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Running head: Vertebral arteries passing through stellate ganglion

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Abstract

Vertebral artery is a branch of 1st part of subclavian artery. Vertebral artery arising from the aortic arch most commonly presents on the left side. The cervical part of sympathetic trunk is closely related to the vertebral artery in the cervical region. Though lots of variations regarding anomalous origin, course of vertebral artery is reported in the literature, here we present a rare anomaly in which vertebral artery after originating from aortic arch is passing through stellate ganglia and it enters into the transverse foramina of higher cervical vertebra (C5). Such variation should be kept in mind by anaesthesitist during stellate ganglion block in order to relieve intractable pain in central nervous system lesion. Surgeons should keep this anomaly in mind during cervical spine surgery otherwise vertebral artery may get injured leading to haemorrhage.

Key words: aortic arch, hemodynamic, Horner syndrome, sympathetic ganglia, vertebral artery
INTRODUCTION

In normal anatomy of aortic arch and its great vessels, vertebral arteries (VA) arises from 1st part of subclavian artery. Numerous articles on vertebral arteries (VA) are available in the literature regarding its anomalous origin, course and tortuosity, fenestration and its entry into foramen transversarium [1, 11, 13, 16, 17]. Here, we present a very rare anomaly in which vertebral arteries are bilaterally passing through the stellate ganglion before entering into foramen transversarium with anomalous origin of left vertebral artery from aortic arch.

The left subclavian artery (LSA) is one of the three branch that arises from aortic arch whereas the right subclavian artery arises from the brachiocephalic trunk (BCT). For description, each subclavian artery (SA) is divided into three parts by scalenus anterior muscle [15].

Vertebral artery (VA) supplies blood to upper spinal cord, brainstem, cerebellum and posterior cerebral hemisphere [15]. It is divided into four segments. First segment (V1) extends from its origin up to its entry into C6 transverse foramen, second part (V2) ascends through upper five cervical transverse foramina, third part (V3) emerges from first cervical vertebra and fourth part (V4) enters cranial cavity, unites with its fellow to form basilar artery [17]. The vertebral artery and corresponding vein extends vertically from the base to apex of scaleno-vertebral triangle. Medial, lateral boundaries and base of the triangle is formed by longus colli, scalenus anterior and first part of subclavian artery respectively. At root of the neck, 1st part of vertebral artery (V1), its accompanying vein and cervical part of sympathetic trunk (CST) are contents of scaleno-vertebral triangle [3].

The Cervical part of sympathetic trunk (CST) runs up medial to the vertebral artery and presents 3 ganglia - superior, middle and inferior. Superior cervical ganglion (SCG) lies in front of C2 and C3 vertebrae. Middle cervical ganglion (MCG) lie medial to the carotid tubercle (C6 vertebra) and the inferior cervical ganglion (ICG) lies behind the commencement of vertebral artery. ICG is often fused with the 1st thoracic ganglion to form stellate (cervicothoracic) ganglion (SG) in front of the neck of 1st rib [14].
CASE REPORT

It was an incidental finding in an embalmed formalin fixed male cadaver during routine undergraduate dissection class of thorax in department of Anatomy. After demonstrating the boundaries and content of middle mediastinum, heart was tried to be removed by sectioning the three major vessels i.e. Brachiocephalic trunk (BCT), Left common carotid artery (LCA) and Left subclavian artery (LSA) arising from arch of aorta but some resistance was found during its removal. On observation it was found that a fourth (4th) vessel is originating from the aortic arch between the left common carotid artery (LCA) and left subclavian artery (LSA) (Fig.1A). Midline incision was given in the cervical region to trace the course of 4th vessel. Skin and fascia were reflected laterally. Sternocleidomastoid muscle was transected and reflected to expose the neurovascular complex. Carotid artery, CST was identified and length and diameter of the 4th vessel was measured using digital Vernier caliper.

For microscopic anatomy of 4th vessel, small piece of artery was dissected out from the middle of the V1 segment and was preserved in 10% formalin solution. The tissue was processed, embedded in paraffin. Sections were taken using rotatory microtome and slide was prepared and stained with hematoxylin and eosin stain (H & E) to look for any pathology. (Fig.1)

Observation of Gross specimen

The 4th vessel arising from aortic arch between LCA and LSA was left vertebral artery (LVA) (Fig.1A). The artery ascended and inclined towards the left for 1.5 cm, passed through the stellate ganglia and then entered foramen transversarium of C5 cervical vertebra (Fig.1B, Fig.2A). In present case, LVA was medial to the sympathetic trunk in its proximal part, superior cervical ganglion was present between C2-C3 level, Middle ganglion at the level of C6 transverse process and the inferior cervical ganglia (ICG) was fused to the 1st thoracic ganglia to form stellate ganglia (SG) at the level of 1st rib on either side. The right vertebral artery (RVA) had its normal origin from right
subclavian artery (RSA) but before entering into the foramen transversarium it (RVA) was also found to be passing through the SG on the right side (Fig. 2B). The average length of V1 segment of left and right VA was 5.46 ± 0.15 cm and 2.53 ± 0.05 cm respectively whereas average diameter of left and right VA was 4.23 ± 0.05 mm and 4.2 ± 0.2 mm respectively. The VA and CST were painted with red and yellow poster colour respectively and photographs were taken. (Fig. 2)

**Observation of microscopic specimen**

Under microscope, H & E stained section of artery showed presence of abundant elastic fibres and smooth muscle fibres in tunica media (Fig. 2C). Irregularity of arterial wall and separation of media was not seen. No hematoma was found. The artery was patent with no obvious occlusive disease.

**DISCUSSION**

Anomalous origin of VA from aortic arch has been reported previously by many authors [9, 16, 19]. Tardieu et al has reported that VA arising from aortic arch take a more medial course over the cervical vertebral bodies and it enters a transverse foramen that was more cranially located than the normal C6 entrance [16]. According to Woraputtaporn W et al, in 78.6% of cases LVA of aortic origin entered the fifth cervical transverse foramina. The prevertebral part of VA of aortic origin was less protected by bone and was twice as long as RVA [19]. Polguj M et al has reported a case of extracranial duplication of VA with coexisting spontaneous dissection of internal carotid artery and Ehlers-Danlos syndrome during multidetector 64 row CT and Doppler ultrasonography B-flow mode. According to the authors LVA having 2 origins from LSA fused to form a single VA which entered transverse foramen of C5 [10]. VA fenestration and duplication predisposing to arterial dissection results in stroke was concluded by Polguj M et al [11]. Dzierzanowski J et al has analysed the morphometry of the intracranial segment of VA (V4) in context of its clinical usefulness using digital subtraction angiography & 3D angio-computed tomography. The authors have reported
that incidence of V4 ectasia was more and was found in the natural location of formation of saccular aneurysm [2]. Elgueta MF et al have reported VA commonly travels adjacent to areas targeted by third occipital nerve procedures and rarely over the access point for atlantoaxial joint injections. Modification to existing techniques may reduce the risk of accidental vertebral artery breach during performance of cervical pain block procedure [4]. A rare variation of vertebral artery was reported by Shoja et al in which LVA after ascent in neck through the transverse foramina passed posteriorly between C3-C4 transverse process and terminated extracranially by supplying posterior muscles of the neck. The RVA continued as basilar artery [12].

In an observational study done by Komiyama M et al, LVA of aortic origin was associated with higher incidence of arterial dissection than VA of subclavian artery origin (Fig.3A). The authors have reported that there is more hemodynamic stress in the artery arising from aorta because of higher pressure and pulsation. As vertebral artery arising from aortic arch receives direct arterial pulsatile flow than the VA of subclavian origin which receives damped flow, alteration of cerebral hemodynamics occurs in VA of aortic origin. The vertebral artery of aortic origin enters at C5-6 intervertebral level. The higher entry of VA to C5 foramen transversarium may cause larger sheer stress in distal portion of the VA. The authors have reported that one elderly patient with aortic origin of LVA presented with left Horner’s sign [7]. Any injury to the sympathetic trunk results in Horner’s syndrome which is characterized by ptosis, enophthalmos, meiosis, and anhidrosis on the affected side [15]. In present case, anomalous LVA of aortic origin that receives high pulsatile flow is passing through the stellate ganglion. Expansion of its (VA) wall during high pulsatile flow may compress the sympathetic fibres producing signs of Horner’s syndrome. To the best of our knowledge, this is the 1st reported case describing RVA and LVA passing through the stellate ganglion before entering into their respective foramen transversarium. Loh L et al has reported that stellate ganglion block relieves certain abnormal painful states whether the lesion causing them is peripheral or central [8]. In a systemic review of complications associated with stellate ganglion nerve block, one death due to massive hematoma leading to airway obstruction has been reported by Goel V et al [5]. In present case, as the VA is passing through the stellate ganglion there is a high chance of it getting punctured during stellate ganglion nerve block (SGNB) technique. Although this
procedure is performed under landmark based technique, fluoroscopy or ultrasound but still complications can occur. (Fig.3)

According to Kiray A et al, anterolateral approach to the cervical spine requires greater retraction of longus colli and longus capitis muscles which has greater risk of injury to CST [6]. If a patient having variation where VA is passing through stellate ganglion (SG) undergoes cervical spine surgery, there is a high chance of injury to CST and VA leading to hemorrhage. According to Tubbs Rs et al, VA makes a medial indentation at C2 as it travels through the transverse foramen. The authors classified the variations of vertebral artery cave which would be helpful to the surgeons during C2 pedicle screw placement [18]. Our present case closely resembles the study done by Tardieu GG et al, Woraputtaporn W and Komiyama M et al up to some extent because in our case, vertebral artery arising from aortic arch on the left side has a more medial course and it enters the fifth cervical transverse foramina (Fig.1B, 3B) and its length is twice as long as the RVA but sign of arterial dissection in VII segment was absent.

CONCLUSIONS

Therefore as vertebral artery and CST are in close relation to each other in cervical region, this rare anomaly should be kept in mind by the anesthetist during stellate ganglion nerve block otherwise it can lead to hemorrhage. Surgeons should be aware of this rare anomaly while performing any surgery in cervical region because lack of knowledge of anatomy of sympathetic trunk and the surrounding anatomy may complicate surgical procedures on the cervical spine. It is of critical importance for preoperative imaging (CT or MRI) to be reviewed and course of VA and structure through which it is passing be assessed to prevent iatrogenic injury to VA and its potentially devastating effect.

Acknowledgements

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REFERENCES


Fig. 1. (A) Four vessels arising from arch of aorta. Left vertebral artery (red arrow) arising from aorta is passing through left stellate ganglion (white arrow). AOA, aortic arch; BCT, brachiocephalic trunk; LCA, left common carotid artery; LSA, left subclavian artery; LVA, left vertebral artery; LSG, left stellate ganglion.

(B) Left vertebral artery (coloured in red) is passing through left stellate ganglia (white arrow). Brachiocephalic trunk is sectioned and its proximal end reflected (yellow arrow) to show normal origin of right vertebral artery from right subclavian artery. BCT, brachiocephalic trunk; RVA, right vertebral artery; RSA, right subclavian artery; RCA, right common carotid artery; ST, sympathetic trunk (coloured in yellow).
Fig. 2  (A) Left vertebral artery (coloured in red) is passing through left stellate ganglia (white arrow). Left stellate ganglia present at the level of 1st rib. ST, sympathetic trunk (coloured in yellow). LVA, left vertebral artery; LSG, left stellate ganglia.

(B) Right vertebral artery (red arrow) is passing through stellate ganglia on right side. RVA, right vertebral artery; RSG, right stellate ganglia.

(C) Hematoxylin and eosin stained section of 1st segment of left vertebral artery showing abundant elastic fibres and smooth muscle fibres in tunica media (a), patent lumen (b). 1 scale bar = 500 µm.
Fig. 3. (A) Schematic diagram showing normal origin of vertebral artery from subclavian artery entering into transverse foramina of sixth cervical vertebra (red arrow). Lower part of first segment of vertebral artery (blue arrow) is lateral to sympathetic trunk. TFS, sixth cervical vertebra transverse foramen; LVA, left vertebral artery; LSA, left subclavian artery; RVA, right vertebral artery; RSA, right subclavian artery; ST, sympathetic trunk.

(B) Our present case, left vertebral artery (blue arrow) of aortic origin is medial to sympathetic trunk in the proximal part and is passing through stellate ganglion (green arrow) before entering into fifth cervical transverse foramen (red arrow). Right vertebral artery of subclavian origin is also passing through stellate ganglion (green arrow). TFF, fifth cervical vertebra transverse foramen.
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