

Cadaveric Study of Aortic Arch Branching and Its Variations**Thimmaraju Sumalatha¹, Chatripalli Sandhya Rani², Dasari Prathik³**¹Professor and HOD, Department of Anatomy, Osmania Medical College, Hyderabad²Associate Professor, Department of Anatomy, Osmania Medical College, Hyderabad³Senior Resident, Department of Anatomy, Government Medical College, Jagtial

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Conflict of interest: Nil

Abstract:

Introduction: Aortic arch is a continuation of ascending aorta, being located in the superior mediastinum. The most common branching pattern in humans consists of three great vessels originating from the arch of the aorta i.e. the Brachiocephalic trunk, Left common carotid artery & Left subclavian artery. The Brachiocephalic trunk again gives off Right common carotid artery & Right subclavian artery. Vertebral artery originates from the first part of Subclavian artery.

Objective: To study and identify variations in the branching pattern of Aortic Arch.

Materials And Methods: The anomalies in the branching pattern of the Aortic arch were identified during routine dissection in a study conducted over a period of 3 years on 30 formalin-fixed cadavers allotted for undergraduates in Osmania Medical College, Hyderabad. After removal of the anterior thoracic wall, fat, and the pericardium covering the ascending aorta, arch of aorta, and the great vessels, the variation in the branching pattern was observed. The aortic arch and its variation in branching were coloured red for their visualisation.

Results: Out of total 30 formalin-fixed cadavers, three cadavers were found to have the left common carotid artery originating from the brachiocephalic trunk which then crossed the trachea anteriorly from right to enter the left side of the neck. The further course, branching, and termination of these arteries (brachiocephalic trunk, left common carotid, and left subclavian arteries) were normal. In another two cadavers, the left vertebral artery was seen to be originating directly from the arch of aorta in between the left subclavian and left common carotid arteries. Its course was traced above up to the foramina transversarium of the C6 vertebra and was found to be normal.

Conclusion: Although anomalous origins of the aortic arch branches are merely anatomic variants, a detailed knowledge of it is needed by Interventional Radiologists, Cardiologists, and Cardio-thoracic surgeons to avoid complications during procedures like Anterior cervical spine surgery, Thyroid surgery, four-vessel cerebral angiography & intervention, Diagnostic & Therapeutic catheter-based Aortic interventional procedures, Thoracic and Head & Neck surgeries. It has been reported that anomalies of the aortic arch branching pattern particularly anomalous origin of the Vertebral artery could lead to cerebral abnormalities by altering the pattern of blood flow in cerebral vessels. In addition, knowledge of abnormal branches originating from the aortic arch is also important in the diagnosis of intracranial aneurysms following subarachnoid hemorrhage.

Keywords: Aorta, Left Common Carotid, Left Vertebral, Anomalous Pattern.

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Introduction

The Aorta is the largest artery of the body which carries oxygenated blood from the left ventricle and distributes it to all the other different parts of the body. Depending on its location in the body it can be called either Thoracic or Abdominal aorta. Thoracic aorta is again divided into three parts namely: Ascending aorta, Arch of aorta, and Descending aorta.

The ascending aorta arises from the aortic vestibule and continues as the arch of aorta at the level of sternal angle i.e., between the T4 and T5 vertebrae.

It develops from Truncus aorticus after its division by the spiral aortico-pulmonary septum.

The arch of aorta is the continuation of the ascending aorta beginning from the sternal angle at the right 2nd costal cartilage in the superior mediastinum. It runs upwards, backward, and to the left in front of the bifurcation of the trachea (T4/T5) arching over the root of the left lung. After its arching, it turns backward and downwards behind the left bronchus up to the level of the lower border of the T4 vertebra and continues down as descending thoracic aorta. The arch of aorta is

developed proximally from the left horn of the aortic sac and distally from the left side 4th aortic

arch artery.

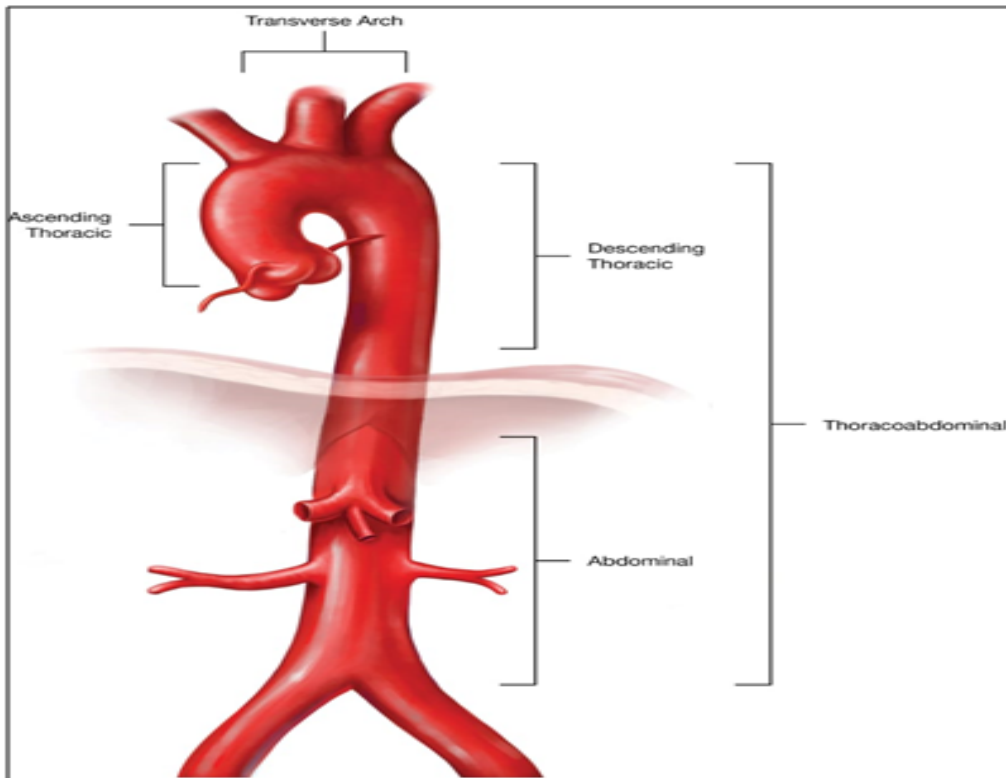


Figure 1: Different parts of Aorta

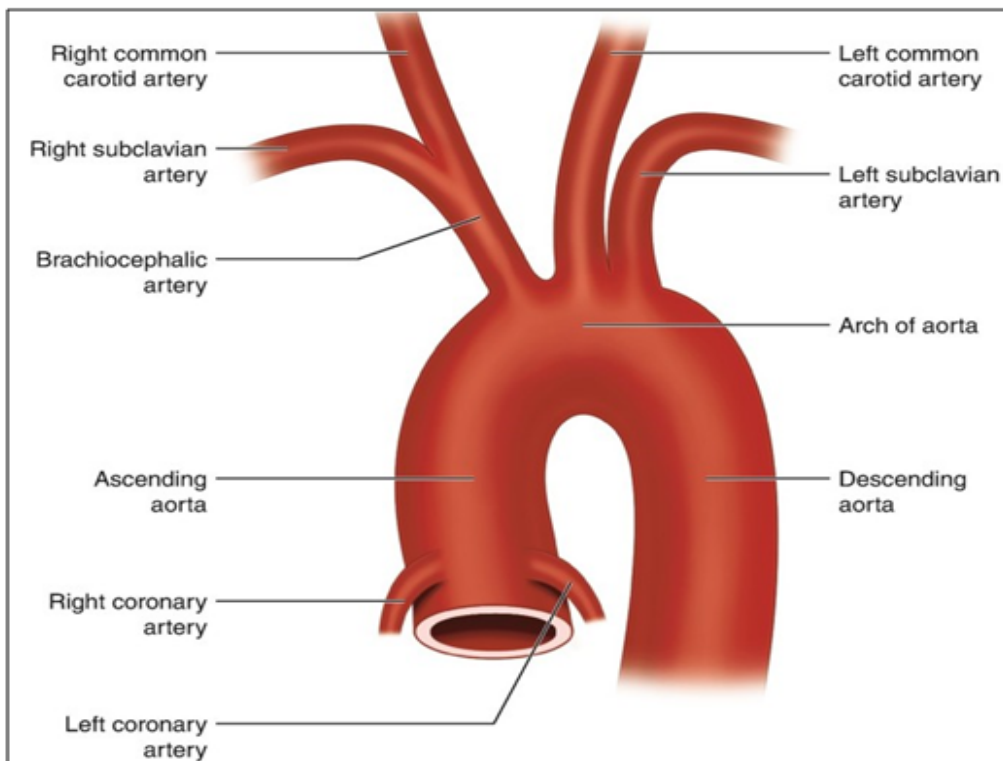


Figure 2: Normal branching pattern of Aorta

The descending thoracic aorta lies in the posterior mediastinum beginning on the left side of the lower border of the T4 vertebra with an inclination

towards the right. It terminates in front of the lower border of the body of T12 vertebra by piercing through the aortic opening of the diaphragm and

continues downwards as the abdominal aorta. It is developed from two sources: the proximal part from the left dorsal aorta distal to attachment of 4th arch artery and the distal part from fused dorsal aortae forming a single median artery. The most common aortic arch branching pattern in humans consists of three great vessels originating from the arch of the aorta. These are the Brachiocephalic artery, Left Common Carotid artery, and Left Subclavian artery. Knowledge of abnormal branching from the aortic arch is important for the diagnosis of intracranial aneurysms following subarachnoid hemorrhage and it may favor cerebral disorders because of a change in the cerebral hemodynamics.

Discussion

Developmental anomalies in aortic arch branching pattern arise from unusual patterns of development of the embryonic aortic arch system of the pharyngeal arches, such that there may be persistence of aortic arches that normally disappear or disappearance of parts that normally persist. Different patterns of aortic branching have been observed in humans and they can be classified as –

Type 1(Normal): The Aortic Arch passes from right to left, giving off the following branches: BT, LCC, and LS arteries.

Type 2(Bovine arch): The Aortic Arch passes from right to left, giving off the following branches: a common trunk giving rise to the BT and the LCC, followed by the LS.

Type 3(Left Vertebral): The Aortic Arch passes from right to left, giving off the BT, LCC, LV, and LS arteries.

Type 4(Bovine and Left Vertebral): The Aortic Arch passes from right to left and gives off a common trunk of the BT and the LCC, followed by the LV and the LS.

Type 5(Common carotid): The Aortic Arch passes from right to left, giving off the RS artery, followed by a common trunk for the RCC and LCC and the LS.

Type 6(Aberrant Right Subclavian): The Aortic Arch passes from right to left, giving off an RCC, an LS, and an aberrant RS.

Type 7(Right arch): The Aortic Arch passes from left to right, giving a "mirrored" pattern or aberrant LS.

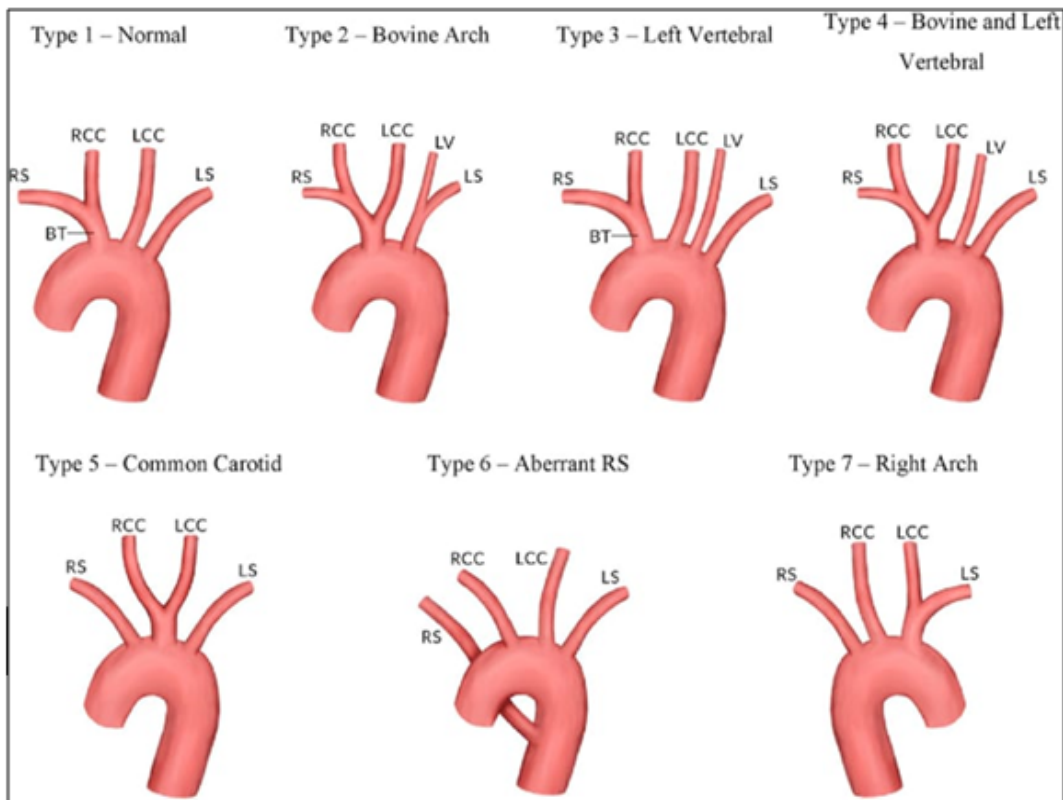


Figure 3:

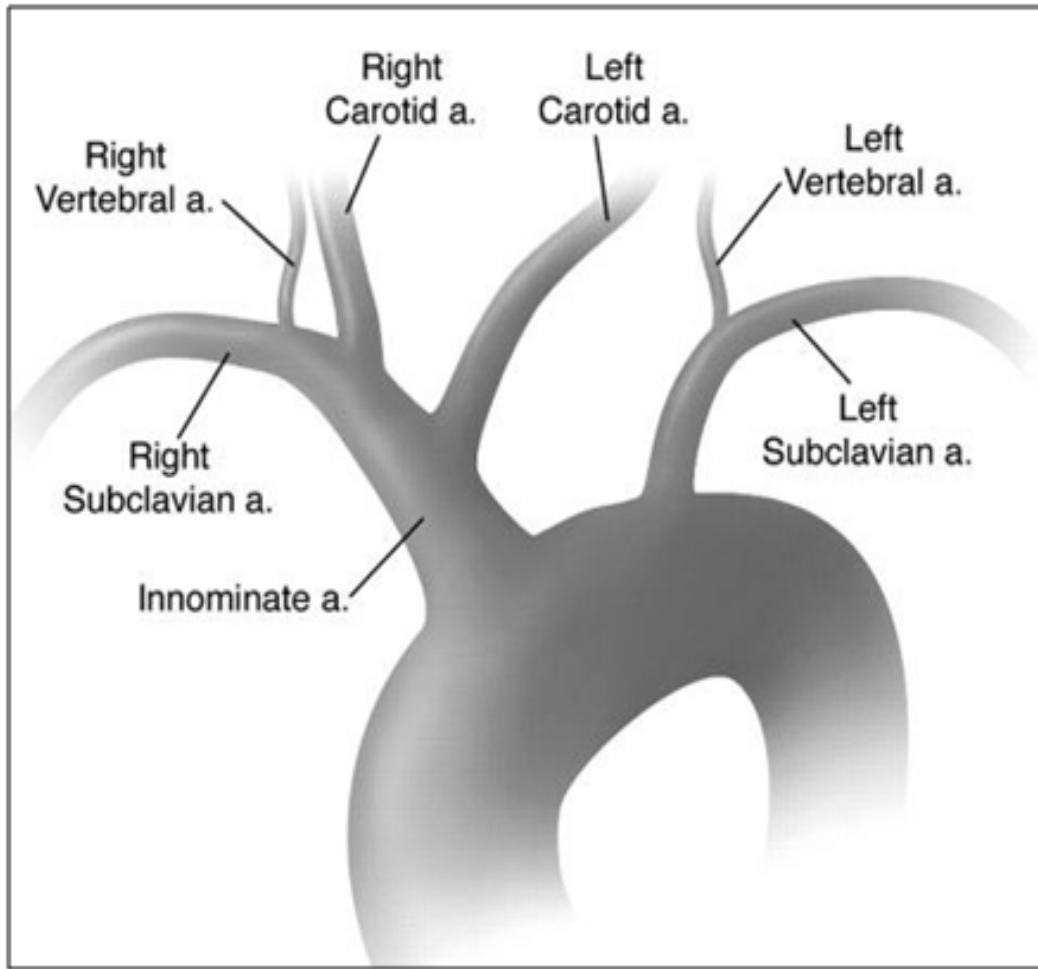


Figure 4: Origin of the Left Common Carotid Artery from the Brachiocephalic Trunk

Origin of the Left Common Carotid Artery from the Brachiocephalic Trunk: Normally, the proximal part of the third aortic arch gets extended and absorbed into the left horn of aortic sac. Instead, if it gets absorbed into the right horn of the aortic sac, it can lead to anomalies where the left common carotid artery arises directly from the brachiocephalic trunk.

When this happens, there are 2 great vessels arising from the arch of aorta. This variant is like the common origin variety or the Bovine variety, except that the left common carotid artery originates from the Brachiocephalic trunk more distally, rather than as a common trunk.

The left common carotid artery originates off the Brachiocephalic trunk at an average distance of less than 1 cm from the aortic arch with the maximal distance being 2.5 cm. This variant also occurs more commonly in blacks (10%) compared with whites (5%), with an overall rate of 9% in the general population.

Origin of Left Vertebral artery from Arch of Aorta: Normally, the vertebral artery (VA) arises from the superior-posterior aspect of the first part of the subclavian artery. It passes through the foramina transversarium of cervical vertebrae C6 to C1, and curves medially behind the lateral mass of the atlas to enter the cranium via the foramen magnum. At the lower border of the pons, it unites with the opposite side vertebral artery to form the Basilar artery.

Embryologically, it is derived from the dorsal division of the 7th cervical intersegmental artery. Failure of development of anastomosis between 6th and 7th cervical intersegmental arteries causes direct origin of the left vertebral artery from the aortic arch between the left subclavian and left common carotid arteries. The literature shows that the frequency of origin of the left VA from the aortic arch is in the range of about 1-3%. The left VA arising from the aortic arch is the third most common aortic arch branching pattern, with an incidence of 0.79-8%.

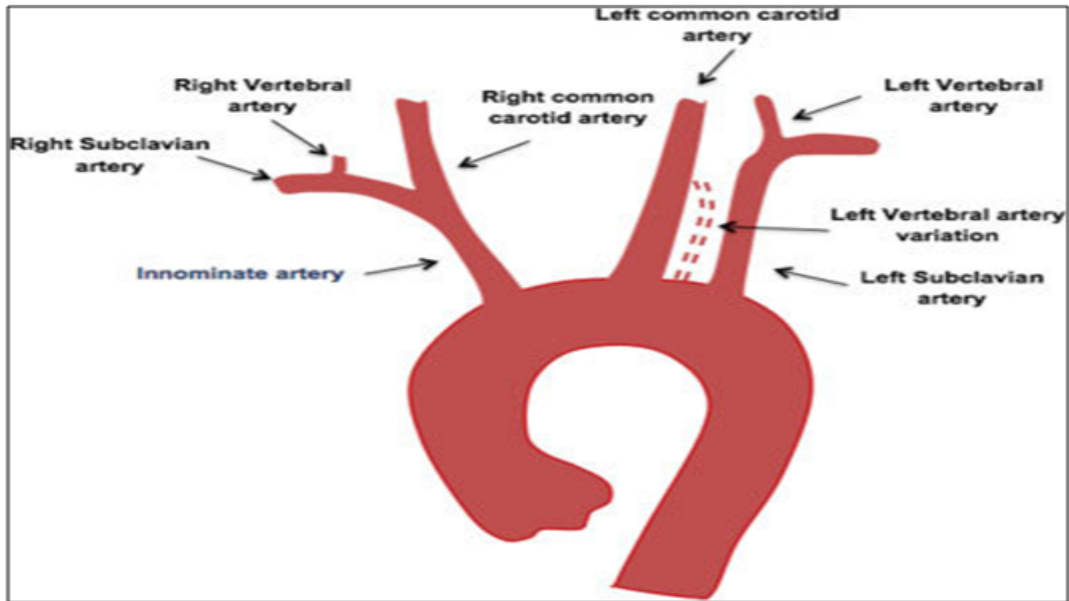


Figure 8: Origin of the Left Vertebral Artery from Arch of Aorta

Materials and Methods

The anomalies in the branching pattern of the Aortic arch were identified during routine dissection in a study conducted over a period of 3 years on 30 formalin-fixed cadavers allotted for undergraduates in Osmania Medical College, Hyderabad. After removal of the anterior thoracic wall, fat, and the pericardium covering the ascending aorta, arch of aorta, and the great vessels, the variation in the branching pattern was observed. The aortic arch and its variation in branching were coloured red for their visualisation.

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Figure 6: Cadaveric dissection showing Type 2 Aortic arch and its branches



Fig.no:7 – Colored representation of Type 2 Aortic arch and its branches

KEY

- 1 - Arch of Aorta**
- 2 - Innominate artery**
- 3 - Left Common Carotid artery**
- 4 - Brachiocephalic Trunk**
- 5 - Left Subclavian artery**
- 6 - Right Subclavian artery**
- 7 - Right Common Carotid artery**

Figure 7:



Fig.no:8 – Colored representation of Type 3 Aortic arch and its branches

KEY

- 1. Arch of Aorta**
- 2. Brachiocephalic Trunk**
- 3. Right Subclavian Artery**
- 4. Right Vertebral Artery**
- 5. Right Common Carotid Artery**
- 6. Left Common Carotid Artery**
- 7. Left Vertebral Artery**
- 8. Left Subclavian Artery**

Figure 8:

Conclusion

Although anomalous origins of the aortic arch branches are merely anatomic variants, a detailed knowledge of it is needed by Interventional Radiologists, Cardiologists, and Cardio-thoracic surgeons to avoid complications during procedures like Anterior cervical spine surgery, Thyroid surgery, four-vessel cerebral angiography &

intervention, Diagnostic & Therapeutic catheter-based Aortic interventional procedures, Thoracic and Head & Neck surgeries. It has been reported that anomalies of the aortic arch branching pattern particularly anomalous origin of the vertebral artery could lead to cerebral abnormalities by altering the pattern of blood flow in cerebral vessels. In addition, knowledge of abnormal branches originating from the aortic arch is also

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References

- Gray H. The Anatomical Basis of Clinical Practice. 40th ed. Susan Standring, Elsevier Churchill Livingstone; 2008. p. 447-9.
- Moore KL, Persaud TV. The Developing Human Clinically Oriented Embryology, 8th ed. Elsevier publications. New Delhi. 2008. p. 319-25.
- Açar, G., Çiçekcibaşı, A. E., Uysal, E., & Koplay, M. (2022). Anatomical variations of the aortic arch branching pattern using CT angiography: a proposal for a different morphological classification with clinical relevance. *Anatomical Science International*, 97(1), 65–78. <https://doi.org/10.1007/s12565-021-00627-6>
- Airan, N., Das, A. R., Mishra, S. K., Agrawal, K. K., & Dwivedi, A. (2017). Variations in the branching pattern of the aortic arch – Its embryological basis and clinical significance. *Journal of the Anatomical Society of India*, 66, S84. <https://doi.org/10.1016/j.jasi.2017.08.264>
- Jalali Kondori, B, Asadi, M. H., Rahimian, E, & Tahsini, M.-R. (2016). Anatomical variations in aortic arch branching pattern. *Archives of Iranian Medicine*, 19(1), 72–74. <https://doi.org/10.1161901/AIM.0013>
- Lale, P., Toprak, U., Yagız, G., Kaya, T., & Uyanık, S. A. (2014). Variations in the branching pattern of the aortic arch detected with computerized tomography angiography. *Advances in Radiology*, 2014, 1–6. <https://doi.org/10.1155/2014/969728>
- Layton, K. F., Kallmes, D. F., Cloft, H. J., Lindell, E. P., & Cox, V. S. (2006). Bovine aortic arch variant in humans: clarification of a common misnomer. *AJNR. American Journal of Neuroradiology*, 27(7), 1541–1542.
- Manyama, M., Rambau, P., Gilyoma, J., & Mahalu, W. (2011). A variant branching pattern of the aortic arch: a case report. *Journal of Cardiothoracic Surgery*, 6(1), 29. <https://doi.org/10.1186/1749-8090-6-29>
- Mohan, K., & Kumar, D. (2021). Branching patterns and anatomical variations of human aortic arch in Indian population. *Indian Journal of Clinical Anatomy and Physiology*, 8(3), 162–165. <https://doi.org/10.18231/j.ijcap.2021.038>
- Nune, G. K. R., Patra, M., & Rao, R. (2014). Left common carotid artery arising from the brachiocephalic trunk : A case report seen in 4 hearts. *Journal of Evidence Based Medicine and Healthcare*, 1(6), 428–434. <https://doi.org/10.18410/jebmh/2014/68>
- Paraskevas, G., Agios, P., Stavrakas, M., Stolidou, A., & Tzaveas, A. (2008). Left common carotid artery arising from the brachiocephalic trunk: a case report. *Cases Journal*, 1(1), 83. <https://doi.org/10.1186/1757-1626-1-83>
- Patil, S. T., Meshram, M. M., Kamdi, N. Y., Kasote, A. P., & Parchand, M. P. (2012). Study on branching pattern of aortic arch in Indian. *Anatomy & Cell Biology*, 45(3), 203–206. <https://doi.org/10.5115/acb.2012.45.3.203>
- Rawlani, S. S., Chauhan, A. M., Gudhadhe, D. R., & Yadgire, G. U. (2016). Variations in the branching pattern of aortic arch – A cadaveric study. *Journal of the Anatomical Society of India*, 65, S35. <https://doi.org/10.1016/j.jasi.2016.08.116>
- Shiva Kumar, G. L., Pamidi, N., Somayaji, S. N., Nayak, S., & Vollala, V. R. (2010). Anomalous branching pattern of the aortic arch and its clinical applications. *Singapore Medical Journal*, 51(11), e182-3.
- Popieluszko P, Henry BM, Sanna B, Hsieh WC, Saganiak K, Pękala PA, Walocha JA, Tomaszewski KA. A systematic review and meta-analysis of variations in branching patterns of the adult aortic arch. *J Vasc Surg*. 2018 Jul; 68(1):298-306.e10. doi: 10.1016/j.jvs.2017.06.097. Epub 2017 Aug 31. PMID: 28865978.
- Onrat, Ece & Uluışık, Işılsu & Ortug, Gursel. (2021). the left vertebral artery arising directly from the aortic arch. *Translational Research in Anatomy*. 24. 10.1016/j.tria.2021.100122.
- Bernardi L, Deton P. Angiographic study of a rare anomalous origin of the vertebral artery. *Neuroradiology*1975; 9:43-7.
- Dasler EH, Anson BJ. Surgical anatomy of the subclavian artery and its branches *Surgery GynecolObstet*1959; 108: 149-74.
- Liechty JD, Shields TW, Anson BJ. Variations pertaining to the aortic arches and their branches. *Q Bull Northwest Univ Med Sch*1957; 31:136-43.
- Budhiraja V, Rastogi R, Jain V, et al. Anatomical variations in the branching pattern of human aortic arch: a cadaveric study from central India. *ISRN Anat*. 2013; 2013: 828969, doi: 10.5402/2013/828969, indexed in Pub med: 25938106.