendelenburg	0.35	0.006	0.36	0.30	0.02	0.31
% RIJV MLD Supine-trendelenburg	-0.37	0.003	0.40	-0.30	0.02	0.31
% LIJV MLD Supine-trendelenburg	-0.14	0.28	-0.14	-0.08	0.53	-0.08
RIJV SVD supine	0.12	0.38	0.12	0.07	0.61	0.07
RIJV SVD trendelenburg	0.07	0.60	0.07	0.16	0.21	0.16
LIJV SVD supine	0.19	0.14	0.20	0.20	0.13	0.20
LIJV SVD trendelenburg	0.10	0.43	0.11	0.06	0.65	0.06
% RIJV SVD Supine-trendelenburg	0.08	0.54	0.08	0.21	0.10	0.21
% LIJV SVD Supine-trendelenburg	-0.04	0.74	-0.04	-0.03	0.81	-0.03

**[Table/Fig-8]:** Association of Right (RIJV) and Left Internal Jugular Vein (LIJV) morphometry in supine and 10° Trendelenburg positions with anthropometric measurements in neonates.

\*Effect size is calculated using Fisher's z. RIJV: Right internal jugular vein, LIJV: Left internal jugular vein, CSA: Cross-sectional area in cm<sup>2</sup>, APD: Anteroposterior diameter; MLD: Medirolateral diameter; SVD: Skin-to-vein distance

## DISCUSSION

The present cross-sectional study examined bilateral IJVs in neonates to understand the significance of analysing bilateral IJVs in a more comprehensive manner. Ultrasound-guided catheter sizing is based on minimising CVR (typically aiming for under 45%, ideally <33%) in the supine position, an approach that is ideal but infrequently adopted clinically [16]. The LIJV becomes a preferred alternative when RIJV cannulation is difficult, especially given the anatomical variations in neonates that affect CVC placement. Notably, patent foramen ovale occurs in approximately 70% of with over 95% closure by the age of two years [17,18]. Additionally, PLSVC is present in 0.3 to 0.5% of the general population and is often associated with right SVC in structurally normal hearts [19,20].

To overcome the difficulties associated with neonatal central venous cannulation, clinicians employ positional variations, lateral neck rotation, Valsalva manoeuvre and ultrasound guidance, achieving a reasonably good success rate [4,5]. Nevertheless, limited data exists on the relative responsiveness of the right versus LIJVs and on the physiological impact of patent shunts or a persistent left SVC on CVC placement success.

Many studies [Table/Fig-9] have found that the RIJV is larger than the LIJV in all positions [4,8,12,15,21,22]. This was also observed in our study, where the CSA of RIJV in the supine (W=1319.5, p=0.001) and 10° Trendelenburg (W=1301, p=0.005) position was significantly larger than the LIJV. The difference can be explained by the drainage of the Superior Sagittal Sinus (SSS). Saiki K et al., reported that the RIJV is larger in 81.3% of cases, while the LIJV is larger in only 11.0%, with the SSS draining into the right Transverse Sinus (TS) in 73.6% of individuals and into the left TS in 12.1% [10]. This suggests that the SSS drainage pattern influences the size of the TS and consequently, the caliber of the IJV.

A significant increase in CSA with a 10° Trendelenburg position was found for both veins (RIJV W=537, p=0.03; LIJV W=232, p<0.001). The optimal angle for maximising IJV CSA has been analysed in several studies, with the underlying mechanisms based on hydraulic

Study	Study design	Place of the study/ Study period	Sample	Results
Kim HY et al., [4]	Prospective study	Seoul, Republic of Korea/ May 2016	CSA of IJV was assessed using USG in 47 anaesthetised paediatric patients with simple congenital heart defects.	In the supine position, the CSA increased by 9.4% (PEEP 5cm H <sub>2</sub> O) and by 19.5% (PEEP 10cm H <sub>2</sub> O). The Trendelenburg tilt alone increased the CSA by 19.0%, and combining the 10° Trendelenburg with a 10cm H <sub>2</sub> O PEEP resulted in CSA increase of 33.3% compared with the supine position with no PEEP.
Karaaslan P et al., [8]	Prospective study	Istanbul, Turkey/ April 2018	RIJV measurements were performed in 58 healthy newborns, weighing between 3000 and 3500 g.	Consecutive measurements were performed in three different Trendelenburg positions at 0°, 15°, and 30°, at two different entry points: The superior and inferior approach. The use of 15° Trendelenburg positioning may have significant advantage for increasing the CSA when used with the inferior approach.
Lee JG et al., [12]	Prospective study	Korea/ Nov 2014	This study enrolled 58 patients with ASA I-II who were undergoing general anaesthesia. CSAs of both the RIJV and LIJV were measured with USG in the supine position and then in a 10° Trendelenburg position in adult subjects.	Of 58 patients, the RIJV CSA was larger in 43 patients (74.1%), and LIJV CSA was larger in 15 patients (25.9%). In the Trendelenburg position, CSAs of the RIJV and LIJV increased 39.4 and 25.5%, compared with the supine position, suggesting that RIJV changed at a rate that was significantly greater than that of the LIJV (p<0.05), respectively.
Gwak MJ et al., [15]	Prospective study	Seoul, Republic of Korea/ March 2010	CSA of RIJV and degree of the carotid artery overlap were measured in 88 infants and children.	The CSA of the RIJV was significantly larger at 40° and 80° head rotation compared with the neutral position in both infants and children (p<0.001). As the head was rotated, the percentage overlap of the carotid artery increased significantly (p<0.001). A 40° head rotation appears to be optimal for RIJV cannulation in paediatric patients.
Dincyurek GN et al., [22]	Prospective study	Bursa, Turkey/March 2015	RIJV diameter was measured using USG in 100 ASA patients aged 2-12 years	The greatest increase in diameter was observed in the Trendelenburg position (15°) with the Valsalva manoeuvre (20 cmH <sub>2</sub> O) (p<0.001)
Present study	Prospective study	Puducherry, India/ May 2024-April 2025	CSA, APD, MLD and SVD were measured in the supine and 10° Trendelenburg position in 60 neonates between 36 weeks-1 month of gestational age using USG	Although the CSA of RIJV in both supine and 10° Trendelenburg position was significantly greater than LIJV but the Differential responsiveness expressed as the mean percentage change in CSA with 10° Trendelenburg position was greater for the LIJV (11.7±27% (4.7-18.7)) vs RIJV (7.2±26% (0.5-14))

**[Table/Fig-9]:** Studies on various manuvres to optimise IJV CSA in paediatric age-group [4,8,12,15,22].

\*CSA: Cross-sectional area; RIJV: Right internal jugular vein; LIJV: Left internal jugular vein; APD: Anteroposterior diameter; MLD: Medirolateral diameter; SVD: Skin-to-vein distance; PEEP: Positive end-expiratory pressure; ASA: American society of Anaesthesiology; USG: Ultrasound

principles, involving gravity and transmural pressure differences, respectively [9,23].

Although RIJV CSA was larger than the LIJV in both supine and Trendelenburg positions, the LIJV showed a greater response to positional change (LIJV mean percentage change=11.7±27 % (4.7 - 18.7) vs RIJV=7.2±26% (0.5-14). This greater responsiveness likely stems from differences in venous drainage. In the Trendelenburg position, the LIJV receives sustained pressure from the innominate vein, causing a relatively larger size change [10]. The RIJV drains more directly into the right atrium and benefits from the decompressing effect of the foramen ovale, allowing pressure dissipation.

These findings have clinical implications for IJV cannulation in neonates. When difficulty is encountered with the RIJV, the LIJV is a viable alternative, especially in the Trendelenburg position, because it exhibits a greater positional increase in CSA, which may improve cannulation success rates. However, using the same size catheter for the LIJV, which is smaller than the RIJV in both positions, alters the CVR disproportionately, reducing venous drainage and increasing thrombosis risk [24-30]. As per the authors' knowledge, this is the first neonatal study to analyse the differential response of RIJV vs LIJV when moving from supine to 10° Trendelenburg position. The only other study that has discussed this was performed in anaesthetised adults by Lee JG et al., [12]. In this study, contrary to our findings, the RIJV was found to be more responsive to position change than the LIJV.

There was no change in SVD from supine to the 10° Trendelenburg position, although the distance was greater for the RIJV compared with the LIJV in both positions but not statistically significant. This can be attributed to the posterior position of the thoracic duct relative to the LIJV, which pushes it anteriorly, thereby reducing the SVD [31]. In the Trendelenburg position the thoracic duct fills further due to gravity, decreasing the SVD and increasing the risk of accidental puncture.

Finding a small RIJV with a larger LIJV in the supine position should prompt consideration of PLSVC, which provides an alternative drainage pathway for venous blood from the left side, reducing flow through the right jugular system [32-34]. The procedural risk with CVC placement is significant because unrecognised PLSVC increases the chance of catheter misplacement and hemodynamic disturbances, making pre-procedural scanning of bilateral IJVs crucial.

### Limitation(s)

The limitations of the present study include operator-dependent pressure variations during ultrasound imaging, which may alter vessel shape and introduce non-uniform dimensional measurements. Additionally, inconsistent USG beam angles can subtly distort vein dimensions, affecting size and shape assessments. Utilising separate catheters for LIJV cannulation enhances procedural costs, yet ensures optimal patient safety.

### CONCLUSION(S)

To conclude, the LIJV exhibits greater differential responsiveness in the 10° Trendelenburg position, though it remains smaller in calibre than the RIJV. Using a catheter sized for the RIJV in the LIJV would decrease the CVR, impair venous drainage and increase thrombosis risk considerably. The authors recommend ultrasound-guided catheter sizing for left-sided cannulation to optimise catheter fit and minimise complications. Future studies should measure venous pressure changes and USG-guided IJV measurements in the Trendelenburg position, providing objective evidence on haemodynamic responses in neonatal vasculature.

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