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Original Research Article

Anatomical organization of aortic arch variation with embryological basis and clinical application

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ABSTRACT

Introduction: The variation in the aortic arch is well known and it has been demonstrated by number of researchers. Changes involved in the development of aortic arch system such as regression, retention or reappearance result in the variation in branching pattern of aortic arch. Variations of the branches of aortic arch are due to alteration of branchial arch arteries during embryonic period. The most common classical branching pattern of the aortic arch in humans comprises of three great vessels, which includes Brachiocephalic trunk, Left Common Carotid artery and Left Subclavian artery.

Aim: The study is to determine the embryological basis correlating with clinical application and surgical procedures.

Materials and Methods: A study was conducted in 50 formalin fixed cadaveric hearts, during a period of two years. In the routine dissection for 1st MBBS and also museum specimens we encountered 3 variations in the branches of arch of aorta.

Results: The variations in aortic arch branching pattern were observed in 4 cadaveric hearts (8%).

Conclusion: The wide spectrum of variation in the human aortic arch and its branches offer valuable information to catheterize in endovascular surgery for diagnostic and surgical procedures in the thorax, head and neck regions.

KEY WORDS: Aortic Arch (AA), Left Common Carotid (LCCA), Left Subclavian (LSA), Brachiocephalic Trunk (BCT), left vertebral artery(LVA).

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INTRODUCTION

Aortic Arch is a continuation of ascending aorta and is located in the superior mediastinum. In the classical anatomical configuration, the AA is on the left side and the most common branching pattern of the AA comprises of three great vessels (65% to 80%) of the cases [1]. First the brachiocephalic trunk (BCT), then left common carotid (LCCA), and the left subclavian artery (LSA). The point of origin of BCT lies to the right of mid vertebral line and that of the LCCA and LSA to the left of mid vertebral line. Variations in the branching pattern of the AA range from differences in the distance between origins of different branches to the number of branches [2,3].

Development of aortic arch occurs during the embryonic period of gestation, with the development of ventral aorta, dorsal aorta and six pairs of aortic arches or branchial arch arteries. The present study describes variations of branching pattern of AA in cadavers. we discuss their embryology, clinical, and surgical implications.

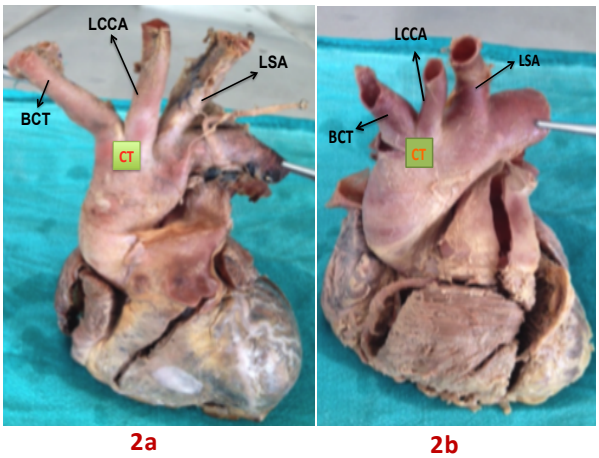
MATERIALS AND METHODS

The study was carried out in 50 formalin fixed adult cadaveric hearts in the Department of Anatomy, Kamineni Academy of Medical Sciences and Research Center Hyderabad. The observations were made for the type of variation in the branching pattern of AA.

OBSERVATIONS AND RESULTS

Usual three-branched aortic arch was found in forty-six adult cadaveric hearts (92%), and AA variations were observed in four cadaveric hearts.

Fig. 1: The cadaveric heart had left vertebral artery as a branch of AA between the origins of LCCA and LSA (2%).



2a **2b**

Fig. 2a & 2b: The 2 cadaveric hearts with common origin of brachiocephalic trunk and left common carotid artery (4%).

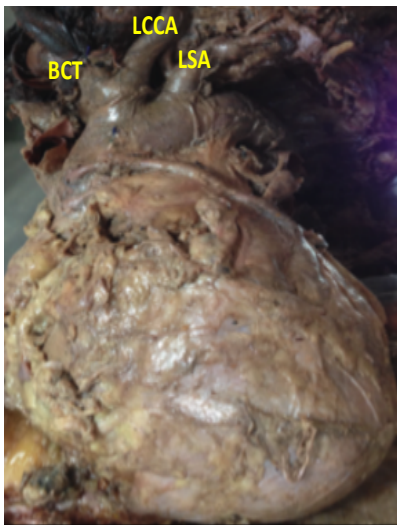


Fig. 3: In this type BCT gives rise to left common carotid artery (2%).

DISCUSSION

Three classical branches spring from convex aspect of the aortic arch: The BCT, LCCA and LSA [3]. Anatomical variations of aortic arch have been reported earlier by number of authors, the aortic arch anomalies are also associated with chromosome 22q11 deletion [4].

The variations in the branching pattern of aortic arch are usually associated with the abnormalities of the heart and truncus arteriosus [5].

Rekha, P. and Senthilkumar, S [6]. A study on branching pattern of human aortic arch 92% of 110 formalin fixed cadaveric hearts. They presented five types of AA variations.

Type I: cadaveric hearts had LVA as a branch of AA between the origin of LCCA and LSA (4.5%).

Type II: cadaveric hearts with common origin of BCT and LCCA (2.7%).

Type III: BCT gives rise to LCCA (0.9%).

Type IV: only two trunks arising from AA, the RBCT & LBCT (0.9%).

Type V: LVA originating from aorta at the upper angle of left Subclavian artery (1.8%).

The research conducted by Young, Chung, Shin et al. (2008) in 25 cadavers showed that the normal branching pattern was observed in 84% of the cadavers, 8% of them showed that orifice of LCCA was slightly above the stem of BCT, remaining 8% presented the origin of LVA from AA [7].

According to Adachi [8], in about 80% of individuals, three branches arise from the arch of aorta: the brachiocephalic trunk, left common carotid artery, and left subclavian artery. Adachi classified this branching pattern as type A.

11% have a common trunk incorporating the LCCA and the BCT leaving only two branches originating from the AA, Adachi's type B.

The type C, has left vertebral artery, a fourth branch of AA, originating proximal to the LSA.

The most common variation of the AA with two branching pattern. The two branch pattern were BCT with LCCA as common trunk and LSA. The incidence is about 10-20% in the literature. This type is also called "bovine aortic arch"[9].

Developmentally, the two-branch pattern of the AA may be explained as follows: aortic sac normally bifurcates into right and left limbs. Left limb of the aortic sac forms the part of arch that intervenes between the origins of BCT and LCCA. If the aortic sac fails to bifurcate, then BCT and LCCA will connect to aortic sac directly resulting in common trunk or bi carotid trunk giving origin to BCT and LCCA. The approximation of LCCA to BCT is an important finding while invading of AA and its branches with instruments and are susceptible to surgical attack and cause fatal consequences [10].

Clinical symptoms related to this variation have been reported and attributed to the widening of the mediastinum [11].

The next common branching pattern of AA is four-branch pattern. The four branches include BCT, LCCA, LVA and LSA from right to left.

The origination of LVA from AA is not uncommon prevalence reported between 2-8% the most frequent location is between LCCA and LSA.

Developmentally the first part of LVA develops from proximal part of dorsal l branch of seventh cervical segmental artery. Second part is derived from longitudinal communications of the post costal anastomosis.

Increased absorption of embryonic tissue of LSA between origins from the AA to the origin of vertebral artery resulting in direct origin of the LVA from aortic arch. Abnormal origin of vertebral artery may also favour cerebral disorders because of alterations in cerebral hemodynamics [12].

Gavishiddappa A. Hadimani et al, in his study noticed one specimen with very rare variation of AA, the two great vessels originating from upper convex surface of AA, the two branches were RBCT and LBCT.

Developmentally the abnormal brachiocephalic trunk (RBCT and LBCT) was formed by the fusion of the proximal part of the left third arch artery and left seventh intersegmental artery into left fourth arch artery [13].

Natsis et al. investigated AA of 663 patients who under went digital subtraction angiography determine 8 types of AA [14].

Type I: Normal AA branching into BCT, LCCA and LSA.

Type II: LCCA originates from BCT.

Type III: LVA originates directly from AA between LCCA and LSA.

Type IV: common carotid arteries originating from common trunk, in this type the order of vessels from right to left are RSA, common trunk giving rise to right common carotid and left common carotid and lastly LSA.

Type V: common carotid artery originated from common trunk and right aberrant subclavian artery is present.

Type VI: common carotid artery originated from common trunk and Subclavian arteries also arise from common trunk.

Type VII: right Subclavian artery, RCCA, LCCA, LSA leave the AA separately.

Type VIII: thyroidea ima artery originates from directly from AA.

Other important AA variations are double aortic arch and right aortic arch.

In the present study we observed normal three-branched AA were found in 46 formalin fixed cadaveric hearts (92%). Three AA variations were observed in four formalin fixed cadaveric hearts.

The current study concludes according to Rekha et al. variations seen are of type I, type

II and type III.

According to Adachi our study presented with type B and type C Aortic Arch variations.

Lastly type II and type III variations were observed in our study according to Natsis et al. angiographic observations.

CONCLUSION

To the best of our knowledge anomalies of AA branching pattern reported could lead to cerebral abnormalities. These vessels arise from aorta and form direct straight-line blood flow to brain involving imbalance flow of blood on left and right side of Circle of Willis and may cause increased incidence of cerebro vascular diseases.

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Conflicts of Interests: None

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