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Anatomical Variations and Surgical Implications of the First Segment of the Vertebral Artery

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Abstract:

Background: The vertebral artery typically arises from the subclavian artery, ascends through the transverse foramina of the cervical vertebrae (C6 to C1), and enters the foramen magnum to join the basilar artery, forming the vertebrobasilar system. The first segment of the vertebral artery is defined as the portion from its origin to its entry into the transverse foramen of the sixth cervical vertebra (C6).

Aims and Objective: The present study aimed to provide anatomic data for the origin and course of first segment of vertebral artery and its clinical importance.

Materials and Methods: Fifty (50) hemi-neck specimens collected from formalin-fixed embalmed cadavers of the South Indian population were dissected. Origin, course, entry level into foramina transversarium(FT) and length was noted.

Results: 92% of vertebral artery originated from first part of subclavian artery,8% from arch of aorta.46% entered foramina transversarium at C6 level, 20% entered at C5 and 34% C4 level.

Conclusion: In conclusion, the first segment of the vertebral artery exhibits significant anatomical variations that are essential for clinicians to recognize and understand. This knowledge ensures safer surgical interventions, accurate diagnostic assessments, and better management of patients presenting with related clinical symptoms.

Keywords: Vertebral artery, Foramina Transversarium, Cervical spine, Arterial insufficiency

Introduction:

Vertebral artery injury is a disastrous complication during cervical spine surgery. Thorough preoperative evaluation is essential to understand the extracranial course of artery. The first segment, from the origin in the subclavian artery also known as the V1 -pre-foraminal segment courses between the two muscles longus colli and the anterior scalene. The V2 foraminal segment along with vertebral venous plexus, sympathetic plexus enters the sixth cervical vertebra. The V3 Atlantic or extradural segment courses in the suboccipital triangle. The V4 - intracranial or intradural segment passes across the suboccipital triangle into the intracranial area via the foramen magnum [1,2,3].

In normal anatomy, the course of the first part of vertebral artery (VA) is short and deeply located in the scaleno-vertebral triangle and enters foramina transversarium (FT) of sixth cervical vertebra (C6) vertebra. Sometimes its origin and course varies. Such incidence of anomalous vertebral artery course is low, but failure to recognize a medially located vertebral artery may result in a life-threatening iatrogenic injury during cervical vertebral decompression

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[4,5]. Other procedure such as instrumentation in cervical spine epidural injection and abscess drainage due to cervical spine infection like tuberculosis can damage the vertebral artery. Thorough knowledge of anatomy of vertebral artery is essential to avoid inadvertent injury during surgery [6,7]. The present study aimed to provide anatomic data for the origin and course of first segment of vertebral artery and its clinical importance.

Materials and Methods:

The present study was conducted in the Department of Anatomy, All India Institute of Medical Sciences, Mangalagiri, India after obtaining clearance from the institute's ethical clearance committee. Fifty hemi-neck specimens collected from formalin-fixed embalmed cadavers of the South Indian population were dissected. The age of the cadavers was between 50 to 70 years. Deep dissection of the neck was done to expose the left and right subclavian arteries. Origin of Vertebral artery was traced from their origins to the entry into the cervical transverse foramina. The lengths of the V1 segment and the outer diameters of the prevertebral parts of the vertebral arteries was measured at their mid-lengths on both sides and noted. Any Variations in the origin, course and the level of the entry into FT were noted.

Results:

Variations in the origin of Vertebral artery: The origin of vertebral artery was categorised into three types - first from subclavian artery and second variant from arch of aorta and third variant from thyrocervical trunk. Based on the origin, out of 25 Right VA, all 25 originated from subclavian artery, On the left side, twenty-one (21) originated from first part of subclavian artery, 4 from arch of aorta. Together 92% of vertebral artery originated from first part of subclavian artery,8% from arch of aorta and none from thyrocervical trunk (Table 1).

Variations in the level of entry of Vertebral artery into Foramina transversarium (FT):

Based on the level of entry into FT, out of 25 Right VA, 15 entered at the C6 vertebral level, five each (5) entered at C5 and C4 level. On the left side, eight (8) entered at C6 level, five (5) entered at C5 level and twelve (12) at the level of C4. Totally 46% entered at C6 level, 20% entered at C5 and 34% C4 level (Table 2).

Origin	Right (n=25)	Left (n=25)	Total (n=50)	Percentage %
Subclavian artery	25	21	46	92
Arch of aorta	0	04	04	8

Table 1: Origin of Vertebral artery

Vertebral levels	Right (n=25)	Left (n=25)	Total (n=50)	Percentage %
C-6	15	08	23	46
C-5	05	05	10	20
C-4	05	12	17	34

Table2: Vertebral artery entry into Foramina transversarium

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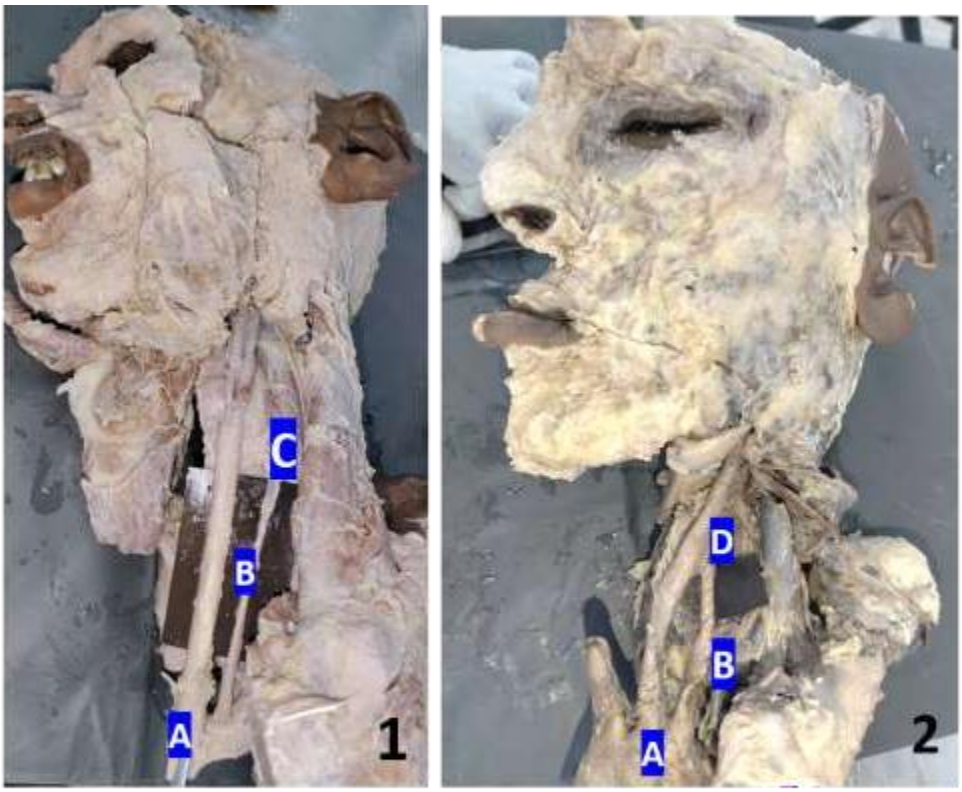

Figure 1 & 2 :Left Vertebral artery arising from the arch of aorta and entering at C4 & C5 Vertebra level, **A**- Arch of Aorta,**B**- Vertebral artery, **C**- C4 Formina transversarium (FT), **D**- C5 FT

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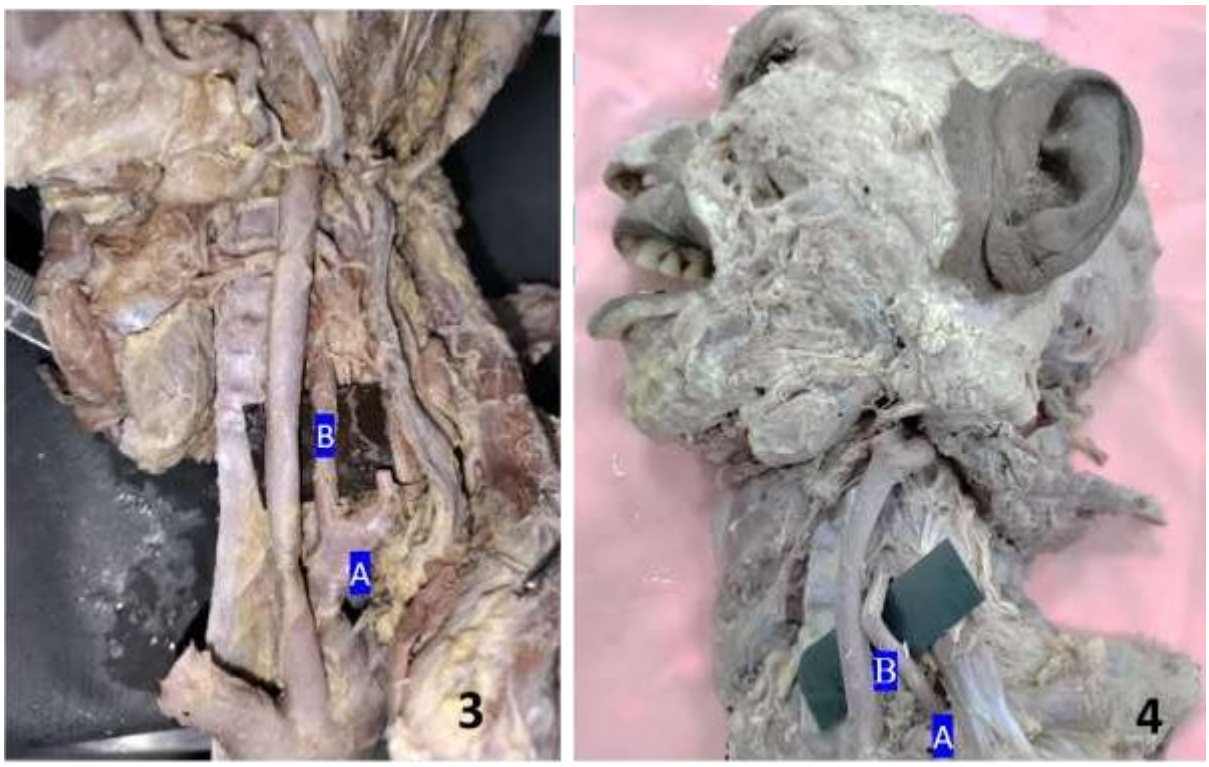

Figure 3 & 4 :Left Vertebral artery of subclavian origin with variable course

Variations in the course of the artery:

Based on the origin and the level of entry into the FT, course of the artery differed on the right and left side. On the left side, vertebral artery of aortic arch origin had a straight long tortuous

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course compared to the artery of non-aortic origin and entered FT higher than the sixth cervical vertebra (Figure 1,2,).In one specimen ,the left VA originated from a high level of subclavian artery (Figure 3) and in another specimen after origin from subclavian artery the course of the artery was medially directed before entering FT (Figure 4).On the contrary the artery on the right side had short and less tortuous course and entered predominantly at C6 vertebral level. The mean length of V1 Segment of left vertebral artery of aortic origin was 7.2 ± 1.02 cm, whereas the length of subclavian origin vertebral artery on both right and left was 2.1±0.03 cm.

Discussion:

In normal anatomy, vertebral arteries originate from the upper surface of first part of subclavian artery on right and left sides. The first segment of vertebral artery is closely related to cervical nerve roots, vertebral veins, and sympathetic plexus [8,9]. Variations in its course can affect these relationships, potentially leading to symptoms related to nerve compression or vascular compromise. In the present study, all right vertebral arteries originated from subclavian artery whereas on the left side, about twenty one (21) VA originated from first part of subclavian artery and the remaining five (4) originated from the upper surface of arch of aorta lateral to the origin of common carotid artery and medial to the origin of left subclavian artery .The incidence of the left vertebral artery of the aortic arch origin of 8% in the present study was in accord with incidence in previous studies, which ranged from 2.4% to 6.9% [8,9,10].

During third week of embryogenesis, the cervical intersegmental arteries forms a vertical anastomosis with each other. Later intersegmental connections disappear to form the vertebral arteries. During the process of fusion of the vertebral arch with the vertebral body, the VA is enclosed into foramina transversaria of cervical vertebrae [11,12].Variation in this process leads to various level of entry into FT. Based on the level of entry into the foramina transversarium (FT) the arteries entered at three levels C6, C5 and C4 vertebral levels. In the current study VA entered at C6 level (46%), at C5 level (20%) and C4 level (34%).Similar to the present study, a study done by Aparjita sikka et al has described different levels of VA enter the sixth cervical foramen in 88% cases, seventh in 5% and fifth in 7% cases[8]. According to Standring's et al the artery enters the foramen transversarium of the 6th cervical vertebra in 90% cases, while those of 7th, 5th, 4th and 3rd in 2%, 5%, 2% and 1% cases, respectively [13]. Thus, the entry of vertebral artery of aortic arch origin is always higher than the normal as reported in aerlier studies [14-18]. Due to the entry of VA at different levels, course of the artery varies based on its entry level into FT.

The present study showed that the on the right side, the course of the pre-vertebral part of the vertebral artery of subclavian origin was short and straight. The mean length of the right VA was 2.1±0.03 cm and thinner compared to the left side 7.2 ± 1.02 cm. Left VA of aortic origin had long course , thicker with large lumen and higher level of entry into FT(Figure 1,2,3,). In majority of the specimens, the prevertebral parts of the left vertebral arteries of aortic arch

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origin ascended medially on the cervical vertebral bodies and intervertebral discs.In one specimen the vertebral artery originated from a higher level from subclavian artery(Figure 3) and in another specimen it was bent medially before entering the FT (Figure 4). In such cases the chances for injury to the vessel is very high.Both theseThis finding suggests that risk of damage to left vertebral artery of variable course might happen during cervical spine operative procedures. Similar to our finding,Tardieu et al. revealed that all cases of the prevertebral parts of the left vertebral arteries of aortic arch origin ascended medially on the cervical vertebral bodies . Hence ,the left vertebral artery of aortic arch origin, which lacks the protection of the bony transverse process is most vulnerable for damage during surgery of the neck such as anterior cervical decompression and fusion operation.

Conclusion:

The findings of the present study suggest that variations in origin of left vertebral artery is most often seen compared to right Vertebral artery. The aortic origin of left vertebral artery takes a long course due to its entry into FT at higher level such as C5 and C4 compared to subclavian artery origin. Hence, we conclude that preoperative imaging is crucial and important to identify the variations and prevent iatrogenic injury to the vertebral artery and to avoid untoward outcomes. Clinicians must be aware of these variations for any preoperative and procedural evaluation.

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