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Original Research Article

Branching patterns and anatomical variations of human aortic arch in Indian population

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ABSTRACT

Background: Knowledge of the aortic arch branching pattern is important during supra-aortic angiography, aortic instrumentation, thoracic and neck surgery. The aortic arch (AA) is located in the superior mediastinum. In 65–80% of the cases, the three branches arise from the aortic arch, namely, the brachiocephalic trunk (BCT), the left common carotid artery (LCCA), and the left subclavian artery (LSA).
Objective: The purpose of this study is to describe different branching patterns of the arch of the aorta in Indian subjects.
Materials and Methods: This observational study is based on dissection performed on Sixty embalmed arches of the aorta in adult Indian cadavers (in manuscript it was written as, 20 dissected heart specimens were collected of still-born fetuses) were exposed and their branches examined during cadaveric dissection in the department of Anatomy. The anatomical variations of the arch of the aorta and its branches, its branches at site of origin, and the distance of each branch from the point of origin to the median plane were measured.
Results: The usual three-branched pattern of arch of aorta was found in 44 specimens (73.33%). The common trunk for both brachiocephalic trunk and left common carotid artery was present in 11 specimens (18.33%). In 2 specimens (3.33%), the arch gives four branches. In 1 specimen (1.67%), give three branches.
Conclusion: The wide spectrum of variations in the anatomical arrangement of the human aortic arch and its branches offer valuable information to catheterize the aortic arch and its branches for safely performing endovascular surgery. These anatomical and morphologic variations in the arch of the aorta and its branches are significant for diagnostic and surgical procedures in the thorax, head and neck regions.

1. Introduction

The aortic arch (AA) is located in the superior mediastinum. In 65–80% of the cases, the three branches arise from the aortic arch, namely. The point of origin of the BCT trunk lies to the right of the mid vertebral line and LCCA and LSA to the left of the mid vertebral line. Variations in the branching pattern of the AA range from differences in the distance between the origins of different branches to the number of branches.[1,2] The anatomical variations in the branching pattern of AA are significant for diagnostic and surgical procedures in the thorax and neck. The present study describes the AA branching pattern in cadavers from south India and discusses the findings according to their embryological and clinical implications.

The aorta is the main arterial trunk of the systemic circulation. It is divided into the ascending aorta, the arch of the aorta, and the descending aorta for descriptive

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purposes, the last being further divided into thoracic and abdominal parts. Three branches usually arise from the arch's convex superior aspect, the brachiocephalic trunk (BCT), left common carotid (LCCA) and left subclavian (LSA) arteries.[3] The study of the branching pattern of the arch of the aorta is of considerable significance due to repeated intervention by cardiothoracic surgery and interventional cardiologist.

Increasing therapeutics in cardiothoracic surgery and interventional cardiology created interest in the study of variations in the branching pattern of the arch of the aorta and the development basis of its variations. Thus, the study aimed to observe the branching pattern of the arch of the aorta, the incidence of its variations, and its clinical significance.

These branches may branch from the beginning of the arch or the upper part of the ascending aorta with varying distances between them. The brachiocephalic trunk later divides into the right common carotid artery and right subclavian artery. Variations in the branching pattern of the aortic arch range from differences in the distance between origins of different branches to several branches.[4]

The present study aimed to study the branching pattern of the aorta arch and identify any variation in the branching pattern. It also aimed to measure the distance of each branch from the median plane and measure the diameter of each branch at the site of origin.

2. Materials and Methods

This observational study was carried out in 60 specimens, 39 aortic arch specimens of human adults, 1 specimen was a pre-dissected adult heart specimen with aortic arch en bloc, whereas 20 dissected heart specimens were collected of still-born fetuses with aortic arch en bloc from January 2014 to December 2014.

The thoracic cavity was opened by a cut through the manubrium of the sternum immediately inferior to its junction with the first costal cartilage. Next, the parietal pleura were cut through intercostal space on both sides. Next, a cut was made through the ribs and intercostal spaces. Finally, the inferior part of the sternum with the costal cartilages and anterior parts of the ribs were elevated gently.

The lungs were pulled laterally and structures in the roots were cut from downwards. Next, an incision was made through the pleural parallel on each side of the phrenic nerve to uncover the pericardium and superior vena cava on the right side and the arch of the aorta on the left side.

The clavicle was being detached from its articulation with the acromion. Manubrium of the sternum was turned upwards to expose the superior mediastinum. The left brachiocephalic vein and superior vena cava were identified. The fat tissue and the pericardium covering the ascending aorta and the vessels were removed.

Variations in the branching pattern, diameter of its branches at site of origin and distance of each branch from the point of origin to median plane were measured. Morphological parameters were recorded using digital vernier caliper and photographs were clicked with digital camera.[5]

The statistical analysis of collected data was performed using SPSS program version 20.

Institutional ethical clearance has been obtained.

3. Results

In this study, the most common three major branches, the brachiocephalic trunk (BCT), Left common carotid (LCCA), and left subclavian (LSA) arteries arise from the arch was observed in 44 specimens (73.33%). Five types of variations were observed in 16specimens (26.67%), either in the form of an increase or decrease in number of branches arising from the arch.

In 11 specimens (18.33%), the arch showed only two branches, whereas, in the other 2 specimens (3.33%), four branches were originated from the arch, as depicted in Table 1.

The distance from the median plane to the origin of BCT was an mean of 3.88+1.58mm to the left and 3.41±1.00 mm to the right. The distance from the median to the origin of LCCA was, of average, 13.44±3.13 mm to the left. The distance from the median to the origin of LSA was an mean of 24.29±3.39mm to the left. The distance from the median plane of the origin of CT (BCT+LCCA) was an mean of 6.25±5.64mm to the left and 3.80±1.27mm to the right. The distance from the median plane to the origin of LVA was an mean of 21.22±6.78 mm to the left. (Table 2)

The mean diameter of BCT was 13.57± 1.59mm. On the other hand, the mean diameter of LCC was recorded as 8.27±0.89mm. Similarly, the mean diameter of LSA was 11.46±1.20mm, as shown I Table 3.

4. Discussion

The aorta is the main arterial trunk of the systemic circulation. Three branches usually arise from the aortic arch's convex superior aspect, the brachiocephalic trunk (BCT), Left common carotid (LCCA), and left subclavian (LSA) arteries. A variant of origin and course of a great vessel arising from the aortic arch is of great clinical value because lack of knowledge of these variations may lead to serious surgical complications during procedures occurring in the superior mediastinum and the root of the neck.

The six pairs of aortic arches are vessels that connect on each side of the aortic sac with the corresponding dorsal aorta from fourth week onwards. At a later developmental stage, the aortic arches are both reduced in number and extensively transformed, and finally, an asymmetric blood supply system is achieved.

Table 1: Description of the types of Branches for the specimens

Type of Variation	Number and description of branches	Frequency(N =60)	Percentage
Usual Pattern	3:BCT, LCCA, LSA	44	73.33%
I	2:CT[BCT+LCCA], LSA	11	18.33%
II	4:BCT, LCCA, LVA, LSA	2	3.33%
III	3:CT[BCT+LCCA], LVA, LSA	1	1.67%
IV	3:BCT, LCCA, CT[LVA+LSA]	1	1.67%
V	2:BCT, CT[LCCA+LSA]	1	1.67%

Table 2: Depiction of Mean Distance of the branches of aorta in the various Specimens

Branches	N	Side of deviation	Mean	SD	Minimum	Maximum	Range
BCT	22	Left	3.88	1.58	2.10	7.98	5.88
	7	Right	3.41	1.00	1.72	4.74	3.02
LCCA	30	Left	13.44	3.13	8.02	18.62	10.60
LSA	38	Left	24.9	3.39	18.26	32.34	14.08
CT (BCT+LCCA)	5	Left	6.25	5.64	1.64	12.48	10.84
	3	Right	3.80	1.27	2.98	5.26	2.28
LVA	3	Left	21.22	6.78	13.52	26.32	12.80

Table 3: Depiction of Mean diameter for thebranches of arch of aorta arc in study Specimens

Branches	N	Mean	SD	Minimum	Maximum	Range
BCT	40	13.57	1.59	9.26	16.52	7.26
LCCA	40	8.27	0.89	6.16	10.03	3.87
LSA	40	11.46	1.20	8.46	14.13	5.67
Ct(BCT+LCCA)	9	2.59	1.98	18.38	24.88	6.50
LVA	3	4.54	1.02	3.68	5.66	1.98

Knowledge of variations in the aortic arch branching pattern is of great importance in patients who have to undergo four-vessel angiography, aortic instrumentation, or supra-aortic thoracic, head, and neck surgery.[6] The position of the aortic arch may vary across the population. The common origin of the carotid arteries (COCA) is a normal aortic arch variant found in approximately 11% of whites[7] with an even higher prevalence, up to 25%, reported in the African-American population.[8] Our study results also comparable with study done by Patil ST et al. on 75 cadavers in Indian population in which 77.33% showed three branches aortic arch whereas 14.66% showed only two branches.[9]

In the present study, the usual branching pattern of 3 major branches, the brachiocephalic trunk, left common carotid ad left subclavian arteries, originated from the arch in 44 specimens (72.33%). This finding correlated with the study conducted by Jakanani GC et al.[10] Vucurevic G et al.[11] Vinnakota S et al.[12]

The present study conducted on the south Indian population may help us to provide adequate information on the branching pattern of the arch of the aorta ad morphometric data about the branches. These variations are well taken into consideration by surgeons while planning any surgical or diagnostic intervention.

5. Conclusion

The present study on the South Indian population provides considerable information on the branching pattern or arch of the aorta. The variation in the branching pattern of the arch of the aorta was at par with the studies in other populations of the world. The various varieties of this study should be considered during aortic angiography, aortic instrumentation, supra-aortic thoracic surgeries, and head and neck surgeries.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

References

1. Alsaif HA, Ramadan W. An anatomical study of the aortic arch variations. *J King Abdulaziz Univ Med Sci*. 2010;17(2):37–54. doi:10.4197/Med.17-2.4.
2. Shin IY, Chung YG, Shin WH, Im SB, Hwang SC, Kim BT. A morphometric study on the cadaveric aortic arch and its major branches in 25 Korean adults: the perspective of endovascular surgery. *J Korean Neurosurg Soc*. 2008;44(2):78.
3. Kumar S, Haq I, Kathiresan K. Study of branching pattern of the arch of the aorta and its variations. *Natl J Clin Anat*. 2012;1(4):176.
4. Luisada AA, Inoue T, Katz M. On the amplitude and duration of the precordial vibrations of normal man. *Cardiology*. 1963;42(5):273–86.

5. Peter L, Williams LH, Bannister MM, Berry P, Collins M, Dyson JE. The anatomical basis of medicine and surgery. In: Gray's anatomy. London: Churchill Livingstone; 1995.
6. Natsis KI, Tsitouridis IA, Didagelos MV, Fillipidis AA, Vlasis KG, Tsikaras PD, et al. Anatomical variations in the branches of the human aortic arch in 633 angiographies: clinical significance and literature review. *Surg Radiol Anat*. 2009;31:319–23.
7. Wells TR, Landing BH, Shankle WR. Anatomical variations in the branches of the human aortic arc. *Pediatr Pathol*. 1993;13(2):203–12.
8. Williams GD, Edmonds HW. Variations in the arrangement of the branches arising from the aortic arch in American whites and negroes (a second study). *Anat Rec*. 1935;62:139–46.
9. Patil ST, Meshram MM, Kamdi NY, Kasote AP, Parchand MP. Study on branching pattern of aortic arch in Indian. *Anat Cell Biol*. 2012;45(3):203–6.
10. Jakanani GC, Adair W. Frequency of variations in aortic arch anatomy depicted on multidetector CT. *Clin Radiol*. 2010;65(6):481–7.
11. Vučurević G, Marinković S, Puškaš L, Kovačević I, Tanasković S, Radak D, et al. Anatomy and radiology of the variations of aortic arch branches in 1,266 patients. *Folia Morphol (Warsz)*. 2013;72(2):113–22. doi:10.5603/fm.2013.0019.
12. Vinnakota S, Bhattam NR. A study on the anatomical organization of the aortic arch anomalies. *J Clin Diagn*. 2012;6(7):1–5.

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