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Original Research Article

Morphometric Analysis of Vertebral Artery in the Scaleno Vertebral Triangle

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ABSTRACT

Background: The vertebral arteries (VA) play a vital role in supplying blood to the brainstem and cerebellum. Vertebral artery anomalies, including abnormal origins, courses, and structural irregularities, heighten the risk of cerebrovascular events. Typically, the vertebral arteries arise from the posterosuperior aspect of the first part of the subclavian artery. The aim of this study is to present the presence of variation in the origin of vertebral artery

Material and Methods: Twenty-eight embalmed cadavers allotted for 1st year MBBS dissection in the Department of Anatomy were used for the study. The triangle of vertebral artery was exposed in all the cadavers, and examined the origin of vertebral artery. Dimensions of the Triangle of Vertebral artery (TVA) and vertebral artery were then measured using a digital vernier caliper and the area and height of the TVA were calculated.

Result: In the present study, we have evaluated the morphometric parameters of the TVA and vertebral artery. Even though there were no noticeable differences in the boundaries of TVA of both sides, the morphometric parameters showed slight difference in the measurements, but not significant. Among the 28 cadavers the unilateral origin of VA in one cadaver was from the arch of aorta between the left common carotid artery (LCA) and left subclavian artery (LSCA) .

Discussion & Conclusion: The mean height of TVA was 26.3mm (range, 23.7-33.7 mm) on the left and 26.2mm (range, 23.5-32.8 mm) on the right. In the current study it was observed the origin of VA from the arch of aorta between the left common carotid artery (LCA) and left subclavian artery (LSCA). The current study found that 3.6% of the variations in the origin of VA. This study highlights the variation in the origin of the vertebral artery and accentuates the importance of identifying these variations in clinical practice.

KEYWORDS: Vertebral Artery, Subclavian artery, Arch of Aorta, foramen transversarium.

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INTRODUCTION

The vertebral arteries (VA) play a vital role in supplying blood to the posterior part of the brain, specifically the cerebellum, brainstem, and occipital lobes. Occlusion in this artery interrupts blood supply to these areas and can cause significant neurological deficits. Typically the vertebral arteries arise from the postero-superior aspect of the first part of the subclavian artery and are divided into four segments [1].

The first segment cervical part, V1 (pre-foraminal) lies within the scalenovertebral triangle or the Triangle of Vertebral Artery (TVA). The scalenovertebral triangle also known as the colliscalene triangle, is bounded laterally by the longus colli, medially by the scalenus anterior, and by the first part of the subclavian artery (SA) at its base [2].

The artery ascends behind the common carotid artery and vertebral vein. It is crossed by the inferior thyroid vein and on the left side by the thoracic duct [3]. The second segment vertebral part V2 (foraminal) lies within the transverse foramina of C6 to C2. Normally enters through the foramen transversarium of the 6th cervical vertebra and ascends upwards through the foramina up to the first cervical vertebra, C1 [4]. The third segment sub occipital part-V3- atlantic, extradural or extraspinal segment or the is the distal extracranial segment that is short and tortuous. The artery passes through the transverse foramen (TF) of the atlas and then curves backwards and medially behind the lateral mass of the atlas. The fourth part, intracranial part - V4- the intradural segment makes a sharp turn to pierce the dura mater, thereby entering the cranium through the foramen magnum. V4 ascends anterior to the roots of the hypoglossal nerve (CN XII) and joins its contralateral counterpart at the lower border of the pons to form the basilar artery [5].

Together, the vertebral arteries and the basilar artery are called the vertebrobasilar system, which is the main blood vessel supply to the brainstem. Spinal branches are given off from the second part and the muscular branches from the first and the third part. Cranial branches arise from the fourth part [6]. Pathological changes like luminal narrowing due to web/diaphragm formation or VA injuries, heighten the risk of cerebrovascular events. As per Denver grading, posterior circulation stroke can result from a vertebral artery injuries (VAI), either from a blunt trauma or from an iatrogenic injury. Denver grade IV lesions are the most prevalent type of VAI complications, which usually affect the V1 segment and account for a modest but significant portion of blunt trauma cases [7,8].

Vertebral artery anomalies, including abnormal origins, courses, and number are common due to its embryological origin. A particularly rare but significant variation is an anomalous VA origin, which requires careful evaluation prior to surgeries involving adjacent large blood vessels like carotid artery, arch of aorta or even arteries supplying oesophagus. Failure to identify this anomaly, especially in cases of “vertebral arteria lusoria”, can lead to serious complications [9, 10]. Surgeons must have a thorough understanding of the anatomy of the VA and its common variations, in order to prevent VAI when performing cervical spine approaches and instrumentation. A careful preoperative examination with the right advanced imaging investigations is required to verify the route of the VA can prevent iatrogenic injury [8, 11].

In this background a cross-sectional morphometric study of vertebral artery and TVA were designed to evaluate the dimensions of TVA and VA, and also to find out the presence of any variation in the origin and course of V1 segment of vertebral artery.

MATERIALS AND METHODS

Twenty-eight embalmed male cadavers of age range 47 to 70yrs, allotted for 1st year MBBS dissection in the Department of Anatomy were used for the study. To expose the vessels and nerves at the root of the neck, standard dissection procedure was followed [12].

The triangle of vertebral artery lies deep in the root of neck and to expose it, first the sternocleidomastoid muscle was reflected from its origin. To expose the contents of carotid sheath- common carotid artery, internal jugular vein, and the vagus nerve, removed the fat, lymph nodes, and remains of the carotid sheath. After removing the cervical part of the brachiocephalic vein and its tributaries, the common carotid artery, internal jugular vein, and vagus nerve were displaced medially to reveal the boundaries of the triangle of vertebral artery (TVA). The vertebral vein severed and exposed the vertebral artery. The vertebral artery was traced up to the apex of

TVA, the sixth cervical vertebra. The origin of the vertebral artery and its variations noted from both the sides. Costocervical trunk and its branches, Ansa subclavia, Phrenic nerve etc. were also traced. The prevertebral fascia was cleared from the anterior part of this angular interval to clear the sympathetic trunk and associated ganglia, and major variations of all these structures were recorded. Dimensions of the TVA and vertebral artery were then measured using a digital vernier caliper.

The following measurements were recorded

1. Length of the vertebral artery from its origin to carotid tubercle
2. Diameter of the vertebral artery at the base of TVA
3. Lateral border Longus colli – side (a)
4. Medial border of Scalenus anterior – side (b)
5. Subclavian artery – Base (c)

The area and height of the TVA were calculated as follows:

Semi-perimeter of the TVA

$$s = \frac{a+b+c}{2}$$

Area

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$

RESULTS

In the present study, we have evaluated the morphometric parameters of the TVA and vertebral artery. Even though there were no noticeable differences in the boundaries of TVA of both sides, the morphometric parameters showed slight difference in the measurements, but not significant.

Table 1: Morphometric parameters of Triangle of vertebral artery and dimensions of V1 segment of vertebral artery.

Morphometric parameters	Measurements (Mean± SD)	Range
Height of left TVA	26.3±2.3mm	23.7-33.7 mm
Height of right TVA	26.2±2.2 mm	23.5-32.8 mm
Area of left TVA	234.0±30.9 mm^2	174.7-307 mm^2
Area of right TVA	232.2±30.7 mm^2	174.7-308.1 mm^2
Length of V1 segment of Left VA	31.4±1.5 mm	29.2-34 mm
Length of V1 segment of Right VA	30.9±1.6 mm	28.1-33.9 mm
Diameter of V1 segment of Left VA	5.0±0.6 mm	4.1-5.7 mm
Diameter of V1 segment of Right VA	4.8±0.6 mm	3.7-5.6 mm

TVA: Triangle of vertebral artery, VA: vertebral artery and V1: preforaminal part of vertebral artery

The mean height of TVA on the left side was 26.3mm and 26.2mm on the right side. The mean Area of TVA was 234.06mm on the left and 232.16 on the right side. The mean length of vertebral artery on the left side it was 31.3mm and on the right side it was 30.8mm. The mean diameter of the VA was 5.00mm on the left side and 4.77mm on the right.

Among the 28 cadavers we observed an abnormal origin of vertebral artery in the left side of a 52-year-old male cadaver. That artery was arising from the upper aspect of the arch of aorta between the left common carotid and left subclavian artery (Fig.1). When tracing the vessel superiorly, it was observed that it was entering into the foramen transversarium of the 4th cervical vertebra. It was confirmed that the vessel was left vertebral artery which has its origin from arch of aorta instead of first part of left subclavian artery. The preforaminal part of this artery which has its origin from aortic arch was longer and narrower compared to the right vertebral artery, which has a normal origin and course. The length of the preforaminal part of the left VA was 87.86 mm and the diameter at the origin was 4.26 mm, while the normal right side artery was 5.3 mm diameter, with a length of 30.7mm.

Fig. 1: Neck of the dissected cadaver showing the origin of left vertebral artery (LVA) from the arch of aorta (AA) not from its usual origin from the first part of Left Subclavian artery (LSCA). The left vertebral artery (LVA) arising abnormally from the arch of the aorta, between the left common carotid artery and the left subclavian artery

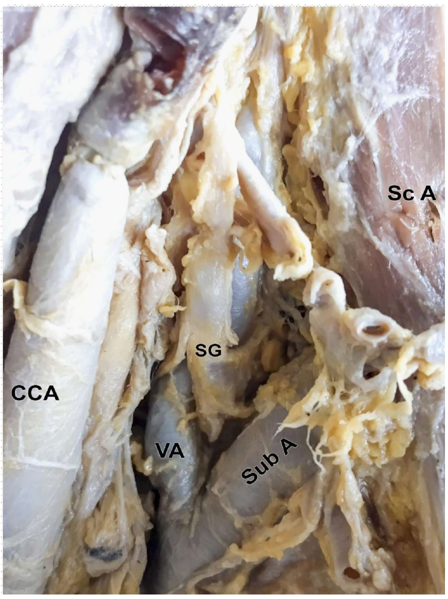

Fig. 2: Triangle of vertebral artery showing the left vertebral artery constricted by the encircling fused stellate ganglia. Stellate Ganglia (SG), Common Carotid Artery (CCA), Vertebral Artery (VA), Subclavian Artery (Sub A), Scalenus Anterior (Sc A)

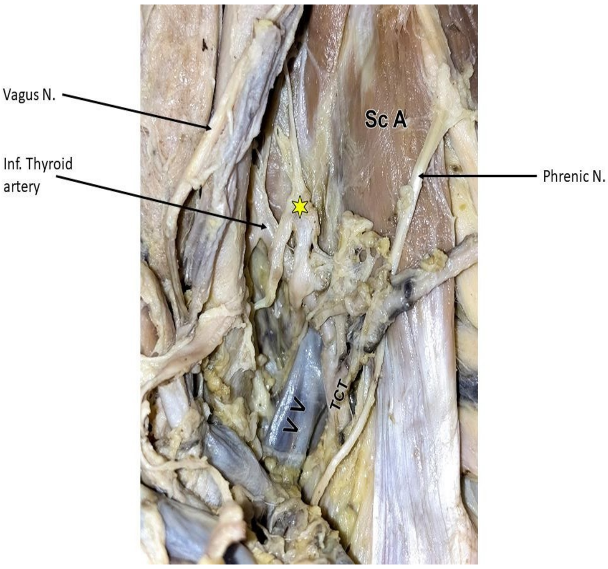

Fig. 3: Association of Middle cervical sympathetic ganglia and inferior thyroid artery. Scalenus Anterior (Sc A), Vertebral Vein (VV), * Stellate Ganglion

In almost all TVA's the vertebral vein and inferior thyroid artery was present anterior to the vertebral artery. The phrenic nerve was found anterior to the scalenous anterior muscle and it never encroached in to TVA in any specimens. The sympathetic chain and inferior cervical sympathetic ganglia were also found in all specimens within the triangle. In one of the cadaver the left side VA was constricted by the stellate ganglia (fused inferior cervical sympathetic ganglia and first thoracic ganglia), which was encircling the vertebral artery (Fig: 2).

In another specimen the middle cervical sympathetic ganglia was encroached in to the apex of TVA and emerging fibers from it were encircling the inferior thyroid artery (Fig.3).

DISCUSSION

Anatomical parameters of TVA are important and useful for surgeons who are doing interventional practices at the root of neck; also it may help the clinicians and radiologist in proper diagnosis of neurological problems. The primary aim of the present study was to assess morphometric parameters of the TVA on both sides in male cadavers. In the present study we could not find any significant difference in the dimensions of the triangle between left and right side (Table:1). The mean height of TVA was 26.3mm (range, 23.7-33.7 mm) on the left and 26.2mm (range, 23.5-32.8 mm) on the right. In the previous studies was 3.2 cm (range, 2.6–3.7 cm), 21.7 + 5.1 mm [2, 13]. Singh et. al. reported that the mean width of TVA (base) was 19.4 + 4.4 mm and in our study it was 17.7mm with a range of 14-21mm.

The area of the TVA was not reported previously and we found that area of left side TVA was 234.0±30.9 mm^2 (range from 174.7 to 307 mm^2) and 232.2±30.7 mm2 (range -174.7-308.1 mm^2) on the right side.

Length of V1 segment of the artery in the present study was found as 31.4±1.5 mm (range, 29.2- 34 mm) on the left side, and 30.9±1.6 mm (range, 28.1-33.9 mm) while in pa previous report it was 28.9 + 8.6 mm. In our study the diameter of VA at its base was found to be 5.0±0.6 mm (range-4.1-5.7mm) on the left and 4.8±0.6 mm (range-3.7-5.6 mm) on the right while it was reported as 3.1 mm to 6 mm previously [2].

Our study contributed data on the origin VA variations and its clinical significance. Out of the 28 cadaver analyzed only one exhibited variations in the origin of the VA. The possible variations in the origin of vertebral artery are unilateral or bilateral origin either directly from aortic arch or with a common trunk with the left subclavian artery [14]. In the current study it was observed the origin of VA from the arch of aorta between the left common carotid artery (LCA) and left subclavian artery (LSCA) and instead of entering in to 6th cervical transverse foramina it was entering in to foramina transvesarium of the 4th cervical vertebra.(Fig.4).

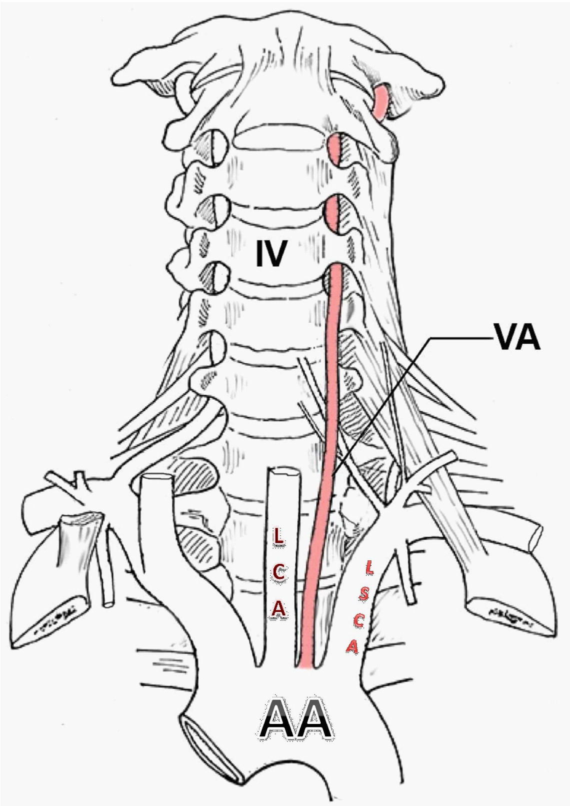

Fig. 4: Schematic diagram to explain the origin and termination of left vertebral artery (red coloured). Left VA arising from arch of aorta(AA) between the left common carotid artery (LCA) and left subclavian artery (LSCA). It ascends superiorly and entering in to foramina transversaria of 4th cervical vertebra.

Sawant SP reported atypical origin of the left VA from the aortic arch is recorded in approximately 6% of the population whereas the current study found that 3.6% of the variations in the origin of VA [15]. To understand the variations in the origin of VA embryological basis of complex development of the aortic arches need to be known. Abnormal regression or persistence of specific segments during embryogenesis can lead to atypical VA origins.

The heart and aorta descend, as the embryo develops leading to the emergence of cervical intersegmental arteries from the aortic arch [16]. The dorsal intersegmental arteries, are interconnected along their length from the 1st to the 6th and connected to the 7th dorsal intersegmental artery at their lower end [17] The origin of the dorsal branch of the 7th cervical intersegmental artery, close to the postcostal anastomosis forms the initial segment of LVA and the second segment arises from the longitudinal connections of the postcostal anastomosis [18]. The persistence of the dorsal division of the left 6th intersegmental as the first part of the vertebral artery instead of that of the left 7th intersegmental artery may be the reason of the aortic origin of left vertebral artery seen in the current study [19].

The relation of stellate ganglia with the left vertebral artery (Fig.2) in one of the cadavers is utmost important clinically. If such association exists and a stellate ganglion block is performed, the artery may get damaged or if the artery is accessed surgically, then it can affect the ganglia.

Knowledge of the variations in the origin of VA is crucial for clinicians, especially surgeons and radiologists. Presence of unexpected VA origin variations can complicate surgical procedures, involving head and neck and upper thorax vascular surgery and increase the risk of vascular injury. Unrecognized variations of VA origins can lead to misinterpretation in imaging, potentially resulting in incorrect diagnoses or missed pathologies [20].

CONCLUSION

Many surgical interventions at the root of the neck require a comprehensive understanding of the TVA anatomy; otherwise, it may lead to neurovascular complications. The present study highlights the measurements of TVA especially the area of the triangle, which was not described previously and it may be useful for the surgeons for planning and executing such surgical interventions in TVA. We found a variation in the origin of the vertebral artery that accentuates the importance of identifying these variations in clinical practice. A thorough understanding of vertebrobasilar variations, especially those involving the vertebral artery, is essential for improving surgical outcomes in skull base and head and neck procedures. Knowledge of these variations also enhances the accuracy of imaging interpretation. Awareness of these anatomical differences is essential for surgeons and radiologists to minimize the risk of complications and optimize patient care. Further research is warranted to explore the long-term clinical implications of these variations.

ABBREVIATIONS

VA: Vertebral Artery,
TVA: Triangle of Vertebral Artery,
LVA: Left Vertebral Artery,
CCA: Common Carotid Artery,
LSCA: Left Subclavian artery,
AA: Arch of Aorta.

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RB: Contributed in plan, protocol writing, implementation, data collection, interpretation of data and conclusion.
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DD: Contributed in plan, interpretation of data and conclusion

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