

Variations in branching pattern of aortic arch and embryological basis- A cadaveric study

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Abstract

Objective: The knowledge of variations in branching pattern of aortic arch is of paramount importance to the surgeons operating in the supra-sternal and retro-sternal region and the radiologists imaging the arch and its branches. The authors therefore conducted a study on the branching pattern of the aortic arches in fifty heart specimens. The different patterns of branching were photographed and correlated with their embryological basis.

Material and methods: Fifty formalin fixed heart specimens of both sexes with age ranging between 40 to 70 years were used for the study. The specimens were dissected and the arch of aorta was exposed and their branching pattern was studied.

Results: Normal anatomical branching pattern with three branches were observed in 38 aortic arches (76%) and a pattern showing 2 branches were noted in 8 aortic arches (16%) and 4(8%) aortic arches showed four branches. The detail of the branching pattern is discussed.

Conclusion: These variations are usually asymptomatic but they may be cause for dyspnoea, dysphagia, coronary and circulatory problems.

Key words: Arch of aorta, variations, vascular surgery.

Introduction

The ascending aorta arising from the left ventricle continues as the arch of aorta. The convex aspect of the arch provides origin to three prominent vessels, namely the brachio-cephalic trunk, the left common carotid and the left subclavian artery respectively from right to left [1,2]. The distance between these origins varies and the most frequent is the approximation of the left common carotid artery to the brachiocephalic trunk. This pattern is seen more commonly than the other types of branching patterns. Variations in the branching pattern of aortic arch are common and the most commonly observed is the variation in the number of branches. Abnormal origins of its branches are also noted quite frequently. Several variations are also associated with other congenital anomalies of the heart and may be observed accidentally during imaging and other investigative procedures. Arch of aorta is developed from the ventral part of aortic sac, the left horn and the

left fourth arch artery. These branching variations of aortic arch are due to the changes in the extent of the fusion between the various arches and absorption of some part of aortic arch into aortic sac [6].

Material and methods

The study was conducted in the department of anatomy at Yenepoya Medical College, Mangalore from 2008-2013. Fifty formalin fixed heart specimens with age ranging between 40 to 70 years were used. The heart specimens were dissected and the arch of aorta was exposed and its branching pattern was studied.

Observation

We classified the branching patterns into 3 types, viz. 2 branches, 3 branches and 4 branches. In our study the most common branching pattern noted was with 3 branches. Out of 50 heart specimens studied:-

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1. A pattern with three branches was noted in 38 (76%) specimens.



Figure1. Type I pattern

2. A pattern with two branches was noted in 8 (16%) specimens

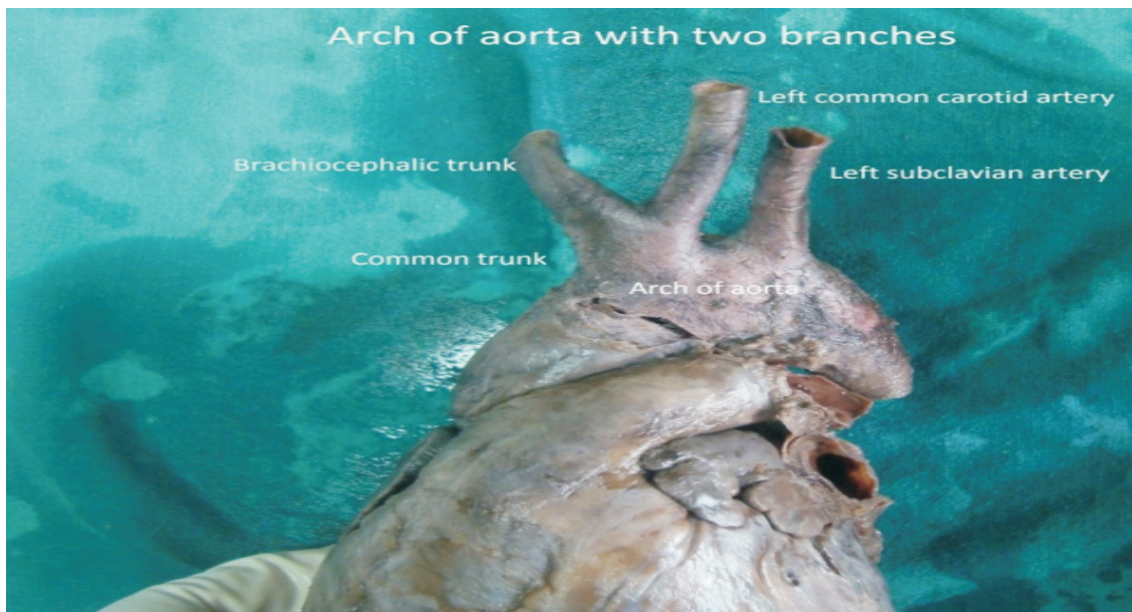


Figure 2. Type II pattern

3. A pattern with four branches was noted in 4 (8%) specimens



Figure 3. Type III pattern

BCT- Brachiocephalic trunk. LCC- Left common carotid artery. LV- Left vertebral artery. LSC- Left subclavian artery

Discussion

The study showed three types of branching patterns of the arch of aorta. The first and most common type (76%) was the pattern with three branches which include the brachiocephalic trunk, left common carotid artery and left subclavian artery. (Type I) The next common pattern (16%) was the one with two branches comprising of a common trunk (giving rise to brachiocephalic trunk and left common carotid artery) and left subclavian artery. (Type II) The third pattern (8%) was the one with four branches which include the brachiocephalic trunk, left common carotid, and an additional branch the left vertebral artery and the left subclavian artery respectively from

right to left. (Type III) The variations of the branching pattern observed are due to variations in the extent of the fusion of the aortic arches and absorption of some of the aortic arches into the aortic sac. Many authors like Wright N L et al [2], Bergman RA et al [3], Shin Y et al [4], Sunitha V [5], Soubhagya RN et al [6], Bhattarai C [7], Ogeng'o JA [9], Rekha P [10], Brown et al [11] Barry [12], Degaris et al [13], Barewell [14], Adachi [15], Mc Donald et al [16], Natsis et.al [17], Mamatha H [18] have studied and documented such branching pattern variations in different population groups [Table 1].

Table 1. Type I- Aortic arch with 3 branches, Type II- Aortic arch with 2 branches, Type III- Aortic arch with 4 branches and Type IV- The brachiocephalic trunk was absent with the right subclavian and right common carotid arteries arising directly from the arch of aorta.

Type	Adachi ¹⁵	Mc Donald and Anson ¹⁶	Mc Donald and Anson ¹⁶	Natsis et.al ¹⁷	Nayak et.al. ⁶	Mamatha H ¹⁸	Present study
Population	516 Japanese	157 American White	59 American Black	633 Greek	62 Indians	40 Indians	50 Indians
I	83.3%	66.9 %	51.7 %	83 %	91.4 %	85 %	76%
II	10.9 %	25.5 %	41.4 %	15 %	4.8 %	2.5 %	16%
III	4.3 %	1.46 %	-	0.79 %	1.6 %	10 %	8%
IV	0.8 %	-	1.7 %	0.16 %	1.6 %	2.5 %	-

Embryology

During the development of arch of aorta and its branches six pairs of vessels connect aortic sac to the corresponding dorsal aorta. Major part of the first, second and fifth arches disappears and third, fourth and sixth arches develops into parts of the arch of aorta and its branches. The spiral septum which is formed in the truncus arteriosus extends into the aortic sac, dividing it into pulmonary trunk and ascending aorta. The arch of aorta is derived from the ventral part of the aortic sac, its left horn and the left fourth arch artery.

Normally the proximal part of the left third aortic arch absorbs into the left horn of the aortic sac forming left common carotid artery. If it gets absorbed

into the right horn then it leads to common trunk bearing brachiocephalic trunk and left common carotid artery [6] (Type II).

The left subclavian artery normally develops from the seventh cervical intersegmental artery. First part of the vertebral artery develops from the dorsal division of the seventh cervical intersegmental artery. Direct origin of the left vertebral artery from the arch of aorta between the origin of left common carotid artery and left subclavian artery (TYPE III) can be explained as the persistent sixth cervical intersegmental artery [6,8] and increased absorption of seventh cervical intersegmental artery up to the dorsal and ventral division.

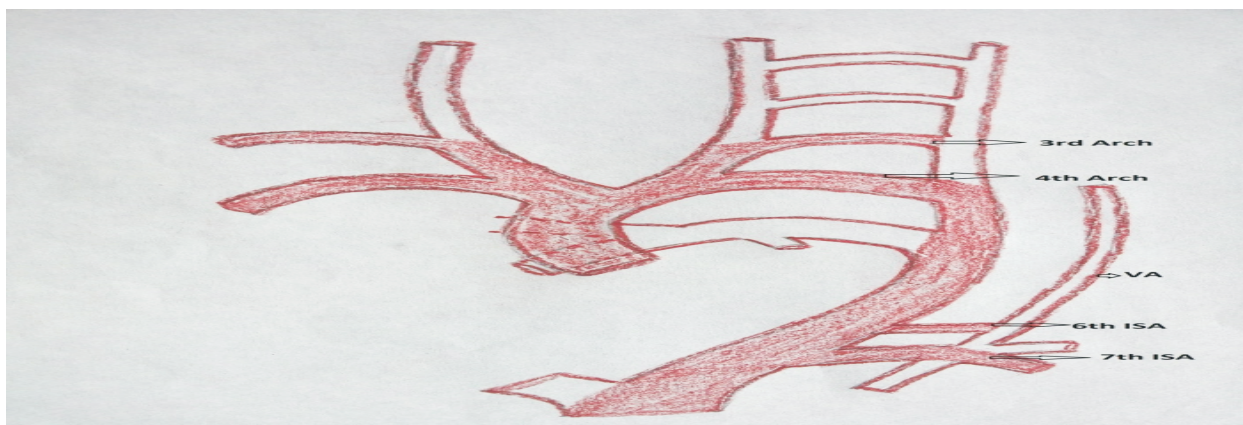


Figure 4. Development of arch of aorta and its branches. VA- Vertebral artery. ISA- Intersegment artery

Conclusion

The branching pattern of aortic arch in Indian population is almost similar to Japanese and Greek population. The variations are more common in American population both in blacks and whites. These variations are usually asymptomatic but they may be cause for dyspnoea, dysphagia, coronary and circulatory problems [19]. The knowledge of such variations is therefore important for cardio-thoracic surgeons and radiologists.

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