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A left vertebral artery arising from the aortic arch: a cadaveric study

Eleni Patera[1], Qiudian Wang[1], Zhenyu Chen[1], Montserrat R. Silva[1], Tarek Almabrouk[2], Abduelmenem Alashkham[1]

[1]Anatomy, School of Biomedical Sciences, University of Edinburgh, Edinburgh, United Kingdom
[2]St. George's International School of Medicine, Northumbria University, Newcastle-upon-Tyne, United Kingdom

SUMMARY

Variations in the major arteries and their branches of the thoracic region have been well described with variations of the aortic arch, pulmonary trunk, common carotid arteries and vertebral arteries being among the most common in the thoracic region. During routine dissection of the thoracic and neck regions, the left vertebral artery in a 58-year-old female cadaver was found to arise from the arch of the aorta between the left common carotid and the left subclavian arteries. The left vertebral artery was traced along its course and was observed to enter the transverse foramen of the fifth cervical vertebral body. With such variation, the findings can influence predisposition to diseases, symptomatology, clinical examination, investigation and patient management, including operative surgery.

Key words: Left vertebral artery – Anatomical variation – Origin of left vertebral artery – Course of left vertebral artery – Arch of aorta

INTRODUCTION

The vertebral arteries are one pair of the major arteries of the neck that, along with the internal carotid arteries, provide arterial supply to the brain. The vertebral arteries along with their branches form the "vertebrobasilar system" which supplies the upper spinal cord, brainstem, cerebellum and occipital lobe of the brain (Brennan et al., 2015). Classical anatomical studies describe the vertebral arteries as the first branch of the subclavian arteries, ascending on each side of the neck through the transverse foramen of the upper six cervical vertebrae and eventually entering the cranial cavity through the foramen magnum (Matula et al., 1997; Gluncic et al., 1999).

Previous case reports showed that the right vertebral artery could arise as the first branch of the right subclavian artery (Bayat et al., 2011; Sikka and Jain, 2012). Satti et al (2007) has reported that the right vertebral artery may arise as the last branch of the aorta, a right vertebral artery arising as the 2nd branch of the right subclavian artery, and a right vertebral artery with proximal duplication as the 2nd branch of the right subclavian artery. The right vertebral artery has been reported to arise as the last branch of the aortic arch in 3 cases (Saeed et al., 2017). Furthermore, a rare variant of the right vertebral artery originating as part of the brachiocephalic trunk in a 76-year-old female cadaver has been reported (Ariyo, 2018). Ali et al (2018) presented a case of a right VA originating from the right common carotid artery in a patient with Down syndrome.

Corresponding author: Dr. Tarek Almabrouk, PhD, MSc, MBchB. Clinical Instructor. St. George's International School of Medicine, Northumbria University, Drill Hall, Northumberland Road, Newcastle upon Tyne, NE1 8ST, United Kingdom. Phone: +44 (0)191 227 3654.
E-mail: talmabro@sgu.edu

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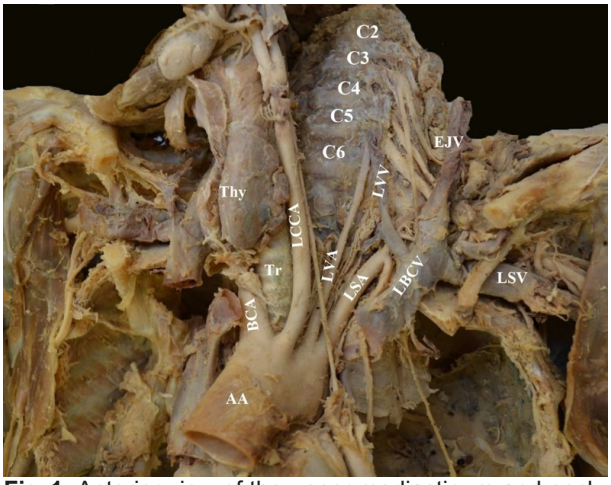

Fig 1. Anterior view of the upper mediastinum and neck. The clavicles and ribs have been cut and removed next to the sternum. Tracheoesophageal block has been shifted to the right to show the left vertebral artery (LVA). The head being slightly rotated to the right allowing visualization of the branches of the arch of the aorta (AA). The arch of the aorta gives off four branches: BCT: Brachiocephalic Trunk; LCCA: Left Common Carotid Artery; LVA: Left Vertebral Artery; LSA: Left Subclavian Artery. The left vertebral artery is shown to course superiorly entering the transverse foramen of the fifth cervical vertebral body. Tr: Trachea; Thy: Left lobe of thyroid gland; LBCV: Left Brachiocephalic Vein; LSV: Left Subclavian Vein; LVV: Left Vertebral Vein; EJV: External Jugular Vein; C2-C6: Second to sixth cervical vertebral bodies.

Whereas, the left vertebral artery commonly arises from the arch of the aorta (Satti et al., 2007; Sikka and Jain, 2012; Einstein et al., 2016). Despite this, Satti and associates (2007) reported that the left vertebral artery may also arise from the subclavian artery as its secondary branch, or from the arch of the aorta as its tertiary branch and the left subclavian artery as its primary branch. The left vertebral artery may arise from the arch of the aorta as the fourth branch ‘’Adachi TYPE C’’ (Adachi, 1928; Lippert and Pabst, 1985). This rarer variant of the left vertebral artery (LVA) departs from the arch of aorta in 1.7% (Quain. et al.,1844) to 4.8% (Adachi., 1928) and even 6.3% (Uchino., 2013). Einstein et al (2016) noted that the left vertebral artery was originating from the aortic arch rather than the left subclavian artery in 4 females out of 27 with a prevalence rate of 14.8%. In another case report by Sikka and Jain (2012), the left vertebral artery took origin directly from the arch of the aorta between the left common carotid artery and the left subclavian artery. Furthermore, the inferior thyroid artery may originate from the vertebral artery in 0.7%. The combined variation of both left inferior thyroid artery and left vertebral artery is very rare and has been reported by a few scientists (Adachi., 1928; Sartor et al., 1980).

Despite various reports found in the literature about the origin of the left vertebral artery from the arch of the aorta, its incidence rate is still underestimated. The current study aimed to describe the variation in the branching pattern of the arch of the aorta, in order to supply the anatomists, radiologists and surgeons with more conclusive data regarding the prevalence of the variation. It is essential to report all cases of vertebral artery variation, as it influences the clinical decision about disease symptoms, the angiographic examinations to assess the blood flow for possible occlusions or stenosis and the conduction of corresponding endovascular interventions.

MATERIAL AND METHODS

This study was conducted in the Anatomy Department at the University of Edinburgh, in accordance to the Human Tissue (Scotland) Act 2006, on a formalin-fixed 85-year female cadaver. During postgraduate cadaveric dissection of the thoracic and neck regions, the vertebral arteries were dissected. The anterior ribcage, the heart along with its pericardium and the lungs were removed exposing the arch of the aorta and its branches. The sternal and clavicular heads of the sternocleidomastoid were detached from their origin. Sharp dissection was performed by using a 15 mm scalpel in order to remove the carotid sheath of the deep cervical fascia that covered the carotid vessels and to explore branches of the arch of the aorta. In the neck, dissection of the retrotracheal space has been performed, and subsequently the prevertebral fascia was removed from the cervical vertebral bodies: this allows better visualization of the cervical vertebral bodies and their intervertebral discs as well as the vertebral artery. Then full dissection of the vertebral artery has been performed.

RESULTS

In a 85-year-old female cadaver, the left vertebral artery was found originating directly from the arch of the aorta as its tertiary branch between the left common carotid and the left subclavian arteries (Fig. 1). The left vertebral artery runs posterior to the internal jugular and vertebral veins, and it is crossed by the inferior thyroid artery and the thoracic duct. The left vertebral artery runs anterior to the transverse processes of the sixth and seventh cervical vertebrae, the sympathetic trunk and its inferior cervical ganglion. The left vertebral artery coursed superiorly posterolateral passing through the transverse foramen accompanied by the vertebral vein of the upper five cervical vertebrae, and eventually entered the cranial cavity through the foramen magnum.

The right vertebral artery originated from the first branch of the subclavian artery, coursed superiorly passing through the transverse foramen of the upper six cervical vertebrae until it entered the cranial cavity through the foramen magnum. Both right

and left vertebral arteries were medial to the vertebral veins (Fig. 1). The left vertebral artery was narrower and longer than the right vertebral artery.

DISCUSSION

During development of the fetus, the intersegmental arteries, which are branches of the dorsal aorta, are responsible for providing blood supply to the somites and their derivatives (Barry A., 1951; Bosmia et al., 2015). In the neck region of the developing fetus, the postcostal longitudinal anastomosis between the C1 and C7 segmental arteries form the VA. The bilateral VAs normally develop from the distal part of the 7th dorsal intersegmental arteries (Congdon et al., 1922). The majority of the first connections of the intersegmental arteries with the dorsal aorta obliterate while others persist. Persistence of certain primitive vessels during development results in the development of structures that constitutes anatomical variations (Tubbs et al., 2016). However, the reasons why some arteries persist while others not are still elusive (Tubbs at al., 2016).

The left vertebral artery typically arises as the first branch of the left subclavian artery and courses superiorly and passes through the transverse foramen of the upper six or seven cervical vertebrae. In the current literature, variations in the origin and course of the left vertebral artery have been reported (Table 1). Patasi et al (2009), Kanasker et al (2014) and Satti et al (2007) reported that variations in the origin of the left vertebral artery from the arch of the aorta were found in males. In contrast, other studies (Einstein et al., 2016; Imre et al., 2010; Sikka and Jain, 2012; Ikegami et al., 2007; Panicker et al., 2002) reported that the same anatomical variation was found in females. These studies highlited that there might be a gender difference in this type of variation.

While various studies reported the arch of the aorta as the origin of the left vertebral artery (Table 1), the level of entry of the artery in the transverse foramen of the cervical vertebrae was different. Patasi et al. (2009) reported that the left vertebral artery entered the transverse foramen of the third cervical vertebra, whereas Sikka and Jain (2012) showed that the left vertebral artery entered the transverse foramen of the fourth cervical vertebra. Results from the present study coincide with results published by Ikegami et al (2007), who reported that the left vertebral artery coursed superiorly running on the anterior surface of the seventh and sixth cervical vertebral bodies, ultimately entering the transverse foramen of the fifth cervical vertebra. A series of studies (Panicker et al., 2002;

Table 1. Frequency of the origin of the left vertebral artery from arch of the aorta.

Reference	Incidence (%)	Cases / Total	Gender	Entrance into the cervical vertebra				
				C3	C4	C5	C6	C7
Adachi (1928)	5.4%	28/516	18 Males 12 Females	0	2	19	4	3
Takafuji and Sato (1991)	6.9%	5/72	Males 3 Females	Unspecified				
Vorster et al. (1998)	5%	2/60	2 Males	Unspecified				
Komiyama et al. (2001)	2.4%	21/860	15 Male 6 Female	Unspecified				
Yamaki et al. (2006)	5.8%	30/514	18 Males 12 Females	2	5	13	10	0
Satti et al. (2007)	Case Report	1	Male	Unspecified				
Patasi et al. (2009)	Case Report	1	Male	1	0	0	0	0
Nurcan Imre (2010)	Case Report	1	Female	0	0	0	1	0
Sikka and Jain (2012)	Case Report	1	Female	0	1	0	0	0
Uchino et al. (2013)	4.1%	94/2287	55 Males 39 Females	0	13	73	8	0
Tetiker et al. (2014)	3.8%	3/79	3 Male	0	1	0	1	1
Kanasker et al. (2014)	Case Report	1	Male	0	0	0	1	0
Einstein et al. (2016)	14.8%	4/27	4 Females	Unspecified				
Tardieu (2017)	4% (cadaveric) 0.78% Retrospective study	2/50 13/1500	Unknown	0 1	1 3	1 7	0 2	0 0
Lin et al. (2018)	3.8%	46/1219	Unknown	0	7	37	2	0
Woraputtaporn et al. (2019)	5.3%	14/266	Unknown	0	1	11	2	0

Kanasker et al., 2014; Watanabe et al., 2016) demonstrated that even though the left vertebral artery arose directly from the arch of the aorta, the artery entered the transverse foramen of the sixth cervical vertebra as if it originated from the subclavian artery.

It could be asked whether individuals with variation of the vertebral artery would be symptomatic. Interestingly, Satti et al (2007) reported a syncope case where the left vertebral artery arose from the arch of the aorta: the authors have also added that individuals with a variation in the origin of the left vertebral artery are more likely to present with symptoms of dizziness or vertigo, as the variant origin can affect the blood flow of the artery. In contrast, Einstein et al (2016) highlighted that variation of the left vertebral artery has no effect on the artery's blood flow.

It is essential to know about the vertebral artery variations. The origin of the vertebral arteries is a common site for the development of stenotic lesions (Berguer et al., 1976; Cloud and Markus, 2003). Atherosclerotic lesions are frequent at the prevertebral segment of the vertebral artery, particularly at its origin, and are responsible for posterior circulation ischemic strokes, and are treated with an endovascular surgery such as vertebral artery vascularization or bypass (Caplan, 2003).

Conclusion

Overall, knowledge of variations in the origin and course of the left vertebral artery is indispensable during the conduction of diagnostic or interventional angiography. A thorough understanding of anomalous in origin and course of the left vertebral artery is therefore crucial for vascular and thoracic surgeons for surgical planning and the conduction of endovascular related procedures.

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REFERENCES

ADACHI B (1928) Das Arteriensystem der Japaner, Band. 1, pp, 138-156 Kyoto: Maruzen.

ALI A, Sedora RNI., Cox M, Kung, D, Choudhri O (2018). Anomalous origin of the right vertebral artery from the right common carotid artery. Cureus, 10(11): 1-6.

ARIYO O (2018) A rare origin of the right vertebral artery and its clinical implications in a proximal occlusion to proximal origin to the brachiocephalic trunk. Ann Cardiovasc Thorac Surg, 2(1): 18-21.

BARRY A (1951) The aortic arch derivates in the human adult. Anat Rec, 111: 221-238.

BAYAT P, GHANBARI A, ESMAEILI S, ESMAEILI K (2011) Abnormal originating of vertebral artery in the superior mediastinum: A case report. Eur J Anat, 15 (2): 117-119.

BERGUER R, ANDAYA LV, BAUER RB (1976) Vertebral artery bypass. Arch Surg, 111(9): 976-979.

BRENNAN PA, MAHADEVAN V, EVANS BT (eds.) (2015) Clinical Head and Neck Anatomy for Surgeons. CRC Press.

BOSMIA AN, HOGAN E, LOUKAS M, TUBBS RS, COHEN-GADOL AA (2015) Blood supply to the human spinal cord: part I. Anatomy and hemodynamics. Clin Anat, 28(1): 52-64.

CAPLAN LR (2003) Atherosclerotic vertebral artery disease in the neck. Curr Treat Options Cardiovasc Med, 5(3): 251-256.

CLOUD G, MARKUS H (2003) Diagnosis and management of vertebral artery stenosis. QJM, 96(1): 27.

CONGDON ED (1922) Transformation of the aortic arch system during the development of the human embryo. Contrib Embryol, 14(9): 47-110.

EINSTEIN EH, SONG LH, VILLELA NL, FASANI-FELDBERG GB, JACOBS JL, KIM DO, PETERS DF (2016) Anomalous origin of the left vertebral artery from the aortic arch. Aorta, 4(02): 64-67.

GLUNCIC V, IVKIC G, MARIN D, PERCAC S (1999) Anomalous origin of both vertebral arteries. Clin Anat, 12(4): 281-284.

IKEGAMI A, OHTANI Y, OHTANI O (2007) Bilateral variations of the vertebral arteries: The left originating from the aortic arch and the left and right entering the C5 transverse foramina. Anat Sci Int, 82(3): 175-179.

IMRE N, YALCIN B, OZAN H (2010) Unusual origin of the left vertebral artery. IJAV, 3: 80-82.

JAYANTHI V, PRAKASH, DEVI MN, GEETHANJALI BS, RAJINI T (2010) Anomalous origin of the left vertebral artery from the arch of the aorta: review of the literature and a case report. Folia Morphol (Warsz), 69: 258-260.

KANASKER N, VATSALASWAMY P, SONJE P (2014) Variation in the origin of left vertebral artery: A case report. Medical J, 7(2): 240-241.

KOMIYAMA M, TOSHIE M, NAKAJIMA H, NISHIKAWA M, YASUI T (2001) High incidence of arterial dissection associated with left vertebral artery of aortic arch origin. Neurol Med Chir (Tokyo), 41: 8-12.

LIN C, LIU Y, CHEN Y, SHIH Y, CHANG C, CHUANG M (2018) Variations in the origin and course of the extracranial vertebral artery on multidetector computed tomography angiography. Iran J Radiol, 15(2): 61623.

LIPPERT H, PABST R (1985) Arterial variations in man. Classification and frequency. JF Bergmann Verlag, Munchen, pp 30-38.

MATULA C, TRATTNIG S, TSCHABITSCHER M, DAY JD, KOOS WT (1997) The course of the prevertebral segment of the vertebral artery: anatomy and clinical significance. Surg Neurol, 48(2): 125-131.

PANICKER H, TARNEKAR A, DHAWANE V, GHOSH S (2002) Anomalous origin of left vertebral artery — embryological basis and applied aspects – a case report.

J Anat Soc India, 51(2): 234-235.

PATASI B, YEUNG A, GOODWIN S, JALALI A (2009) Anatomical variation of the origin of the left vertebral artery. Int J Anat Variations, 2: 83-85.

QUAIN R (1844) The Anatomy of the Arteries of the Human Body with its application to pathology and operative surgery; in a series of plates and commentaires. Taylor and Walton, London.

SAEED UA, GORGOS AB, SEMIONOV A, SAYEGH K (2017) Anomalous right vertebral artery arising from the arch of aorta: report of three cases. Radiol Case Reports, 12(1): 13-18.

SARTOR K, FRECKMANN N, BOKER DK (1980) Related anomalies of origin of left vertebral and left inferior thyroid arteries. Neuroradiology, 19: 27-30.

SATTI SR, CERNIGLIA CA, KOENIGSBERG RA (2007) Cervical vertebral artery variations: an anatomic study. Amer J Neuroradiol, 28(5): 976-980.

SHANE TUBBS R, SHOJA M, LOUKAS M (2016). Bergman's comprehensive encyclopedia of human anatomic variation. 1st ed. Malden, MA: Wiley-Blackwell, pp 1 -1423.

SIKKA A, JAIN A (2012) Bilateral variation in the origin and course of the ertebral artery. Anat Res Int, 2012: 580765.

TAKAFUJI T, SATO Y (1991) Study on the subclavian artery and its branches in Japanese adults. Okajima Folia Anat Jpn, 68: 171-186.

TARDIEU GG, EDWARDS B, ALONSO F, WATANABE K, SAGA T, NAKAMURA M, MONTEITH S (2017) Aortic arch origin of the left vertebral artery: an anatomical and radiological study with significance for avoiding complications with anterior approaches to the cervical spine. Clin Anat, 30(6): 811-816.

NAKAMURA M (2017) Aortic arch origin of the left vertebral artery: an anatomical and radiological study with significance for avoiding complications with anterior approaches to the cervical spine. Clin Anat, 30(6): 811 -816.

TETIKER H, CIMEN M, KOSAR MI (2014) Evaluation of the vertebral artery by 3D digital subtraction angiography. Int J Morphol, 32: 798-802.

TUBBS RS, SHOJA MM, LOUKAS M (Eds.) (2016) Bergman's comprehensive encyclopedia of human anatomic variation. John Wiley & Sons, pp 1-1423.

UCHINO A, SAITO N, TAKAHASHI M (2013) Variations in the origin of the vertebral artery and its level of entry into the transverse foramen diagnosed by CT angiography. Neuroradiology, 55: 585-594.

VORSTER W, DU PLOOY P, MEIRING J (1998) Abnormal origin of internal thoracic and vertebral arteries. Clin Anat, 11: 33-37.

WATANABE K, SAGA T, IWANAGA J, TABIRA Y, YAMAKI KI (2016) A rare case of dual origin of the left vertebral artery without convergence. Folia Morphol, 75(1): 136-142.

WORAPUTTAPORN W, ANANTEERAKUL T, IAMSAARD S, NAMKING M (2019) Incidence of vertebral artery of aortic arch origin, its level of entry into transverse foramen, length, diameter and clinical significance. Anat Sci Int, 94(4): 275-279.

YAMAKI K-I, SAGA T, HIRATA T, SAKAINO M, NOHNO M, KOBAYASHI S (2006) Anatomical study of the vertebral artery in Japanese adults. Anat Sci Int, 81(2): 100-106.