JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH

How to cite this article:
POONAM , SINGLA R K , SHARMA T . INCIDENCE OF ANOMALOUS ORIGINS OF VERTEBRAL ARTERY – ANATOMICAL STUDY AND CLINICAL SIGNIFICANCE. Journal of Clinical and Diagnostic Research [serial online] 2010 June [cited: 2010 June 7]; 4:2626-2631

Available from
http://www.jcdr.net/back_issues.asp?issn=0973-709x&year=2010 &month= June &volume=4&issue=3&page=2626-2631

EXPERIMENTAL RESEARCH

Incidence of Anomalous Origins of Vertebral Artery – Anatomical study and Clinical significance

POONAM*, SINGLA R K ** , SHARMA T ***

Context: The anatomical and the morphological variations of the vertebral artery are significant for diagnostic and surgical procedures in the head and neck region, where an incompatible knowledge can lead to serious implications

Aims: This study was conducted to know the variations in the origins of vertebral arteries and to discuss their clinical implications while performing diagnostic and interventional angiography, both to identify them correctly and to know where to look when vertebral arteries are not seen in the normal position.

Material And Methods: Eighty vertebral arteries belonging to 40 cadavers were dissected in the head and neck region. Their source and mode of origin were studied. Out of the total cadavers, four were found to have abnormal origins of vertebral arteries, which were studied in detail along with their clinical implications.

Results: An extremely rare and interesting case of the origin of the left vertebral artery from the external carotid artery was encountered in one of these specimens. The direct origin of the left vertebral artery from the aortic arch was also found in three cadavers, out of which one was found to be bifurcating after taking origin. No abnormality in the origin was encountered on the right sided vertebral arteries.

Conclusion: The described morphological variations have clinical applications in the wide field of surgery, in the head and neck region. To know about these findings seems to be very important before undertaking any surgery or endovascular treatment in that region. Cerebral angiography must be included in the evaluation of patients with unexplained neurological findings.

Key Words: Subclavian artery, Left vertebral artery, Left external carotid artery, Proatlantal intersegmental artey, carotid-vertebral anastomosis.

*(Asstt. Prof., MS, Anatomy), Department of Anatomy, Jhalawar Medical College, Jhalawar, Rajasthan(India)
**(Associate Prof., MS, Anatomy),
*** (Professor, MS, Anatomy) Department of Anatomy, Govt. Medical College, Amritsar, Punjab ,(India)
Corresponding Author:
Dr. Poonam Asstt. Professor, Department of Anatomy Jhalawar Medical College, Jhalawar (Rajasthan) – 326001Ph. No.: 09602512911, 09799333445,
Email: drpoonamdel@yahoo.co.in

Introduction

The vertebral artery, the largest branch of the subclavian artery, arising from the posterosuperior aspect of its first part, 0.5 to 2 cm medial to the thyrocervical trunk, is divided into four segments: [1]:

1. Pre vertebral / VI segment: From its origin to the foramen transversarium of the C_6 vertebra.
2. Vertebral / V2 segment: From the foramen transversarium of the C_6 vertebra till that of the C_1 vertebra.
3. Atlanto axial/V3 segment: From the foramen transversarium of the C_1 to the foramen magnum.
4. Intracranial/V4 segment.

An abnormal origin of the vertebral artery may favour cerebral disorders because of alterations in cerebral haemodynamics [2] and predispose the patients to intracranial aneurysm formation [3].

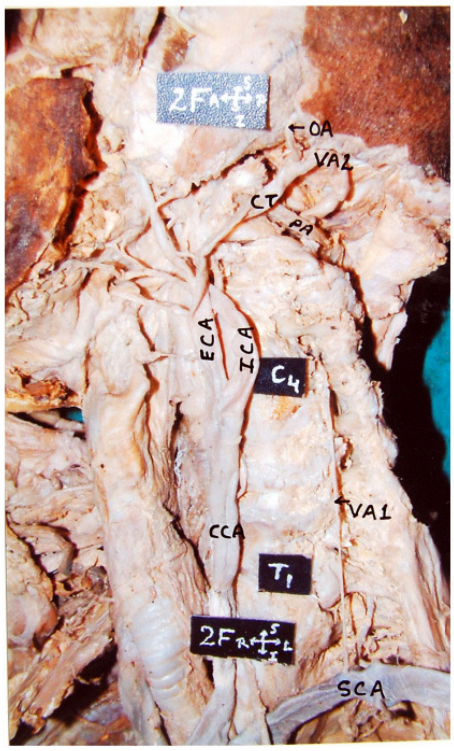
Material and Methods

Forty cadavers (37 males; 3 females) were dissected for the study of variations in the origin of the vertebral artery. Deep dissection was done in the head and neck region to expose the vertebral

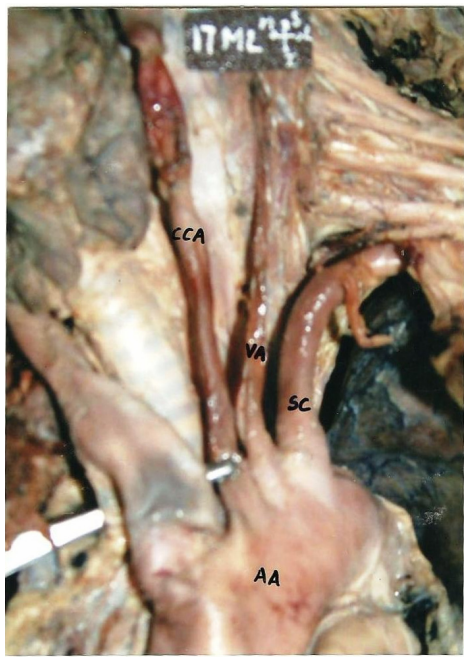
arteries in the scalenovertebral triangle on both the right and the left sides and so, a total of 80 vertebral arteries were exposed. The arteries were explored and their source as well as their mode of origin was ascertained. A real abnormality in origin was encountered in four out of 40 cadavers and all those were on the left side. The course of these abnormal originating arteries was studied in detail and was compared with previous studies by scanning accessible literature. No anomalous origin was seen on the right side.

Results

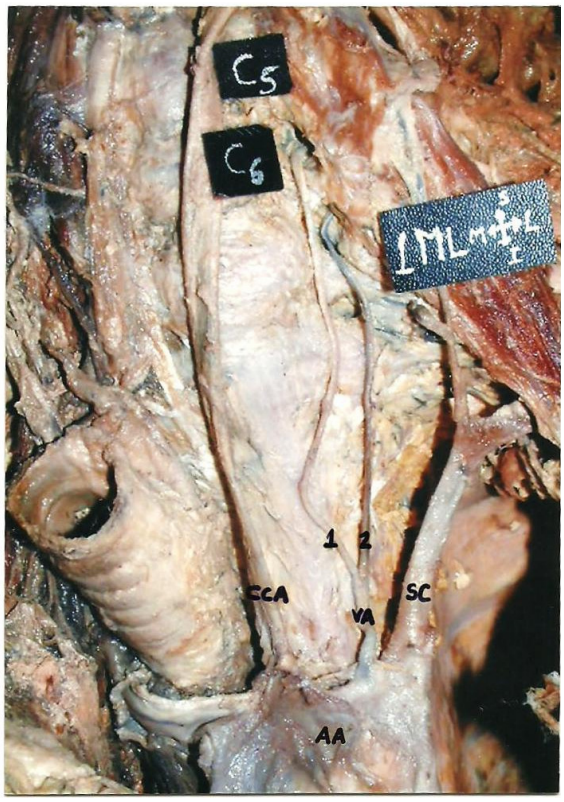
In one female cadaver, a variant origin of the left vertebral artery from the external carotid artery was encountered. This was found to be a very interesting and extremely rare variant in which a thin and hypoplastic vertebral artery (VA_1) with a diameter of 0.9 mm representing the V_1 and V_2 segment, emanated from the first part of the subclavian artery and entered the foramen transversarium of C_6. It was traced in the foramen transversariums of C_6 – C_4 by cutting their costotransverse bars, but beyond that, it became too thin to be dissected and so, no further attempt was made to trace it in this part. Then, it was dissected in the suboccipital region and it was traced to its source of origin. A dominant vertebral artery (VA_2) with a diameter of 3.6mm originated from the external carotid artery in the common with occipital artery at the intervertebral disc between the C2 and C3 vertebrae and took the course of the V_3 and V_4 segment without entering any foramen transversarium [Table/Fig 1] . The basilar artery was formed by the union of two vertebral arteries, a normal one on the right side and the one of external carotid artery origin on the left side. In three other male cadavers, the left vertebral artery came from the aortic arch in between the left common carotid and the left subclavian arteries[Table/Fig 2]. In one out of these three cadavers, the stem of the left vertebral artery, after taking origin from the aortic arch, was bifurcated into two. One entered C6 and the other into the C5 foramen transversarium [Table/Fig 3]. No other associated anomaly of the vascular system or any other system was seen in the study.



(Table/Fig 1)
A hypoplastic vertebral artery (VA1) arising from subclavian artery (SCA). A dominant vertebral artery (VA2) arising in common with occipital artery (OA) from external carotid artery (ECA). [CCA: Common carotid artery, ICA: Internal carotid artery, CT: Common trunk for occipital artery and dominant vertebral artery, PA: Posterior arch of Atlas.



(Table/Fig 2)
Left vertebral artery (VA) coming from aortic arch (AA) between left common carotid artery (CCA) and left subclavian artery (SC).



(Table/Fig 3)
Left vertebral artery (VA) coming from aortic arch (AA) between left common carotid artery (CCA) and left subclavian artery (SC), bifurcating into two branches (1 and 2) and entering into foramen transversarium of C5 and C6 vertebrae respectively.

Discussion

Though the overall incidence of the anomalous origin of the prevertebral segment of the vertebral artery is low [4], it occurs mostly on one side, usually on the left [5]. In our study, all variations in the origin of the vertebral artery that had been encountered, were on the left side. However, a variety of anomalous origins of the vertebral artery on the right side has been reported [Table/Fig 4]describes some important variations of origins of the vertebral artery with their clinical significance as documented in the literature.

On reviewing the literature, it was found that the external carotid artery origin of the left vertebral artery is a very rare variant. It was Flynn[19] who had made mention of such an entity first of all, followed by Matula et al[20]. Yilmaz et al [21] performed selective cerebral angiographies in 4400 cases and encountered only one such case (i.e. 0.023%).

Ontogenically, this type of anomaly occurs due to the persistence of the proatlantal intersegmental artery. In early embryonic life (5.3 mm embryo), the primitive trigeminal artery, the primitive otic artery, the primitive hypoglossal artery and the proatlantal intersegmental artery account for important blood supply from the internal carotid arteries to the precursors of the basilar artery. These occur in the form of pairs and are called presegmental arteries. During embryonic development, these usually atrophy, but the persistence of one or the other may lead to carotid-basilar or carotid- vertebral anastomosis [22].

According to Lie [23], in a 5 mm embryo with the atrophy of the primitive hypoglossol artery, the pro-atlantal intersegmental artery supplies blood to the caudal part of the bilateral longitudinal neural artery. In a 12-14 mm embryo, the proatlantal intersegmental artery gradually disappears by forming the intra-cranial part of the vertebral artery. In the case of its persistence, the pro-atlantal intersegmental artery constitutes a carotid-vertebral anastomosis. It originates from the internal carotid artery or the external carotid artery and unites with the horizontal part of the vertebral artery in the suboccipital region [24].

In the present case, it was anastomosis between the external carotid artery and the vertebral artery. Further, it seems that with the persistence of this anastomosis, the V_1 and the V_2 segments of the vertebral artery proper failed to develop fully haemodynamically and thus, a hypoplastic vertebral artery (V_1 and V_2 segments) resulted. The main blood supply for the V_3 and the V_4 segments came through this persistent proatlantal anastomosis between the external carotid artery and the vertebral artery, giving the appearance as if V_3 and V_4 are arising from the external carotid artery primarily.

In the course of the surgical treatment of certain aneurysms, arteriovenous malformations and carotid cavernous fistulae, the necessity of ligating the common carotid artery or its external or internal branch arises. A ligation of the common carotid artery or the external carotid in cases like this specimen, would definitely result in a serious compromise of the posterior cerebral circulation. So, pre-operative carotid angiography must be done before undertaking such surgeries.

(Table/Fig 4)Variations of vertebral artery documented in the literature.

Anomalies	Incidence (%)	Clinical significance
1. Double origin of vertebral artery [3, 6, 7, 8]	0.72 – 1.6	-Mimics dissection on conventional Angiography [8] -Thick stem prone to extracranial aneurysm and thin stem render the risk of arteriovenous fistula due to trauma [7] - Increased incidence of associated injury during intervention [3]
2. Right vertebral artery from aortic arch [6, 9]	<1	- May go unnoticed during angiography
3. Right vertebral artery from right common	0.18-0.28	- Failure to demonstrate it by right brachial or transaxillary angiography so exclude it by alternate technique prior to carotid clamp to avoid induced vertebrobasilar ischaemia [10] -Due to close relation with thyroid gland, meticulous care needed to avoid an inadvertent injury to vertebral artery during thyroidectomy [11]
4. Right vertebral artery as a branch of thyrocervical trunk [6]	2.6	Implications in angiography and surgical procedure on head and neck
5. Left vertebral artery from thyrocervical Trunk [6, 12]	<1	Injury of vertebral artery in extended lateral decompression during anterior cervical spine injury which result exsanguination and permanent neurological deficits [12]
6. Trifurcation of brachiocephalic trunk [6, 13]	1.1	Knowledge of variant is important in angiography and surgical procedures
7. Left vertebral artery arises from aortic arch at the junction of subclavian with aorta [6]	3.5	Implications in angiography and supra-aortic surgery.
8. Left vertebral artery of aortic arch origin with subclavian stenosis [14]	--*	Variant of subclavian steal syndrome
9. Both vertebral arteries as a branch of aortic arch [15,16]	--*	- Knowledge of potential vertebral artery origin variant appear to be mandatory for planning arotic arch surgery and endovascular intervention.
10. Bilateral aortic arch origin of vertebral arte ries with retro-oesophageal course of right vertebral artery [17]	--*	Signs and symptoms similar to retro-oesophageal right subclavian artery and angiographic misinterpretation.[18]

*Case reports, incidence not mentioned

The sole case reported by Yilmaz et al [21], out of 4400 angiographies, had an aneurysm and it was associated with cerebellar ataxia and dysdiadochokinesia. They performed an exhaustive review of the earlier literature on the persistent primitive trigeminal artery, the hypoglossal artery, the otic artery and the proatlantal intersegmental artery and found that most commonly these anastomoses were seen in combination with intracranial vascular anomalies and with cranial nerve symptoms such as trigeminal neuralgia. They also appear to be associated with various neurological diseases such as intracranial tumour, vertebro-basilar insufficiency, multiplesclerosis, subdural haematoma, epilepsy and moyamoya disease.

This led Yilmaz et al [21] to believe that although primitive anastomoses are rarely observed, they may have pathological significance in the development of a variety of intracranial vascular anomalies. So, from the clinical point of view, they recommended that cerebral angiography must be included in the evaluation of patients of any age with unexplained neurological findings.

Among other variants found in the present study, a left vertebral artery of aortic origin between the origins of the left common carotid and the left subclavian artery was encountered in three (7.4%) cadavers. Literature shows the frequency of this anomalous origin to be in the range of 1-5% [25]. Argenson et al [13], in their study on 104 cadavers, noted six cases in which the vertebral artery took origin from the aortic arch (5.8%) , all being left sided. However, its incidence is increased manifold (40%) in Down's syndrome [26].

Embryologically, the vertebral artery is formed between the 32nd and 40th gestational day, from the fusion of the secondary persistent segments of the cervical arteries and the primitive dorsal aortic arch [20]. Abnormalities in this fusion process leads to abnormal origins. A left vertebral artery of aortic origin may be because of the persistence of the dorsal division of the left 6th intersegmental artery as the first part of the vertebral artery instead of that of the left 7th dorsal intersegmental artery [4].

A left vertebral artery of aortic origin is found to be associated with a significantly higher incidence of vertebral artery dissection than that of a normal origin [27].

One cadaver was showing bifurcation of the vertebral artery after coming out from the aortic arch. Ontogenically, this condition may be due to the persistence of both precostal and postcostal longitudnal anastomosis. Duplicated vertebral arteries,, because of less diameters, render the risk of vertebral arteriovenous fistula during the injection of the dye for vertebral angiography. Also, since the blood flow is diverted through two channels, it predisposes the patient to vertebrobasilar insufficiency. Moreover, such thin and hypoplastic stems of the vertebral artery are at an increased risk of trauma during surgery of the region, again predisposing the patient to vertebro basilar insufficiency. So, the knowledge of such a condition for a surgeon as well as a physician is indispensable [7].

Without a thorough understanding of the anomalous origins of the great vessels, angiography can be difficult or impossible. If the vertebral arteries are not identified in their normal position, this finding can be misinterpreted as the vessels being congenitally absent. This information is important for vascular or cardiothoracic surgical planning [28]. Anomalous origins may lead to altered haemodynamics and may predispose the patient to intracranial aneurysm formation. Therefore, in patients with these anomalies, a thorough search for coexisting aneurysms should be undertaken. Endovascular therapy of intracranial aneurysms can be performed before they present clinically as subarachnoid haemorrhages or mass effect and thereby decrease morbidity and mortality [3].

In this study, we came across a rare anomaly of the left vertebral artery coming from the external carotid artery, which developed due to the persistence of primitive anastomosis, which may have a pathological association with various intracranial anomalies. Therefore, the anatomical arrangement of the major arteries to the brain must be studied before undertaking any surgeries in the head and neck region and in evaluating the patients with neurological pathologies. Secondly, one must be aware of the variations of the vertebral arteries while performing diagnostic and interventional angiography to both identify them correctly and to know where to look when vertebral arteries are not seen in the normal position.

References

[1] Williams PL, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE et al.. Cardiovascular system – subclavian system of arteries, In:Gabela G. Edr. Gray's Anatomy. 38th Edn, New York, London, Churchill Livingstone; 1995: 1529-36.

[2] Bernardi L and Dettori P. Angiographic study of a rare anomalous origin of vertebral artery. Neuroradiol 1975; 9: 43-47.

[3] Satti SR, Cernigilia A, Koenigsberg RA. Cervical vertebral artery variations-An anatomical study. Am J Neuroradiol, 2007; 28: 976- 80.

[4] Panicker HK, Tarnekar A, Dhawane V, Ghosh SK. Anomalous origin of left vertebral artery – embryological basis and applied aspects – A case report. J Anat Soc Ind 2002; 51(2): 234-35.

[5] Rieger P and Huber G. Fenestration and duplicate origin of left vertebral artery in angiography. Neuroradiol 1983; 25: 45-50.

[6] Daseler EH and Anson BJ. Surgical anatomy of subclavian artery and its branches. Surg Gynaecol Obstet 1959; 108: 149-74.

[7] Rath G and Parkash R. Double vertebral artery in an Indian cadaver. Anatomia Clinica 1984; 6: 117-19.

[8] Nogueira TE, Chambers AA, Brueggemeyer MT, Miller TJ. Dual Origin of the Vertebral Artery Mimicking Dissection. Am J Neuroradiol 1997; 18:382-84.

[9] Wasserman BA, Mikulis DJ, Manzione JV. Origin of the right vertebral artery from left side of the aortic arch proximal to origin of left subclavian artery . Am J Neuroradiol 1992; 13: 355-358.

[10] Palmer FJ. Origin of right vertebral artery from right common carotid artery. Angiographic demonstration of three cases. Br J Radiol 1977; 50: 185-87.

[11] Park JK, Kim SH, Kim BS, Chai G . Two cases of aberrant right subclavian artery and right vertebral artery that originated from the right common carotid artery. Korean J Radiol 2008 Jul;9 Suppl:S39-42.

[12] Strub WM, Leach JL, Tomsick TA. Left Vertebral Artery Origin from the Thyrocervical Trunk: A Unique Vascular Variant Am J Neuroradiol, 2006; 27:1155–56.

[13] Argenson C, Francke JP, Sylla S, Dintimille H, Papasian S, di Marino V. The vertebral arteries (segment V_1 and V_2). Anatomia Clinica 1980; 2: 29-41.

[14] Denkhaus H, Weichert HC, Horn P. Variants der subclavian steal syndrome bei isohert abgehender arteria vertebralis sinistra. Radiologe 1981;21:77-80. Cited by Schwarzacher SW and Krammer EB. Complex anomalies of human aortic arch system: unique case with both vertebral arteries as additional branches of aortic arch. Anat Rec 1989; 225:246-50.

[15] Albayram S, Gailloud P, Wasserman BA. Bilateral arch origin of the vertebral arteries. Am J Neuroradiol 2002;23:455–58.

[16] Goray VB, Joshi AR, Garg A, Merchant S, Yadav B, Maheshwari P. Aortic Arch Variation: A Unique Case with Anomalous Origin of Both Vertebral Arteries as Additional Branches of the Aortic Arch Distal to Left Subclavian Artery. Am J Neuroradiol 2005; 26:93–95.

[17] Schwarzacher SW and Krammer EB. Complex anomalies of human aortic arch system: unique case with both vertebral arteries as additional branches of aortic arch. Anat Rec 1989; 225:246-50.

[18] Walker TG, and Geller SC. Aberrant right subclavian artery with a large diverticulum of Kommerell: A potential for diagnosis. Am J Radiol 1987; 149: 447-48.

[19] Flynn RE. External carotid origin of dominant vertebral artery. J Neurosurg 1968; 29: 300-1.

[20] Matula C, Trattnig S, Tschabitscher M, Day JD, Koos WT. The course of the prevertebral segment of the vertebral artery: anatomy and clinical significance. Surg Neurol 1997;48: 125-31.

[21] Yilmaz E, Ilgit E and Taner D. Primitive persistent carotid-basilar and carotid-vertebral anastomosis: A report of seven cases and a review of the literature. Clin Anat 1995; 8: 36-43.

[22] Garza-Mercado R and Cavazos E. Persistent trigeminal artery associated with intracranial arterial aneurysm. Neurosurg 1984; 14: 604-7.

[23] Lie TA. Congenital anomalies of the carotid arteries. Amsterdam: Excerpta Medica Foundation; 1968:pp. 52-94.

[24] Obayashi T and Furuse M. The proatlantal intersegmental artery: A case report and review of the literature. Arch Neurol 1980; 37: 387-89.

[25] Vorster W, Du Plooy PT, Meiring JH. Abnormal origin of internal thoracic and vertebral arteries. Clin Anat 1998; 11: 33-37.

[26] Rathore MH and Sreenivasan VV. Vertebral and right subclavian artery abnormalities in the Down syndrome. Am J Cardiol 1989; 63: 1528-30.

[27] Komiyana M, Morikawa T, Nakajiman H, Nishikawa M, Yasui T. High incidence of arterial dissection associated with left vertebral artery of aortic origin. Neurology Medical Chir (Tokyo) 2001; 41(1): 8-11.

[28] Giuffre R, Sherkat S. The vertebral artery. Developmental pathology. J Neurosurg Sci 1999;43: 175-89.