Original Article

Effects of Varying Entry Points and Trendelenburg Positioning Degrees in Internal Jugular Vein Area Measurements of Newborns

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ABSTRACT

Background: Recent guidelines from the National Institute for Clinical Excellence recommend the use of ultrasonography in the central venous catheterization of children. In this study, we aimed to compare area measurements using ultrasonography and efficiency of varying Trendelenburg degrees on the area measurements, for two different entry points used as internal jugular vein (IJV) cannulation points in newborns. **Methods:** Fifty-eight healthy newborns, weighing between 3000 and 3500 g, were recruited for this prospective study. Right IJV (RIJV) consecutive measurements were performed in three different Trendelenburg positions at 0°, 15°, and 30°, at two different entry points: The superior approach and an inferior approach. The landmark used in the superior approach was the top of the triangle formed by the two heads of the sternocleidomastoid muscle with the clavicle; while in the inferior approach, it was taken as the midpoint of the clavicle, as measured from the upper edge of the clavicle. **Results:** The cross-sectional area (CSA) of the RIJV was significantly increased when using the inferior approach, compared to that in the superior approach, in all Trendelenburg degrees, including the neutral position. Both 15° and 30° Trendelenburg positioning resulted in a significant increase in CSA, both in superior and inferior approaches, when compared to neutral positioning. **Conclusion:** The use of 15° Trendelenburg positioning may have significant advantage for increasing the CSA when used with the inferior approach.

Keywords: *Internal jugular vein area, preprocedural ultrasonography, Trendelenburg positioning degrees*

Introduction

Central venous cannulation (CVC) management is an invasive procedure required for hemodynamic monitoring and administration of vasoactive drug treatments. While possible in many different vein catheterizations, the right internal jugular vein (RIJV) is the preferred site of cannulation in our center because of the limited distance between the RIJV and superior vena cava (SVC), the fact that the RIJV is contralateral to the thoracic duct, and a greater distance from pleura, thus exhibiting lower complication rates.[1]

Difficulty in determining the cannulation site in pediatric patients results from small vein diameters, short adjacency distance to the carotid artery, and a lack of well-developed neck muscles.[2,3] In different studies regarding pediatric anesthesia, cannulation success rate is between 61% and 81%, with carotid puncture rates between 4% and 25% in infant RIJV cannulation using anatomic landmarks without ultrasonography (usg) guidance.[2,4-6]

Studies performed on adults indicate that use of ultrasound guidance in cannulation increases success rate, decreases cannulation time, and decreases complication rate.[7-10] Recent guidelines from the National Institute for Clinical Excellence recommend the use of USG in central

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venous catheterization of children.[11] IJV cannulation is routinely performed with USG in our clinic.

Trendelenburg positioning is recommended while performing IJV cannulation to improve the success rate and to reduce air embolism.[12] A survey study by Ely *et al*. indicates that 91% of clinicians routinely prefer the use of upside-down positioning in central venous catheterization practices.[13] In our clinic, Trendelenburg positioning is used in all the central venous catheter applications, unless contraindications exist. As the most effective entry point and the most significant Trendelenburg degree, for CVC in newborns, are not yet clear in the literature, we have, in this study, aimed to compare area measurements and efficiency of varying Trendelenburg degrees on the area measurements using ultrasonography, for two different entry points used as IJV cannulation points in newborns.

Materials and Methods

Sixty-three healthy newborns weighing between 3000 and 3500 g were included to this prospective study, following approval from the Ethical Board of our university (10840098-14/16.05.2013) and informed consent from families of the newborns. Power analysis was performed in G power 3.1.9.2 in Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS Inc., Chicago, IL, USA) and based on the previous area measurements for 95% actual power, total sample size was found to be 47 newborns. Exclusion criteria included prematurity, congenital disease, and previous RIJV cannulation. RIJV area consecutive measurements were made in 3 different Trendelenburg positions at 0°, 15°, and 30° and at two different entry points: the superior approach and an inferior approach. Procedures that could have effect on IJV area measurements, such as Valsalva maneuver or liver compression were not performed. Measurements were performed in spontaneously sleeping newborns, by one anesthesiologist and one radiologist, both of who were experienced in vascular USG evaluation. A total of 6 measurements were made for each baby. A 5–12 MHz linear i12L-RS probe was used to provide USG (VIVID Q; GE, Horten, Norway) and in the process of taking measurements. The probe was held such as to avoid exerting pressure on the RIJV. Effective RIJV area measurements were made from subsequent ultrasound records by pausing live imagery [Figure 1]. Cross-sectional area (CSA) measurements were automatically made with the program included in the software of the ultrasound device. The landmark used in the superior approach was the top of the triangle formed by the two heads of the sternocleidomastoid muscle with the clavicle; while in the inferior approach, it was taken as the midpoint of the clavicle, as measured from the upper edge of the clavicle. In all measurements, the same roll used routinely in our clinical setting was placed below the shoulder, ensuring slight head extension (to eliminate anatomical difficulty stemming from a short neck and large head in infants), with all measurements made by measuring with a protractor, whereas the head was turned 40° to the left. During the examinations:

1. RIJV area measurement was made in superior and inferior entry points at supine position at 0°
2. RIJV area measurement was made in superior and inferior entry points at 15° Trendelenburg positioning
3. RIJV area measurement was made in superior and inferior entry points at 30° Trendelenburg positioning.

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS Inc., Chicago, IL, USA). Besides descriptive measures; due to normal variation of demographic data, independent variables were tested by independent *t*-test. Dependent variables were compared with paired sample *t*-test. Values of $P < 0.05$ were accepted as statistically significant.

Results

Distribution of newborns was even in terms of demographic data [Table 1]. Five of the 67 cases were observed to move during at least one of the measurement phases, and were subsequently excluded, as it has been assumed that this may alter the measurements. Six consecutive measurements were made on each of the remaining 58 newborns, with the study containing a total of 348 measurements. Distribution of newborns was even in terms of demographic data [Table 1]. The CSA of the RIJV was significantly increased when using the inferior approach, compared to that in the superior approach, in all Trendelenburg degrees, including the neutral position. Table 2 shows the CSA of RIJV in each measurement. Both 15° and 30° Trendelenburg

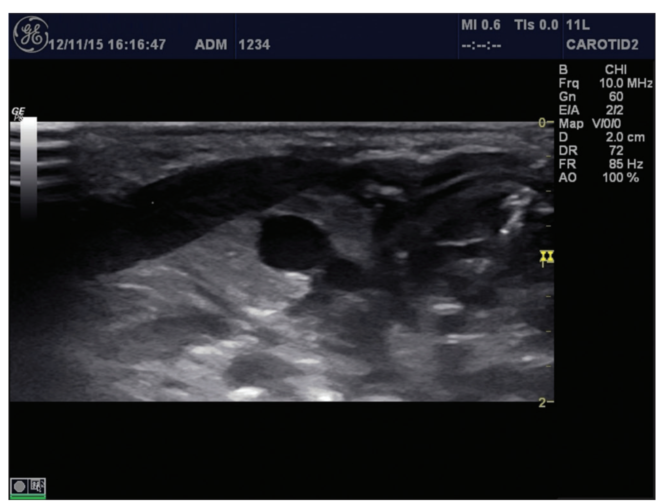

Figure 1: Ultrasonography image of inferior approach

Table 1: Demographic data

	Mean±SD	Minimum-maximum
Age (days)	17.89±5.88	3-28
Weight (g)	3190±179.17	3000-3800
Height (cm)	48.01±2.71	40-54
BMI (kg/m^2)	13.16±1.60	10.29-18.75

BMI=Body mass index; SD=Standard deviation

Table 2: Cross-sectional area for all measurements (mean±standard deviation) *P* values are for comparing conventional and inferior approaches for all Trendelenburg degrees

	Conventional	Inferior	*P*
0	0.18±0.03	0.21±0.04	<0.001
15°	0.24±0.05	0.29±0.05	<0.001
30°	0.21±0.04	0.28±0.05*	<0.001

*When comparing 15° Trendelenburg positioning to 30°, no significant increase in CSA was observed. CSA=Cross-sectional area

positioning resulted in a significant increase in CSA, both in superior and inferior approaches, when compared to neutral positioning ($P < 0.001$). When comparing 15° Trendelenburg positioning to 30°, no significant increase in CSA was observed. Following these results, the use of 15° Trendelenburg positioning has notable significance for CSA when used with the inferior approach. Fifteen-degree Trendelenburg positioning appears sufficient, with use of 30° Trendelenburg positioning not found to provide an increase in CSA when compared to 15°. In inferior approach, average area at 0° has been 0.21 ± 0.04; at 15° 0.29 ± 0.05 ($P < 0.001$, when compared to neutral position) and at 30° 0.28 ± 0.05 ($P < 0.001$, when compared to neutral position). There was no significant difference in RIJV CSA between 15° and 30° Trendelenburg positioning ($P > 0.05$).

Discussion

There is no other study in the literature that evaluates the correlation between Trendelenburg positioning in both superior and inferior cannulation methodologies, with RIJV area measurements, in healthy newborns of this weight to the best of our knowledge. In this study, a significant increase in CSA was observed in the inferior approach, with respect to superior approach, in all Trendelenburg positioning degrees, including the neutral position. Hwang *et al*. compared entry point area measurements using the conventional cannulation method in adults and have found area measurements in high entry to be lower with respect to conventional in all Trendelenburg degrees.[14] The broadest RIJV CSA measurement in the study performed by Hwang *et al*. was observed at 20° Trendelenburg positioning, when using a conventional approach, in adults. In our study, the broadest RIJV CSA was observed when using a 15° Trendelenburg position, in conjunction with an inferior approach in newborns. We have not compared right and left jugular measurements in this study since the RIJV is the first preference for cannulation with regard to its shortest distance to the SVC. Moreover, it is contralateral to the thoracic duct; it is distant to the pleura and thus exhibits fewer complications.[1] For these reasons, our first choice is always RIJV cannulation for newborns in our clinic.

In a study reported by Bellazzini *et al*., it was indicated that Trendelenburg positioning is responsible for a 40% increase in CSA.[15] Contrary to most data in the literature, Nassar *et al*. found that Trendelenburg positioning does not increase IJV area in adult patients.[16] However, an increase of 38% in RIJV area between 0° and 15° Trendelenburg positioning in newborns has been observed in our study. Following repetition of measurements for varying Trendelenburg degrees in inferior entry cannulation, we observed a significant difference between 0° and 15° positioning, whereas we could not identify any difference between 15° and 30° positioning. Deep Trendelenburg positioning has certain risks, especially in patients with clinical problems such as intracranial or intraocular pressure increase, gastroesophageal reflux risk, malignant cardiac arrhythmias, hypoxia, mitral valve insufficiency, and decreased pulmonary reserve.[17-21] Complication rates should be reduced with use of the lowest sufficient Trendelenburg degree, taking all risks into consideration. As a result of our findings, we speculate that 15° Trendelenburg positioning is sufficient for newborn RIJV cannulation, with a 38% increase in RIJV area between 0° and 15° in newborns.

In light of findings by Gwak *et al*., where carotid and RIJV overlap probability is increased when turning the head to the left, we have taken, as a basis, a 40° contralateral head rotation, as suggested in the given study.[1] In addition, we used an under-shoulder roll in all newborns; otherwise, an approach to the jugular becomes difficult with the anatomical form of the newborn (large head combined with a short neck). Literature information suggests that overlap is mitigated with a high entry point.[4] This confirms the need for careful ultrasound imaging when choosing the inferior approach; however, as we solely measured area, without catheterization, we cannot speak to the superiority of a superior approach in terms of carotid puncture risk or the success rate.

Although we did not perform cannulation, we could only discuss about the increases of CSA, however not for success rates. In a study performed in infants and young children by Verghese *et al*., an increase in CSA using some maneuvers including Trendelenburg position was shown but no success rates could be discussed.[22] Similarly, in another study, the head down at 10° effectively increased CSA when the IJV flattening ratios at 0° was more than 0.3 in higher age group but again no success rate was declared.[23]

As catheterization with USG requires holding a probe with one hand and directing a needle with the other, whereas simultaneously monitoring a screen, USG requires good hand-eye coordination, skill, and experience.[2] However, real-time visual cannulation is the safest method, especially for such small babies. Currently, we perform cannulation routinely with real-time USG in our clinic and believe we have found satisfactory entry and Trendelenburg positioning parameters for obtaining the most correct, clear images, and limiting complications.

Verghese *et al*. have indicated that they have achieved 100% success in a cannulation study with USG performed on infants.[2] Success of cannulation with USG has been proven with many similar studies, and further to this, we aimed to identify the most correct point for USG with babies under 3500 g. Furthermore, Lamperti *et al*. strongly recommended ultrasound assessment of vessels to determine the optimal site for cannulation.[24] This seems similar to the point of aim of our study. Similar studies should be planned to determine the most correct cannulation point for each age group, with different entry points, different Trendelenburg degrees and different head rotation degrees, when using USG, which has been shown to be superior to use of anatomical landmarks. It is necessary to fully abandon performing cannulation based solely on anatomical landmarks, especially in newborns, and preference identification of a location where cannulation with USG can be performed most easily and with minimum complication.

The most important limitation of this study resulted from a measurement protocol limited to healthy babies, without performing catheterization. Therefore, it is impossible to indicate whether catheterization success and duration vary the observed parameters. We did not encounter any complications. Following this result, we plan to carry out another study for the purpose of comparing our success rates in catheterization, again in newborns.

Conclusion

The use of 15° Trendelenburg positioning may have significant advantage for increasing the CSA when used with the inferior approach.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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