Translational Research in Anatomy 33 (2023) 100264

Contents lists available at ScienceDirect

Translational Research in Anatomy

journal homepage: www.elsevier.com/locate/tria

Anatomical analysis of Sedillot's triangle as a reliable landmark for insertion of central venous catheters in neonates using a central approach

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ARTICLE INFO

Keywords:
Sedillot's triangle
Neonates
Central approach
Catheter
Internal jugular vein
Venous access

ABSTRACT

Introduction: Surgeons employ central venous catheterization as a therapeutic or preventive measure in the pediatric population. These catheters are introduced into the internal jugular, subclavian, or femoral veins using the central approach, involving the insertion of the needle into the apex of Sedillot's triangle, a well-defined anatomical reference point. Using a neonatal sample, this study ascertained the precise positioning of the internal jugular vein to evaluate its suitability as a central venous catheter insertion site. We also determined the location of the vein in relation to Sedillot's triangle.
Materials and methods: Nineteen formalin-fixed neonatal cadavers, encompassing both the left and right sides of the neck region (totaling 38 sides), were dissected to expose the underlying soft tissues and neurovascular structures. Thereafter, the three boundaries of Sedillot's triangle were identified, demarcated, and measured. The internal jugular vein's position within Sedillot's triangle was meticulously recorded, and the diameter of the vein was measured.
Results: Among the 38 sides examined, only three exhibited fully formed triangles, with most of the samples featuring a groove instead. When the needle was placed at the apex of Sedillot's triangle (or within the groove), the needle consistently accessed the internal jugular vein only 65.8% of the time. In 23.7% of cases, the apex was observed lateral to the internal jugular vein, and in 10.5% of cases, the apex was positioned medially.
Conclusion: The apex of Sedillot's triangle is an unreliable anatomical landmark for the insertion of central venous catheters in neonates. Caution should be exercised when employing this landmark in the absence of ultrasound guidance.

1. Introduction

Central venous catheters (CVCs) constitute a vital aspect of critical care and treatment. However, in pediatric patients, CVCs are not always the first treatment option. For neonates in particular, peripherally inserted catheters, placed in the veins of the upper extremities, or umbilical catheters are usually preferred [1]. Peripherally inserted catheters offer versatility, durability, and prolonged venous access. Additionally, they can be easily and quickly inserted at the bedside [2]. Although peripherally inserted catheters enjoy popularity among medical professionals, some studies challenge this paradigm, asserting that CVCs offer superior efficacy for pediatric patients, with lower associated risks and complications [3,4].

CVCs are indicated in several clinical instances including the administration of intravenous chemotherapeutic drugs, parenteral nutrition, and apheresis [5]. Commonly, catheters are inserted via the internal jugular vein (IJV), subclavian vein, and femoral vein as these sites provide safe and reliable access to the venous system [6]. Each of these veins has several advantages [7]. Cannulation via the IJV minimizes catheter tip misplacement, reducing the number of re-entry attempts and the risk of damaging nearby neurovascular structures. In cases of accidental arterial puncture, a hazard due to the proximity of the common carotid artery, the anatomy of these longitudinal blood vessels in the neck permits effective pressure application. Cannulation via the IJV is also associated with fewer infectious complications [7,8]. Additionally, Han et al. [9] support use of the IJV as a CVC insertion site. They compared cannulation success rates across four different insertion sites and found that catheters inserted into the right and left IJVs had the highest success rates (89.7% and 79.4%, respectively) than catheters inserted into the subclavian veins. However, CVCs carry inherent risks

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https://doi.org/10.1016/j.tria.2023.100264
Received 24 August 2023; Received in revised form 16 September 2023; Accepted 16 September 2023
Available online 16 September 2023

and complications, underscoring the importance of a comprehensive understanding of the venous system and its associated structures.

The central approach for placing CVCs in the IJV is usually determined using the anatomical landmark known as Sedillot's triangle, a triangular space defined by the two heads of the sternocleidomastoid muscle. Sedillot's triangle is defined by three borders: the posterior aspect of the sternal head of the sternocleidomastoid muscle, the anterior aspect of the clavicular head of the sternocleidomastoid muscle, and the superior border of the clavicle inferiorly [10]. Three different approaches for IJV entry though Sedillot's triangle exist: the anterior, central, and posterior approach. The anterior approach involves inserting the needle along the medial edge of the sternocleidomastoid muscle, while the posterior approach entails inserting the needle at the posterior edge of the sternocleidomastoid muscle, midway between the mastoid process and the clavicle [6]. The central approach involves inserting the needle percutaneously into the apex of Sedillot's triangle at a 40–45° angle, directed inferiorly towards the ipsilateral nipple [6,11]. This procedure is performed with the patient in a supine position, shoulders supported by a rolled-up towel, and the head tilted contralaterally.

CVCs are commonly inserted under ultrasound guidance, using the percutaneous puncture method, the landmark technique, or the venous cutdown method [1]. Ultrasound-guided CVC placement reduces the risk of complications and ensures higher success rates [12]. However, ultrasound imaging is not always available, in which case an accurate description of the IJV's location within Sedillot's triangle in neonates is imperative. Elucidating this clinically important relationship could increase the success rate of IJV-inserted CVCs and reduce procedural complications. Here, we critically evaluate and discuss the position and morphology of the IJV in relation to Sedillot's triangle in neonates. This endeavor encompasses delineating the dimensions of Sedillot's triangle in a neonatal cohort, describing the position of the IJV in relation to Sedillot's triangle, and determining the diameter of the IJV.

2. Methods

2.1. Materials

The sample included 19 formalin-fixed neonatal cadavers, all aged less than 28 days old and ranging from very low (<1.5 kg) to normal birth weight (≥1.5 kg). These cadavers had been donated to the Department of Anatomy, University of Pretoria, in accordance with the provisions of the South African National Health Act, 61 of 2003, for research and teaching purposes. This study was approved by the University of Pretoria's Faculty of Health Sciences Research Ethics Committee (Ethical clearance number: 175/2022). Neonatal cadavers with any signs of developmental abnormalities in the head and neck regions were excluded, as were those with disrupted anatomy due to previous dissections. Sex and ancestry were not considered as exclusion criteria.

2.2. Dissection and measurements

With the cadavers positioned supinely, the anterior surface of the neck on both sides was meticulously exposed. Subsequently, the skin, superficial fascia, and platysma muscle of the anterior neck region was reflected laterally to afford a clear view of the sternocleidomastoid muscles, encompassing their sternal and clavicular heads. The latter were then cleaned using blunt dissection. Afterwards, Sedillot's triangle, delineated by the clavicle inferiorly and the two heads of the sternocleidomastoid muscle, was demarcated using three colored pins at each corner of the triangle to facilitate the determination of its dimensions (Fig. 1). Needles were carefully inserted perpendicular to the table.

The dimensions of Sedillot's triangle was measured using a mechanical dial caliper (accuracy of 0.01 mm). The width of the triangle was measured from the medial border of the clavicular head of the sternocleidomastoid muscle (point A) to the lateral border of the sternal head of the sternocleidomastoid muscle (point B). The height of the triangle was measured from the midpoint of the width of the triangle (point C) to the apex of the triangle, situated at the juncture of the two heads of the sternocleidomastoid muscle (point D) (Fig. 2).

After the measuring Sedillot's triangle, the sternocleidomastoid muscle was reflected while maintaining the position of the needles, enabling observation and recording of the relative location of the IJV in relation to the needle positioned at the apex of Sedillot's triangle. This step involved identifying adjacent structures, such as the omohyoid muscle and the common carotid artery. In cases where the apex needle did not intersect the IJV but instead was found medial or lateral to it, the distance from the needle to the midpoint of the IJV was measured (Apex-IJV measurement). Lastly, a mechanical sliding caliper was used to measure the diameter of the IJV at the level of the apex of Sedillot's triangle, with careful attention given to avoiding compression of the vein walls.

3. Statistical analysis

Data were summarized using descriptive statistics, including means, minimums, maximums, standard deviations, ranges, as well as 95% confidence intervals (95% CI). Following removal of outliers, measurements from the left and right sides were compared using either a paired *t*-test or Wilcoxon Signed Rank test, depending on the distribution of the data. Depending on the linearity of correlation pairs, the Pearson's correlation or Spearman's rho test was used to investigate correlations between measurements and between measurements and demographic data (weight, height). Additionally, an inter- and intra-observer error

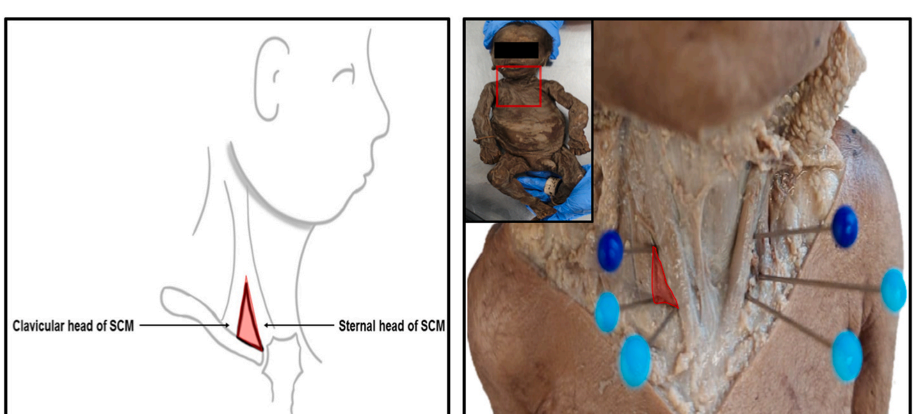

Fig. 1. Neonatal cadaver with fully formed Sedillot's triangle with three defined borders. Inferior border defined by the clavicle, medial and lateral border demarcated.

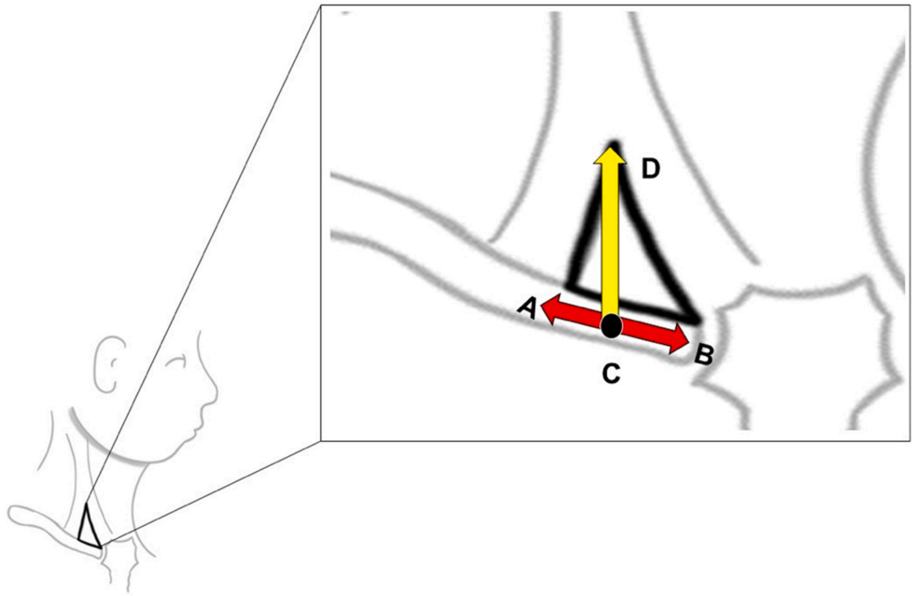

Fig. 2. Dimensions of Sedillot's triangle. Measurement (A–B) - width. Measurement (C–D) - height.

analysis was conducted to assess the repeatability and accuracy of measurements, respectively, and measurements were interpreted using the Bland and Altman [13] method.

4. Results

The neonatal cadavers (n = 19) had a mean weight of 1.02 ± 0.49 kg (range: 0.40–2.20 kg) and a mean height of 0.33 ± 0.03 m (range: 0.29–0.38 m). Among the cadavers, the height of Sedillot's triangle on the right side of the neck and the diameter of the IJV were not normally distributed. The Wilcoxon signed ranks test revealed no significant difference between the right and left sides in terms of height of Sedillot's triangle and IJV diameters. We thus combined these measurements for analysis. Similarly, left and right distances from the apex to the IJV did not differ significantly and were therefore combined for analysis (Table 1).

The mean height of Sedillot's triangle was 7.71 ± 2.58 mm (range: 6.86–8.56 mm). Width could only be measured in three sides and was 3.50 ± 1.75 mm (range: 0.00–7.86 mm) (Fig. 3). The height of Sedillot's triangle ranged between 3.78 mm and 12.90 mm. Additionally, the width of Sedillot's triangle (n = 3) ranged between 1.49 mm and 4.70 mm. None of the measurements were significantly correlated.

Among the 19 neonatal cadavers (38 sides), only three (8%) fully formed Sedillot's triangles with three clear borders were noted (Fig. 1), while most of the neonates (92%) presented with a groove that only had a height measurement (Fig. 3).

In terms of the position of the apex relative to the IJV, the needle in the apex corresponded directly with the IJV in 66% of cases, while the needle missed the IJV laterally and medially in 24% and 10% of cases, respectively. On the left side of the neck, the needle corresponded directly with the IJV in 69% of cases while the needle missed the vein laterally in 26% of cases and medially in 5% of cases. On the right side of the neck, the needle corresponded directly with the IJV in 63% of cases while the needle missed the IJV laterally in 21% of the cases and medially in 16% of cases (Table 2).

For the intra- and inter observer measurements, a one-sample t-tests were conducted to assess the difference in height, diameter, and distance between the apex of Sedillot's triangle and the midpoint of the IJV for both the left and right sides following the Bland and Altman [13] methodology. These tests revealed no significant differences between the two sets of measurements. Moreover, there was no clear bias, and all measurements were considered accurate and repeatable as all data points fell within the upper and lower margins as prescribed by the Bland and Altman method.

5. Discussion

This study evaluated the anatomy of Sedillot's triangle in the context of CVC placement at the IJV in neonates. Broadly speaking, the procedure entails accessing the IJV by inserting a catheter needle into the apex of Sedillot's triangle [6,11]. In this study, the apex of Sedillot's triangle corresponded directly with the IJV in only two thirds (66%) of cases, while the IJV was lateral to the apex of Sedillot's triangle in 24% of cases and medial to it in 10% of cases. The IJV is the most superficial structure within the carotid sheath, lying anteriorly to the laterally placed vagus nerve and the common carotid artery, which is positioned

Table 1
Descriptive statistics for the anatomy of Sedillot's triangle (ST) as well as the distance from its apex to the internal jugular vein (IJV) (in cases where the two were not in direct relation with one another). n = sample size; SD = standard deviation; CI = confidence interval.

		Weight (kg)	Height (m)	ST height (mm)	ST width (mm)	Diameter of IJV (mm)	Apex-IJV (mm)
n		38	38	38	3	38	13
Mean		1.02	0.33	7.71	3.50	2.71	2.66
SD		0.48	0.03	2.58	1.75	0.62	0.75
Minimum		0.40	0.29	3.78	1.49	1.13	1.66
Maximum		2.20	0.38	12.90	4.70	4.90	4.00
Range		1.80	0.09	9.12	3.21	3.77	2.34
95% CI	Upper	1.17	0.34	8.56	7.86	2.92	3.11
	Lower	0.86	0.31	6.86	0.00	2.51	2.20

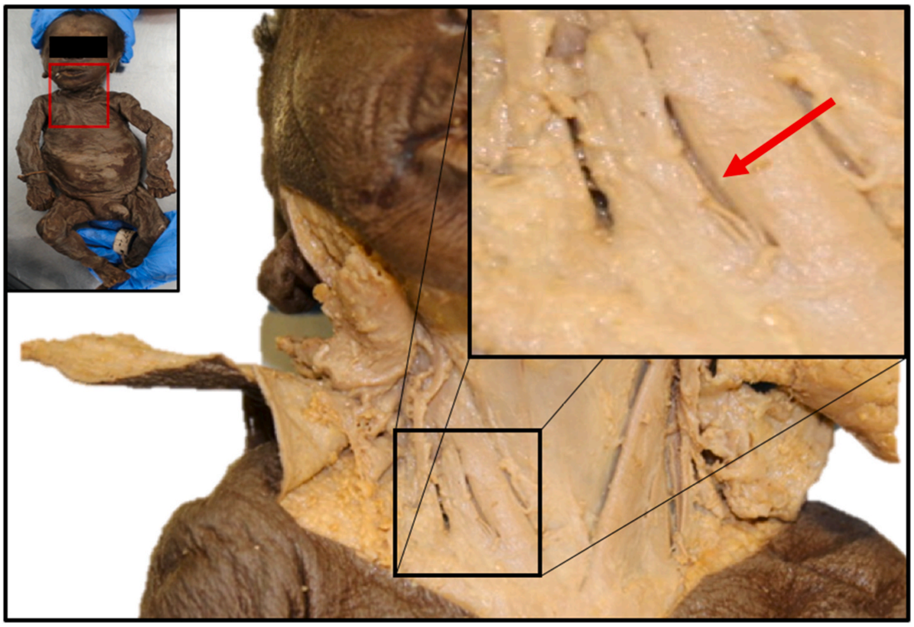

Fig. 3. Neonatal cadaver with a groove (indicated by the red arrow) with only a height measurement instead of a fully formed Sedillot's triangle. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Table 2
Frequency distribution for the position of the internal jugular vein (IJV)in relation to the apex of Sedillot's triangle.

	Total sample		Left side		Right side	
Position of IJV	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
In relation	25	65.8	13	68.4	12	63.2
Lateral	9	23.7	5	26.3	4	21.1
Medial	4	10.5	1	5.3	3	15.8
Total	**38**	**100.0**	**19**	**100.0**	**19**	**100.0**

medially [10]. These results imply that mispositioning the needle carries a heightened risk of accidently puncturing the common carotid artery, which can result in serious complications.

In recent years, the consensus has grown stronger that these procedures should be guided by real-time ultrasound to reduce the number of attempts to gain vascular access and reduce procedural duration [14–17]. While real-time ultrasound guidance is arguably more successful than the landmark approach, no differences in complication rates have been noted [17]. While mastering the use of real-time ultrasound is an acquired skill, this practice still needs to be fully integrated into medical routines in developing countries [18]. Therefore, the conventional landmark approach still holds value until medical operators gain sufficient expertise in ultrasound device catheter placement [17].

Studies by Han et al. [9], Botha et al. [19], and Dunne et al. [20] corroborated that many physicians prefer the right IJV when employing the central approach as there is a more direct course to the superior vena cava than when using other viable vessels. Additionally, the right IJV was frequently found to be directly posterior to the apex of Sedillot's triangle. Han et al. [9] inserted catheters into the right and left IJVs and reported 89.7% and 79.4% success rates, respectively. Similarly, Botha et al. [19] reported a 97.14% success rate for right IJV and a 78.79% success rate for the left IJV. In the study done by Dunne and colleagues [20] the right IJV was pierced in 71.4% of the cases, while the left in only 52.5% of the cases. However, in contrast to these studies, this study found that the apex of Sedillot's triangle only corresponded directly with the right and left IJVs in 63% and 69% of cases, respectively. Consequently, needle insertion accuracy was similar between the left and right IJVs. This discrepancy may be attributed to the small sample size and the inability to palpate the common carotid artery before needle insertion. Another possible reason for the discrepancy between the presented results and those off Male et al. [8], and Han et al. [9] may be the fact that the latter studies focused on older infants, between 6 and 12 months and younger than 12 months (average 5.5 months), respectively.

Notably, among the 19 neonatal cadavers (38 sides), only three exhibited fully formed Sedillot's triangles with distinct borders (Fig. 1). Contrary to expectations, most of the sample presented with a visible groove, lacking clear separation between the sternal and clavicular heads of the sternocleidomastoid muscle (Fig. 3). This can be considered a limitation of the study since the two heads of the sternocleidomastoid muscle were indistinguishable, and this overlap made it difficult to locate the apex of the groove, which may have influenced the accuracy of needle placement. However, it can be argued that because the needle was inserted under direct visual guidance (with the skin over the sternocleidomastoid muscle removed), accuracy was not affected. Attempting this procedure in living neonatal patients could be even more difficult, possibly leading to an even higher degree of mispositioning. Dunn et al. [20] found similar results using an adult population showing 14% of the cases on the right side of the neck and 10% on the left side having no gap between the clavicular and sternal heads of sternocleidomastoid, which resulted in the puncture of related structures and mispositioning of the catheter needle. These results suggest that the central approach may not be the most reliable technique to blindly cannulate the IJV in neonates, given the difficulty in locating the apex of Sedillot's triangle (or groove) without exposing the muscle.

The reasons for the absence of a clear triangle can only be theorized at this juncture. The clavicle bone may still be growing outward laterally as the neonate develops, which could cause the clavicular head of the sternocleidomastoid muscle to move with the growing clavicle, separating the two overlapping heads of the sternocleidomastoid muscle, forming the triangular space of the Sedillot's triangle. Notably, this study represents the first description of a groove rather than the expected Sedillot's triangle. Future studies could attempt to corroborate the absence of the triangle in a living neonatal sample and investigate the development of Sedillot's triangle in a living population over several months or years to determine the age at which the two heads of the sternocleidomastoid muscle separate to form the distinctive triangle.

The small infant cadaveric population can be considered a limitation. This is attributed to the scarceness of such resources. Nonetheless, any anatomical insights gained from pediatric samples are considered invaluable and significantly contribute to the placement of CVCs in this unique patient population.

6. Conclusion

The absence of a clearly defined Sedillot's triangle within neonatal cadavers, along with the IJV being directly aligned with the apex of Sellidot's triangle in just two-thirds of cases, suggests that employing Sellidot's triangle as a conventional landmark for cannulation may be problematic and is not recommended for neonates. Bruzoni et al. [12] suggested that using ultrasound-guided techniques may be more favorable, reducing the number of cannulation attempts and lowering the risk of complications. Although, if ultrasound imaging is not available, Sedillot's triangle may be used to guide the insertion of CVCs [11]. This study supports the findings of Bruzoni and co-workers [12] and recommends that when using the central approach to place CVCs, direct ultrasound should be used to guide the procedure or, if ultrasound is not available, the cut-down method should be used.

Ethics approval and consent to participate

The studies involving human participants were reviewed and approved (Ethics clearance number: 175/2022) by the Health Sciences Research Ethics Committee at the University of Pretoria, South Africa. All methods and observations were carried out in accordance with the relevant requirements, guidelines, and regulations stipulated in the South African National Health Act (61 of 2003). The authors wish to sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially improve patient care and increase mankind's overall knowledge. Therefore, these donors and their families deserve our highest gratitude.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Funding source declaration

The authors declare that this research and publication is not funded by any financial supporting body.

CRediT authorship contribution statement

Amelia Ayres: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Roles, Writing – original draft, Writing – review & editing. **Daniël J. van Tonder:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Roles, Writing – original draft, Writing – review & editing. **Albert-Neels van Schoor:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Roles, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: All authors wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. However, AvS would like to disclose that he is a part of the editorial board of this publication.

Acknowledgements

The authors wish to acknowledge Dr Cheryl Tosh (University of Pretoria) for language editing the revised manuscript. We would also all sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially improve patient care and increase mankind's overall knowledge. Therefore, these donors and their families deserve our highest gratitude.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tria.2023.100264.

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