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Direct Aortic Arch Origin of the Left Vertebral Artery: A Case Report

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Abstract

Vertebral arteries (VAs) typically arise from the subclavian arteries; however, variations in their origin occur and have important clinical implications. During a routine cadaveric dissection, the left VA (LVA) was found to originate directly from the aortic arch (AA) between the left common carotid and left subclavian arteries. This variation may result from persistence of embryologic intersegmental arteries and can influence surgical planning, angiographic interpretation, and risk of cerebrovascular pathology. Recognition of this variant is important for surgeons, radiologists, and clinicians.

Categories: Anatomy
Keywords: anatomical variation, aortic arch, arterial variation, left vertebral artery, left vertebral artery variation, vertebral arteries

Introduction

In typical anatomy, each vertebral artery (VA) arises from the superior aspect of the ipsilateral subclavian artery and ascends through the transverse foramina of the cervical vertebrae, most commonly entering at the level of C6. After traversing the transverse foramina from C6 to the atlas, the arteries curve medially across the superior surface of the posterior arch of the atlas (C1) and enter the cranial cavity through the foramen magnum, where the paired VAs unite to form the basilar artery. These vessels supply vital structures including the brainstem, cerebellum, cervical spinal cord, and portions of the cerebrum [1].

Although this configuration represents the classic anatomical pattern, variations in the origin, course, branching, tortuosity, and termination of the VAs can occur. Among the reported variations are: 1) single left, right, and dual aberrant origins off of the aortic arch (AA), 2) as the second branch of the subclavian (rather than the first), and very rarely 3) origins off the distal AA with a retro-esophageal course, or 4) originating as branches of the external, common, or internal carotid arteries. The most common variant documented in both cadaveric and angiographic studies [2-6] involves the left VA (LVA) originating directly from the AA, most frequently arising between the left common carotid artery and the left subclavian artery. While prevalence varies across studies, systematic reviews have reported rates of occurrence between 4.81% [7] and 6.7% [8], and some cadaveric studies have reported percentages as high as 14.8% [3] and 15.3% [2]. The wide range of reported prevalence likely reflects several methodological and population-related factors. Population differences may contribute to real variation in frequency.

Recognition of such vascular variants is clinically important. Atypical VA origin may influence endovascular access; complicate surgical procedures involving the AA or supra-aortic vessels [9]; and may potentially alter hemodynamic stresses within the vertebrobasilar circulation [10]. Additionally, failure to recognize variant origins during angiography may lead to misinterpretation of imaging findings or difficulty in catheterization of the vessel [10].

This report describes a case identified during cadaveric dissection in which the LVA originated directly from the AA. This case highlights the anatomical features of this variation and discusses its embryological basis and potential clinical implications.

Case Presentation

During an educational dissection of a female cadaver (age 67), the LVA was observed to arise directly from the AA rather than from its typical origin at the left subclavian artery (Figure *1*). The AA gave rise to four branches, in order from right to left: the brachiocephalic trunk, the left common carotid artery, the LVA, and the left subclavian artery.

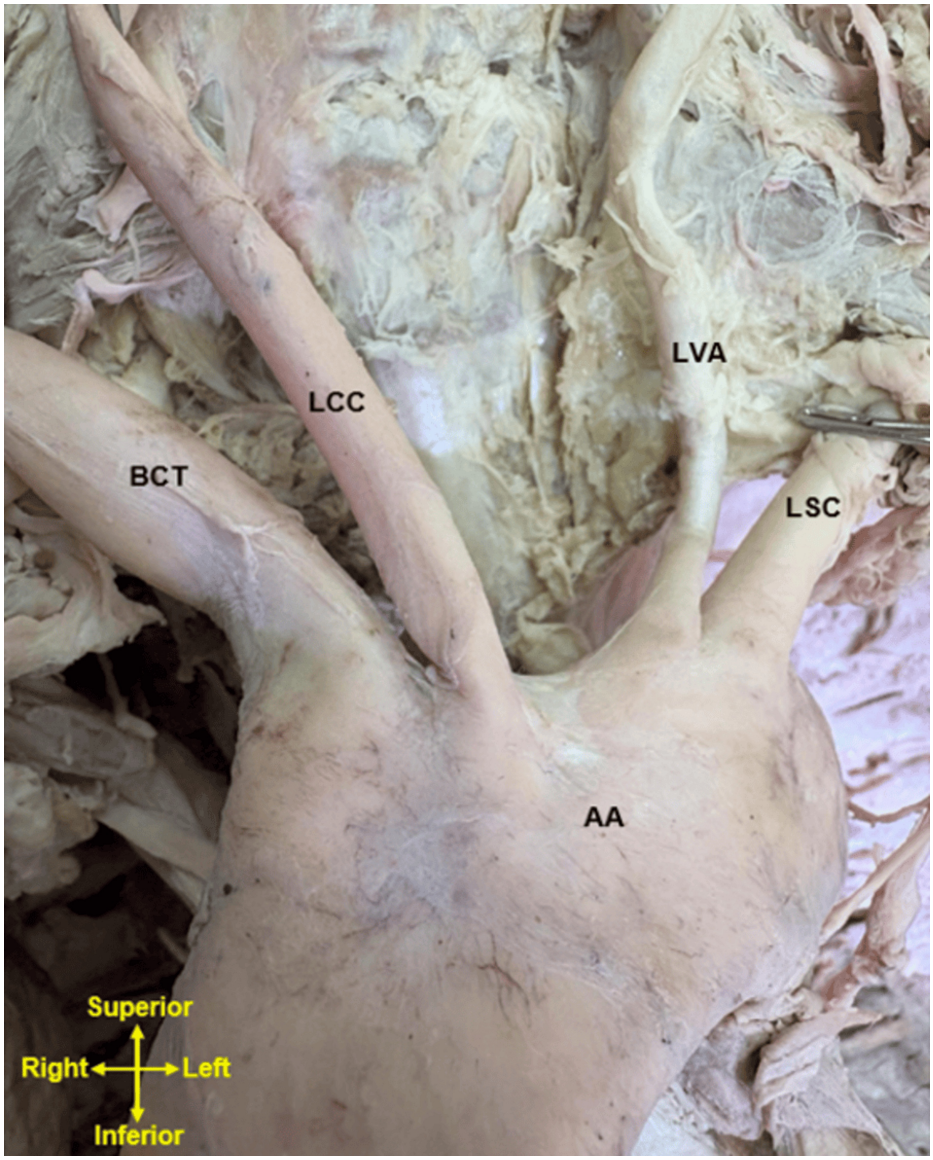


FIGURE 1: LVA branching directly from the AA.

AA: aortic arch; BCT: brachiocephalic trunk; LCC: left common carotid artery; LVA: left vertebral artery; LSC: left subclavian artery.

The right VA originated normally from the right subclavian artery, and both VAs were seen ascending the neck and entering the C6 transverse foramina (Figure *2*). No other vascular variations were observed in the AA or its major branches, and no other anatomical variations were noted in the thorax or neck.

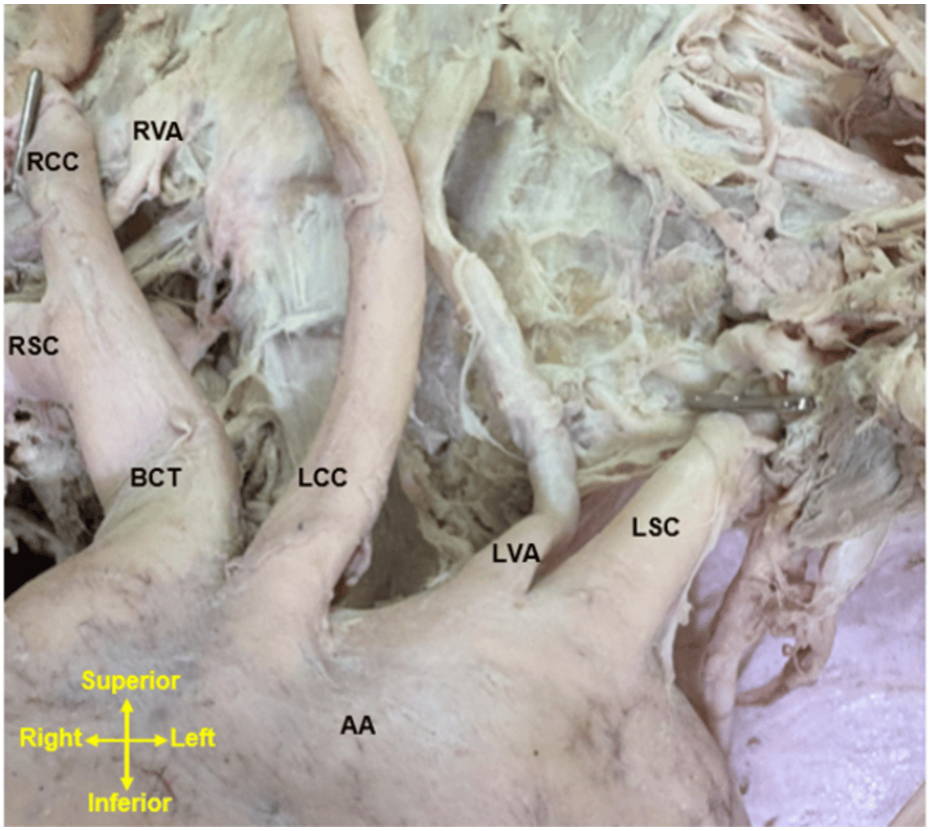


FIGURE 2: LVA and RVA ascending the neck and entering the C6 transverse foramina.

AA: aortic arch; BCT: brachiocephalic trunk; LCC: left common carotid artery; LVA: left vertebral artery; LSC: left subclavian artery; RCC: right common carotid artery; RVA: right vertebral artery; RSC: right subclavian artery.

Discussion

Embryological basis

The AA and its branches develop from the pharyngeal arch arteries and paired dorsal aortae during the fourth and fifth weeks of gestation [11]. Each VA forms from a longitudinal anastomosis that links the first seven cervical intersegmental arteries. As development proceeds, the connections of the first six intersegmental arteries to the dorsal aorta regress. The seventh intersegmental artery then forms the proximal subclavian artery, and the VA normally arises from it [11].

An LVA arising from the AA between the left common carotid and left subclavian arteries is most often explained by persistence of a more cranial intersegmental connection, typically the sixth, together with regression of the anastomotic segment that normally joins the VA to the seventh intersegmental artery [12, 13].

Another possible factor involves the abnormal vascular development mediated by growth factors including vascular endothelial growth factor-A164/165 and placenta growth factor [3]. These factors regulate the formation of large, stable blood vessels and influence vascular remodeling. Variations in their expression or activity may promote structural changes in the development of arch vessels, allowing the LVA to arise directly from the AA instead of the left subclavian artery

Surgical implications

An anomalous LVA arising from the AA has important implications for operative planning during AA and supra-aortic arch procedures. This variant can complicate arch reconstruction by increasing technical difficulties or prolonging cross-clamp times [9]. Qi et al. reported that, despite these challenges, total arch replacement can be performed with favorable outcomes, including no in-hospital mortality and limited perioperative complications [9]. Management requires tailored approaches for reimplantation of the anomalous VA to preserve cerebral perfusion, as multiple reconstruction techniques may be necessary depending on the anatomical configuration. However, with appropriate surgical planning and technique, total arch replacement in the presence of this variant can be both safe and feasible [9].

In addition, the variant may make angiographic identification difficult when the vessel is not found in its expected position, increasing the risk of misinterpretation as absence. This has implications for operative and endovascular planning, as failure to recognize the variant anatomy may complicate vascular access, reconstruction, or perfusion strategies [14].

Other clinical implications

This anatomical variation may carry many other clinical implications beyond surgical planning. Previous studies have found that the VAs with aortic origin have a higher association with arterial dissection, likely due to the longer extracranial course and increased stress on the vessel, suggesting this anatomical variation may represent a potential risk factor for posterior circulation ischemia and stroke [15]. Recognition of this variant is therefore clinically significant, particularly in patients presenting with vertebrobasilar symptoms or unexplained posterior circulation infarcts. These findings may assist clinicians in diagnosis as well as risk of cerebrovascular disease.

Limitations

This report describes a single cadaveric specimen. The finding was made during an educational dissection, and limited clinical history was available for the donor, including cerebrovascular symptoms or cause of death. As a result, the clinical significance of the variant in this individual cannot be determined. In addition, no morphometric measurements, such as vessel diameter or extracranial length, were obtained.

Furthermore, the intracranial course of the vertebral arteries, vertebral dominance, and the vessel wall histology were not assessed. The clinical implications discussed above, including dissection, aneurysm, atherosclerosis, and stenosis, are drawn from the existing literature and were not observed in this specimen. Similarly, the proposed embryological mechanisms are interpretive and cannot be confirmed from an adult cadaveric specimen alone.

Conclusions

This case report documents an LVA originating directly from the AA, producing a four-branch AA. The variation was found during a routine educational dissection. The variant was photographed, documented, and retained for educational purposes. Because no relevant clinical history was available, its clinical consequences for this donor are unknown. Recognition of this variant is important for surgeons, radiologists, and interventionalists, as it may influence surgical planning, angiographic interpretation, and the risk of vertebrobasilar pathology. Awareness of this anatomical variation contributes to improved diagnostic accuracy and safer operative management. The present case study contributes to the overall knowledge of VA variants and highlights the importance of anatomical awareness in clinical practice. Future documentation of this variation should acquire morphometric data, including the diameter of both VAs at origin, the extracranial length of the LVA, and the level of entry into the transverse foramen. These measurements would allow direct comparison with published reports.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Acquisition, analysis, or interpretation of data: Kara J. Coffman-Rea, Dylan J. Fuchs, Julia P. Negrin, Karen E. Samonds

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Disclosures

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