International Journal of Anatomy and Research,
Int J Anat Res 2022, Vol 10(3):8426-29. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2022.176

Case Report

Normal and Abnormal Development of Left Vertebral Artery and Its Implications in Cervical Region Surgery

Nagaswami Vasan [1], Elizabeth Hilt [2], Pallavi Patil [2], Olivia Schreiber [2], Ahmed Shahzad [2], Tanner Gill [2], Cheryl Melovitz-Vasan *[1].

*[1] Associate Professor, Department of Biomedical Sciences, Cooper Medical School of Rowan, University, Camden, New Jersey 08103, USA.

[2] M2 medical students, Cooper Medical School of Rowan University, Camden, NJ 08103.

ABSTRACT

Aortic arch (AA) anomalies occur in approximately 3-5% of cadavers, but these atypical branches remain a point of discussion in cervical region surgery. This case report describes a 73-year-old Caucasian female who died of renal failure following a complicated urinary tract infection whose left vertebral artery (LVA) originated from the AA between the left common carotid and subclavian arteries. The preforaminal part of the LVA was 5 mm in diameter and entered the C6 transverse foramen while the right vertebral artery (RVA) arose from the right subclavian was 6.5 mm in diameter and entered the C5. Embryologically, VAs are formed during weeks four through eight by development of longitudinal anastomoses linking the cervical intersegmental arteries (ISA). The ISA regress except the seventh, which becomes the proximal subclavian artery, the point of origin of the adult VA. Persons with LVA that arises from the AA may be asymptomatic; however, secondary dilatation of the RVA may be implicated in the development of cerebrovascular disorders and atherosclerotic changes due to increased blood flow. Additionally, the anatomical positioning of a left vertebral artery is important when considering an anterior approach for cervical spine surgery and other head-neck procedures when soft structures arteries, veins and muscles are retracted to reach the cervical spine.

KEY WORDS: Vertebral artery anomaly, Developmental error, Cervical region surgery, Cerebral circulation, Clinical correlation.

Corresponding Author: Cheryl Melovitz-Vasan, PT., DPT., Ph.D., Associate Professor, Department of Biomedical Sciences, Cooper Medical School of Rowan University, 401 South Broadway, Camden, New Jersey 08103, USA. Phone: +1 (856) 361-2889
E-Mail: melovitz-vasan@rowan.edu

Access this Article online	Journal Information
Quick Response code	**International Journal of Anatomy and Research** ISSN (E) 2321-4287 | ISSN (P) 2321-8967 **https://www.ijmhr.org/ijar.htm** **DOI-Prefix:** https://dx.doi.org/10.16965/ijar
DOI: 10.16965/ijar.2022.176	**Article Information** Received: 19 Apr 2022 Accepted: 20 Jun 2022 Peer Review: 22 Apr 2022 Published (O): 05 Sep 2022 Revised: None Published (P): 05 Sep 2022

INTRODUCTION

The blood supply to the brain divides into an anterior and posterior circulation. The anterior circulation derives blood from the bilateral internal carotid arteries and supplies blood to the majority of the cerebral hemispheres, including the frontal lobes, parietal lobes, lateral temporal lobes and anterior part of deep cerebral hemispheres. The posterior circulation derives blood from the bilateral vertebral arteries (VA). It supplies the brainstem, cerebellum, occipital lobes, medial temporal lobes and posterior part of the deep hemisphere (mainly the thalamus). Regardless of where the vertebral arteries arise, they contribute to the posterior brain circulation [1]. The circle of Willis is an anatomical structure that provides an anastomotic connection between the anterior and posterior circulations.

Embryologically, the VA is formed during weeks four through eight. At this time, the horizontal portion of 1-6 intersegmental arteries (ISA) regress and by development of longitudinal anastomoses linking the cervical ISA, the seventh ISA becomes the proximal subclavian artery, the point of origin of the adult VA. The vertebral artery develops in the embryo as a longitudinal channel connecting the cranial intersegmental arteries and is, therefore, usually a branch of the subclavian artery. Incorporation of the proximal left seventh intersegmental artery into the developing aorta results in the left vertebral artery arising directly from the aortic arch [2, 3]. Failure of involution in one of the first six ISAs (i.e., a persistent ISA) causes a variety of abnormal origins of the VA [1, 2]. In some cases, the left VA arises directly from the aorta between the common carotid and subclavian arteries (Figs 1A, B). Failure of involution in one of the proximal six ISAs causes a variety of abnormal origins of the vertebral artery [4, 5]. If the persistent ISA occurs in the upper (1 & 2) ISAs, the result is an abnormal origin of the vertebral artery from the internal or external carotid artery [4, 5] and if it occurs in the lower 3-6 ISAs, the result is an abnormal origin of the vertebral artery from the aortic arch or the common carotid artery [2, 3, 4, 6]. In 3-5% of people, the left vertebral artery arises directly from the aortic arch [7] (figs. 1, 2) and thus it is of clinical relevance during neck surgery [8, 9].

Anatomically, the vertebral artery is divided into four segments: pre-foraminal aka proximal segment (from origin to the transverse foramen of C5/C6); intraforaminal segment (passage through transverse foramen of cervical vertebra; extradural segment (from the second cervical transverse foramina to the base of the skull); and intracranial segment to join the VA from the other side to form the basilar artery [9].

MATERIALS AND METHODS

The cadaveric specimen in this study was obtained from the willed body program for the purpose of medical student dissection. The donor was a 73-year-old Caucasian female who died of renal failure following a complicated urinary tract infection. During routine cadaveric dissection of the thorax, we observed the left vertebral artery (LVA) a typically originated from the aortic arch (AA) between the common carotid and subclavian arteries (Figures 1, 2).

RESULTS

As shown in Table 1, there is marked differences in the preforaminal length of right (5.5cm) and left (9.0cm) VA. Both the preforaminal VAs showed some natural tortuosity and left VA was more tortuous than the right VA. In this context, it is worthy to note that the right and left VA entered the foramen transversarium at 5th and 6th cervical vertebra. Additionally, the width (6.5 cm) and lumen (6 mm) size of proximal VA of right was greater compared to left VA (5 mm and 4.6 mm respectively). There was no difference either in the diameter or lumen size between right and left distal part of the VAs. Both right and left VAs showed a 'kink' and distension prior to entering the foramen transversarium. The diameter of the intracranial segment of both right and left VA diminished as it formed the basilar artery.

Table 1: Various measurements of the vertebral arteries.

Vertebral artery	Right	Left
Length	5.5cm	9.0cm
Proximal VA diameter	6.5mm	5.0mm
Proximal VA lumen diameter	6.0mm	4.6mm
Distal VA diameter	5.0mm	5.0mm
Distal VA lumen diameter	4.0mm	4.0mm

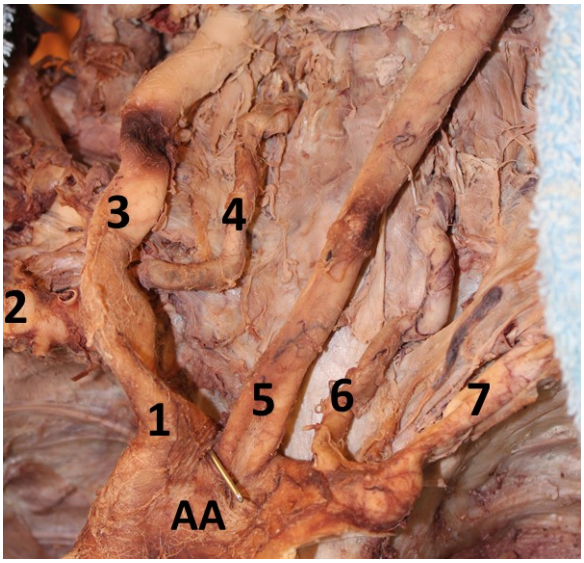

Fig. 1: AA: Aortic Arch; 1: Right brachiocephalic trunk, 2: Right Subclavian Artery, 3. Right Common Carotid Artery. 4: Right Vertebral Artery, 5: Left Common Carotid Artery, 6: Left Vertebral Artery, 7: Left Subclavian Artery.

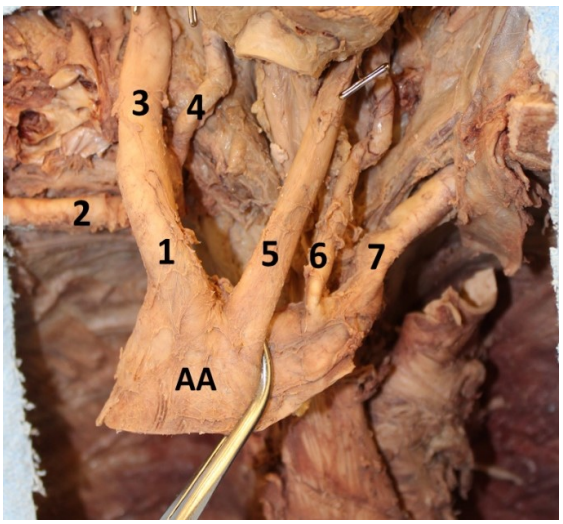

Fig. 2: Both the Right and Left Vertebral Arteries entered the foramen transversarium at C6 and C5 respectively. Prior to enter the foramen the vertebral arteries exhibited dilatation.
AA: Aortic Arch; 1: Right brachiocephalic trunk, 2: Right Subclavian Artery, 3. Right Common Carotid Artery. 4: Right Vertebral Artery, 5: Left Common Carotid Artery, 6: Left Vertebral Artery, 7: Left Subclavian Artery.

DISCUSSION

Persons born with left VA that arise from the aortic arch (AA) may live asymptomatically. However, secondary dilatation of the right VA has been implicated in the development of cerebrovascular disorders and atherosclerotic changes due to increased blood flow [6].

Moreover, the recognition of the anomalous origin and anatomical positioning of a left VA is important when considering an anterior approach for cervical spine surgery [6] and other head-neck procedures when soft tissue structures such as nerves, arteries, veins and muscles are retracted to reach the cervical spine. The extracranial portion, especially the prevertebral part of the VA is frequently affected from atherosclerosis and it is the common site of stenosis [10]. In the case study presented here, we found that the LVA was sclerotic and narrower [Figs 1,2] and the RVA was dilated due to increased blood flow thereby protecting the brain from ischemia [11]. The observed tortuous course of the prevertebral VA (39%) is in line with an earlier report [9]. Furthermore, there was a difference in the tortuosity of right and left VAs in that 32% of the right VA and 68% of left VA was tortuous [9]. Tortuosity of the proximal or preforaminal segment of VA does not have any hemodynamic consequences [12] but the loops of the proximal segments have been reported to cause radicular symptoms by nerve root compressions [12].

Other authors believe that anomalous origins and the distribution of the large aortic arch vessels can cause changes in cerebral hemodynamics that may lead to cerebral abnormalities [13]. In a review of anomalous origin of right VA, the authors brought attention to changes in cerebral hemodynamics that may lead to cerebral pathology [14]. The true value of detecting anomalous origins is the diagnostic gain prior to the surgery of supraaortic arteries [6, 15]

Uncharacteristic origin of the left vertebral artery from the aortic arch often times is benign but warrants attention when anterior cervical surgery or any diagnostic vascular study is planned. It is also worth careful consideration when supraaortic arch surgery is planned to address situations such as aortic dissection, aneurysm and other pathology. There is no conclusive evidence that these variants lead to a predisposition to cerebrovascular disorders [16]. Nevertheless, some authors hypothesize that anomalous origins and the distribution of the large aortic arch vessels can cause changes in cerebral hemodynamics that may lead to cerebral abnormalities [13]. In a review of anomalous origin of right VA, Lemke et al [14] brought attention to changes in cerebral hemodynamics that may lead to cerebral pathology.

Anterior cervical decompression surgery is performed for a variety of reasons. The operative indications for surgery in the cervical region include spondylosis, spinal stenosis, herniated inter-vertebral disc, tumor, infection and trauma. An understanding of the anatomy of these arteries and the surrounding bony anatomy is essential to prevent iatrogenic VA injuries [17]. Laceration of the VA is a most challenging surgical dilemma during anterior cervical spinal surgery; gaining control of the massive hemorrhage from a ruptured VA is difficult and could possibly result in an uncertain neurological morbidity [18]. In surgery, angiography and in all non-invasive procedures, it is of great importance to know the

exact details of the course of the proximal segment of the VA to prevent catastrophic laceration of the VA during the surgical procedures.

Prior studies have demonstrated a higher incidence of vascular anomalies in patients with Down syndrome showed that the incidence of VA anomalies and aberrant Right Subclavian Carotid Artery (RSCA) in patients with Down syndrome is 40% and 36%, respectively. The case demonstrates both an aberrant RSCA and an anomalous origin of the right VA from the right Common Carotid Artery in a patient with Down syndrome [19, 20]. Chromosome 22q11 deletion or CATCH 22 is associated with DiGeorge syndrome, conotruncal anomaly face syndrome, and velocardiofacial syndrome. Associated anomalies of the aortic arch, aortic branches, ductus arteriosus, and pulmonary arteries are more frequent in patients with the deletion than in those without the deletion [21].

A phenomenon called "subclavian steal" occurs when there is significant stenosis or occlusion of the subclavian artery proximal to the origin of the VA. In such cases, blood is carried from the contralateral VA to the basillar artery and then retrogradely through the ipsilateral VA to the subclavian artery, distal to the blockage. This arrangement provides collateral flow to the affected arm [22].

Subclavian steal syndrome describes symptoms of posterior circulation ischemia such as vertigo or ataxia precipitated by the exercise of the upper extremity supplied by the stenotic subclavian artery. If the left VA arises from the AA, such a compensatory mechanism will not be useful.

CONCLUSION

This study explains the embryological cause of the left vertebral artery originating from the aortic arch and its clinical relevance in cervical region and supraaortic arch surgery. Additionally, the tortuosity of the proximal vertebral artery, the aortic origin of the LVA and their relevance to hemodynamic of cerebral circulation is correlated. While other studies have reported just the anomaly this study reviews the clinical importance and occurrences in other birth defects such as Down syndrome and the likes.

ABBREVIATIONS

AA-Aortic arch; **ISA**-Intersegmental arteries;
VA-Vertebral artery; **LVA**-Left Vertebral artery;
RVA-Right Vertebral artery;
RSCA-Right Subclavian Carotid Artery.

ACKNOWLEDGEMENTS

The authors sincerely thank the donor and her family for their generosity, which made this study possible and facilitated scientific and medical innovations in patient care.

Funding: This study is supported by the Cooper Medical School of Rowan University research and innovation grant.

Disclosure: This case report was presented as a poster at the Experimental Biology 2022 meeting host society of American Association for Anatomy, on April 4th 2022 in Philadelphia, PA USA. All authors have participated in the research/dissections and the article preparation. CMV envisioned the project prepared and edited the final manuscript. All the authors approved the final form of the paper.

Conflicts of Interests: **None**

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How to cite this article: Nagaswami Vasan, Elizabeth Hilt, Pallavi Patil, Olivia SchreibeR, Ahmed Shahzad, Tanner Gill, and Cheryl Melovitz-Vasan. Normal and Abnormal Development of Left Vertebral Artery and Its Implications in Cervical Region Surgery. Int J Anat Res 2022;10(3):8425-8429. **DOI:** 10.16965/ijar.2022.176