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Embryology

Elixir Embryology 99 (2016) 43225-43229

ISSN: 2229-712X

COMMON ANOMALOUS ORIGIN OF LEFT VERTEBRAL ARTERY AND ITS EMBRYOLOGICAL BASIS

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ARTICLE INFO

Article history:
Received: 16 September 2016;
Received in revised form:
12 October 2016;
Accepted: 17 October 2016;

Keywords
Left vertebral artery,
Left subclavian artery,
Left common carotid artery,
Cervical intersegmental artery,
Fourth aortic arch artery,
Arch of aorta.

ABSTRACT

The vertebral arteries (VA) are most important vessels for posterior cerebral circulations. The anomalous aortic origin of the left vertebral artery (LVA) is relatively common congenital anomalies, incidence up to 84.8%. On the dissected human heart specimens with the aortic arch branches, we observed two different patterns of anomalous aortic arch origin of left vertebral artery. The unusual aortic arch origin of LVA was observed between the LCCA & LSA in one specimen and after LSA in another. The present study aimed to establish the concept of the embryological basis behind the common anomalous aortic origin of left vertebral artery.

Introduction

The vertebral arteries (VA) are the major blood vessels for posterior cerebral circulations. The variability in the course and origin of vertebral arteries [1] are more significant to understand the clinical and surgical aspects of cerebral disorders [2, 3]. The knowledge about the common anomalous in the origin and course of vertebral arteries are also imperative for head and neck surgeries, angiography and arterial dissections [4]. VA pathologies due to its anomalous origins are not only implicating in cerebrovascular disorders but also, in VA dissection [4].

The high yield knowledge about the common anomalous of arterial system is utmost important in the era of carotid artery stents, vertebral artery stents, also in new therapeutic options in intracranial interventions [5]. Understanding the variations in the great vessels of aortic arches is more necessity in diagnostic and interventional angiography for endovascular interventionist. The anomalous in the origin of vertebral artery are more considerable, incompatible knowledge can lead to complications. The aim of the present study to establish the concept of the embryological basis behind the common anomalous aortic origin of left vertebral artery.

Incidence

The congenital anomalies are the most important cause of death in infants under one year of age [Ganesh Elumalai and Sushma Chodisetty, 2016]. Most commonly the anomalous origin of the vertebral artery was observed into the left side. The unusual aortic arch origin of the left vertebral artery (LVA) was observed between the left common carotid (LCCA) and left subclavian arteries (LSA) in one specimen and after LSA in another. The incidence ranges from 2.4 – 84.8 % of aortic arch origin of the left vertebral artery were observed by the previous workers [6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16] [Table-1].

Table 1.Incidence of Anomalous Aortic arch origin of Left Vertebral Artery.

PREVIOUS WORKERS	INCIDENCE (%)
Bean et al. (1905)	5.2%
Adachi et al. (1928)	5.4 %
Aso et al. (1932)	3.2%
Mori et al. (1941)	6.9%
Stein et al. (1962)	6.0%
Argenson et al. (1980)	5.8%
Nizanowski et al. (1982)	3.1%
Lipper Pab et al. (1985)	3.0%
Cavdar et al. (1989)	8.3%
Takafuji et al. (1991)	6.9%
Vorster et al. (1998)	5.0%
Komiyama et al. (2001)	2.4%
Panicker et al. (2002)	5.0%
Yamaki et al. (2006)	5.8%
Nurcan Imre et al. (2010)	2.5%
Shi-Min Yuan (2016)	84.8%

Observations

On the dissected human heart specimens with the aortic arch branches, we observed two different patterns of anomalous aortic arch origin of the left vertebral artery. The pattern one shows the anomalous aortic arch origin of the left vertebral artery (LVA) between the left common carotid (LCCA) and left subclavian arteries (LSA). On the other pattern, the anomalous aortic arch origin of the left vertebral artery (LVA) was observed after the origin of the left subclavian artery (LSA) from the arch of the aorta (Fig-1).

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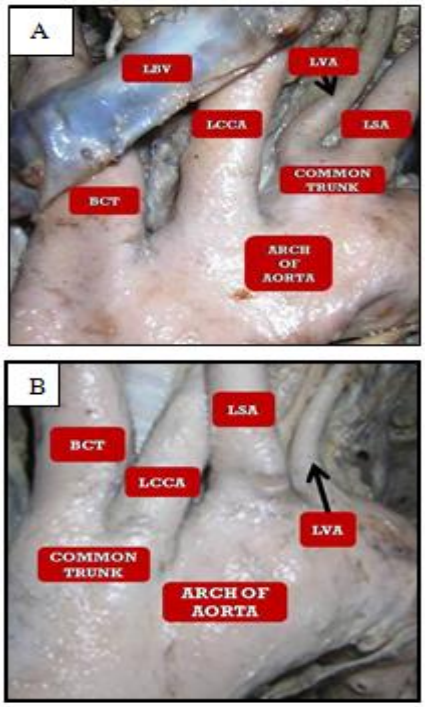

Fig 1. The Anomalous Aortic arch origin of the left vertebral artery (LVA) was observed between A. Pattern-1: between the left common carotid (LCCA) and left subclavian arteries and, B. Pattern-2: after the origin of the left subclavian artery (LSA) from the arch of the aorta. (BCT-Brachiocephalic Trunk and LBV-Left Brachiocephalic vein).

After its origin, the first part of the left subclavian artery followed its normal course to enter the foramen transversarium of the sixth cervical vertebra. On the other hand, the right vertebral artery branched out normally from the first part of right side subclavian artery.

Normal Ontogenesis

The small intersegmental branches arise from the dorsal aorta, extends from the cranial (cervical) to the caudal (sacral) region, to vascularize the somites of the developing embryo. In the cervical region, these intersegmental arteries are named as C1 to C7. The vertebral artery normally developed from the cervical intersegmental arteries. The dorsal branches (distal part) from the cervical intersegmental arteries from C1 to C7 are fused to form the postcostal longitudinal anastomosis. Normally, the first part of vertebral artery developed from the seventh cervical intersegmental artery and its (proximal part) dorsal branch (proximal to postcostal anastomosis). The sixth cervical intersegmental artery and its dorsal division are usually disappeared. The second part is derived from postcostal longitudinal anastomosis between the C6 to C1 (Fig-2 - 4).

Embryological basis for anomalous origin of LVA

In pattern one, where the vertebral artery arises from aortic arch between the left common carotid and left subclavian arteries. In this pattern, the left sixth intersegmental artery and its dorsal branch may fail to disappear. The blood from aortic arch directly flows to the persisting sixth cervical intersegmental artery forming the aortic arch origin of the left vertebral artery.

This persisting sixth cervical intersegmental artery remains as the aortic arch origin of the left vertebral artery. This preferential blood flows through the persisting left sixth intersegmental channel, results in diminishes the normal flow through the seventh cervical intersegmental artery (to its dorsal branch), which ultimately disappear.

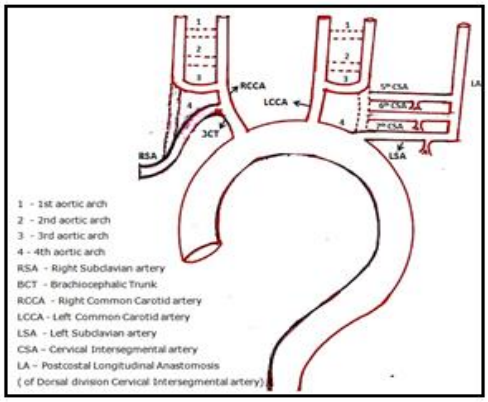

Fig 2. Ontogenesis of normal development Aortic arch and its branches.

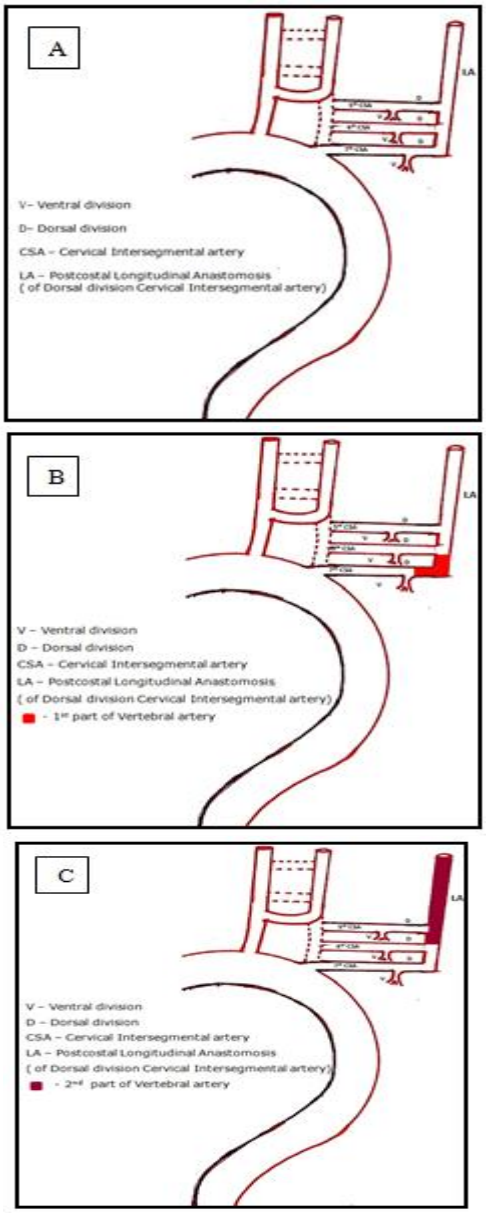

Fig 3.The schematic representation shows the Ontogenesis of: A. connections of 5th to 7th cervical intersegmental arteries with the Dorsal aorta, B. development of 1st part of left vertebral artery from the dorsal branch of 7th cervical intersegmental artery alone, and C. the 2nd part of left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) 6th and above cervical intersegmental arteries.

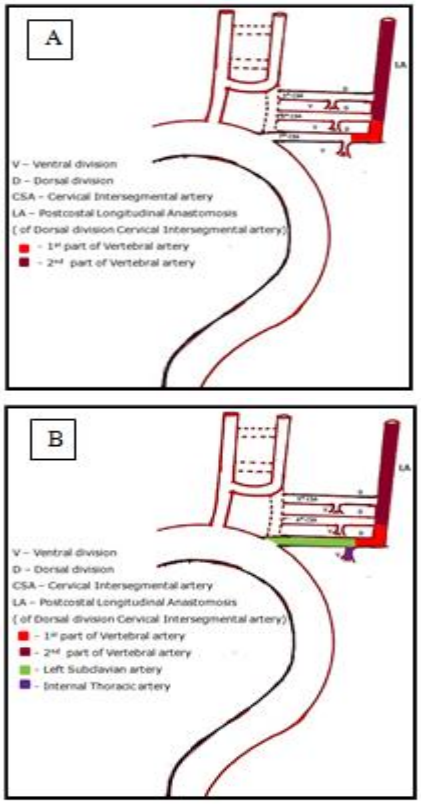

Fig 4. The schematic representation shows the Ontogenesis of: A. normal source of development of left vertebral artery (LVA). B. normal source of development of left subclavian artery (LSA) from the 7th cervical intersegmental artery and its branch called internal thoracic or internal mammary artery from the ventral branch of 7th cervical intersegmental artery.

The first part of the left vertebral artery derived from the sixth intersegmental artery and also from the small proximal portion of its dorsal branch. The ventral branch of the sixth intersegmental artery was disappeared completely. The second part of the left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) sixth and above cervical intersegmental arteries. It gives the pattern of the left vertebral artery arises from aortic arch between the between the LCCA and LSA (Fig- 5and 6).

In pattern two, the vertebral artery arises from aortic arch beyond the level of origin of the left subclavian artery (LSA) from the arch of the aorta. In this pattern, the dorsal branch of the left sixth intersegmental artery was disappeared. Whereas, the proximal part of the left sixth intersegmental artery with its ventral branch are persisted. The proximal part of left sixth intersegmental artery continuous as a left subclavian artery and, its ventral branch remains as an internal thoracic (mammary) branch (Fig-7 and 8).

The first part of the left vertebral artery derived exclusively from the seventh intersegmental artery and also from the small proximal portion of its dorsal branch. The ventral branch of the seventh intersegmental artery was disappeared completely. The second part of left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) seventh and above cervical intersegmental arteries. It gives the pattern of the left vertebral artery arises from aortic arch beyond the level of origin of the left subclavian artery (LSA) from the arch of the aorta (Fig-7and 8).

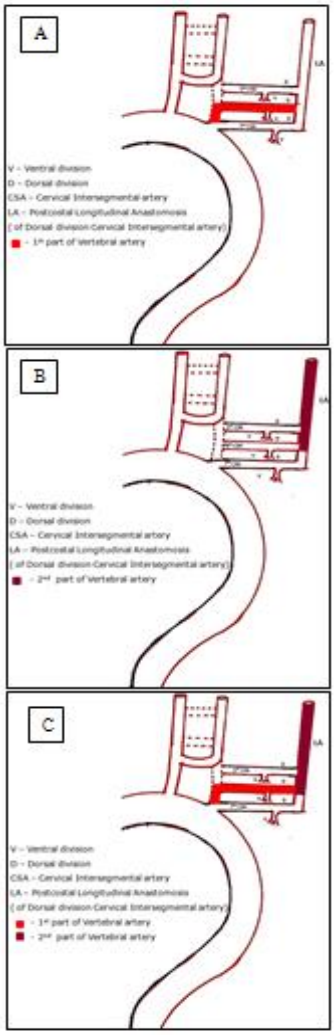

Fig 5. The schematic representation shows the Embryological basis of: A.Pattern:1 - anomalous origin of 1st part of left vertebral artery from the left sixth intersegmental artery and its dorsal branch, B. Normal development of the 2nd part of left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) 6th and above cervical intersegmental arteries, and C. Pattern:1 - the anomalous Aortic arch origin of left vertebral artery from the left sixth intersegmental artery.

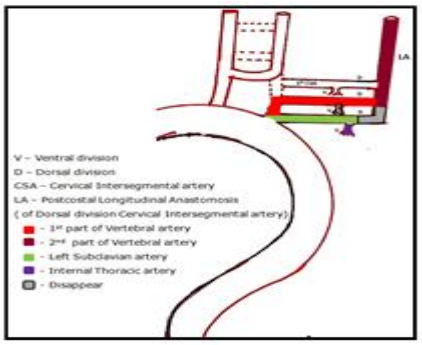

Fig 6. Pattern: 1 - The anomalous Aortic arch origin of left vertebral artery (LVA) between the LCCA and LSA (green shaded). The normal source of development of left subclavian artery (LSA) from the 7th cervical intersegmental artery and its branch called internal thoracic or internal mammary artery from the ventral branch of 7th cervical intersegmental artery.

Discussion

The left vertebral artery normally arises as the first posterior branch of the left subclavian artery. The anomalous aortic origin of the left vertebral artery is relatively common congenital anomalies in the aortic arch with an incidence rate up to 84.8% [16]. The vertebral artery normally developed from the cervical intersegmental arteries. The dorsal branches (distal part) from the cervical intersegmental arteries from C1 to C7 are fused to form the postcostal longitudinal anastomosis. Normally, the first part of vertebral artery developed from the seventh cervical intersegmental artery and its (proximal part) dorsal branch (proximal to postcostal anastomosis). The sixth cervical intersegmental artery and its dorsal division are usually disappeared. The second part is derived from postcostal longitudinal anastomosis between the C6 to C1 (Fig-2 - 4). In our observations, the pattern one and two exhibits the anomalous aortic arch origin of the left vertebral artery.

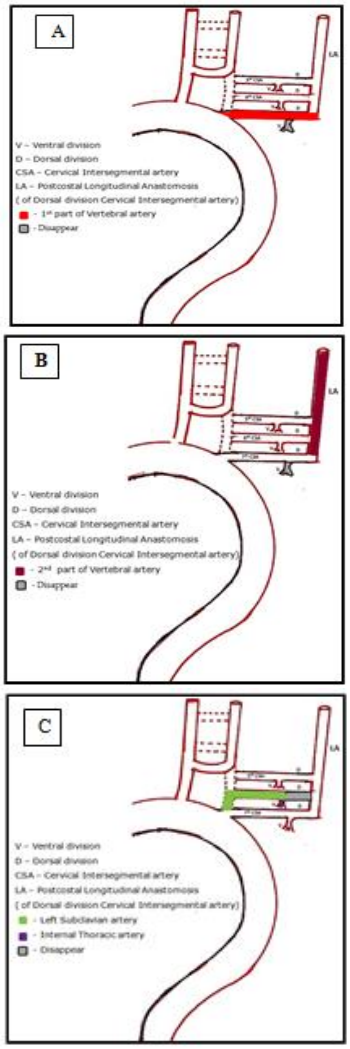

Fig 7. The schematic representation shows the Embryological basis of: A.Pattern:2 - anomalous origin of 1st part of left vertebral artery from the left seventh intersegmental artery and its dorsal branch, B. the unusual development of the 2nd part of left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) 7th and above cervical intersegmental arteries, and C. the anomalous origin of left subclavian artery(green shaded) from the left sixth intersegmental artery.

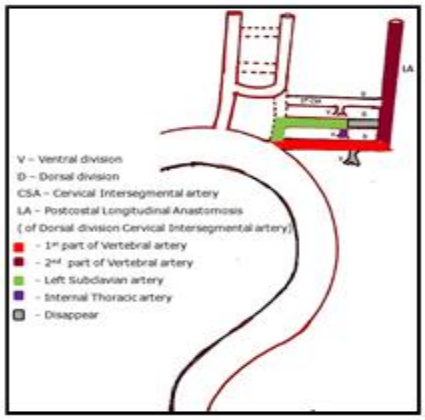

Fig 8. Pattern: 2 - The anomalous Aortic arch origin of left vertebral artery (LVA), LVA originated directly from the aortic arch after the left subclavian artery (green shaded)(LSA). The anomalous origin of left subclavian artery (green shaded) from the left sixth intersegmental artery.

In pattern one, where the vertebral artery arises from aortic arch between the left common carotid and left subclavian arteries. The embryological basis behind this pattern was understood as, the left sixth intersegmental artery and its dorsal branch may fail to disappear. The blood from aortic arch directly flows to the persisting sixth cervical intersegmental artery forming the aortic arch origin of the left vertebral artery. This preferential blood flows through the persisting left sixth intersegmental channel, results in diminishes the normal flow through the seventh cervical intersegmental artery (to its dorsal branch), which ultimately disappear.

The first part of the left vertebral artery derived from the sixth intersegmental artery and also from the small proximal portion of its dorsal branch. The ventral branch of the sixth intersegmental artery was disappeared completely. The second part of the left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) sixth and above cervical intersegmental arteries. It gives the pattern of the left vertebral artery arises from aortic arch between the between the LCCA and LSA (Fig- 5and 6).According to Satti et al. (2007), the persistence of the first or second dorsal intersegmental artery to the fourth left aortic arch gives rise the left vertebral artery from the aortic arch, proximal to the left subclavian origin [17], which was the controversy towards our discussion. In this pattern, we also observed the common trunk for the left subclavian and left vertebral arteries. Hence, this pattern of a common trunk was also referred as a "vertebro-subclavian trunk (VST)" (Fig-1).

In pattern two, the vertebral artery arises from aortic arch beyond the level of origin of the left subclavian artery (LSA) from the arch of the aorta. This pattern of observation in the anomalous aortic arch origin of left vertebral artery was less explained by the previous workers. The embryological source for the pattern two was implicit as, the dorsal branch of the left sixth intersegmental artery was disappeared. Whereas, the proximal part of the left sixth intersegmental artery with its ventral branch are persisted.

The proximal part of left sixth intersegmental artery continuous as a left subclavian artery and, its ventral branch remains as an internal thoracic (mammary) branch (Fig-7 and 8).

The first part of the left vertebral artery derived exclusively from the seventh intersegmental artery and also from the small proximal portion of its dorsal branch. The ventral branch of the seventh intersegmental artery was disappeared completely. The second part of left vertebral artery developed from the postcostal Longitudinal Anastomosis (LA) formed by the fusion of (distal segment of dorsal branches from) seventh and above cervical intersegmental arteries. It gives the pattern of the left vertebral artery arises from aortic arch beyond the level of origin of the left subclavian artery (LSA) from the arch of the aorta (Fig-7and 8). In this pattern, we also observed the common trunk for the brachiocephalic trunk and left common carotid artery. Hence, this pattern of a common trunk has been referred as a "bovine arch" (Fig-2).

Conclusion

In this era of carotid and vertebral arteries stents, the anomalous aortic origin of the left vertebral artery was reported as more common congenital anomalies, up to 84.8% [16]. Hence, the knowledge about these common anomalous are utmost important and also, it is more necessity to note seriously. The results from the cadaveric studies of this arterial system are very helpful, not only to understand the anomalous origin of the left vertebral artery, also to designs the arterial stent. The perceptive through these anatomical variations and its embryological basis are utmost important, for any interventional or surgical procedures in thorax and neck regions. The patients with neurological symptoms and those who are with interventional or surgical procedures in thorax and neck regions should be carefully screened, for the possibility for these anomalous origins of vertebral arteries. The knowledge about these aortic arch arterial systems is very much helpful to avoid any unexpected events, due to its anomalous origins [18 -23].

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