

# Anatomical Variations in Branching Pattern of Arch of Aorta - A Cadaveric Study in South Indian Population

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## Abstract

**Background:** Knowledge of the branching pattern of arch of aorta is important in avoiding surgical and accidental injuries during aortic instrumentation, thoracic and neck surgeries. **Subjects and Methods:** The present study is based on dissections that were performed on 50 properly embalmed human cadaver specimens. The anatomical variations of arch of aorta and its branches, diameter of its branches at site of origin and distance of each branch from the point of origin to median plane were measured. **Results:** The usual three branched pattern of arch of aorta was found in 36 specimens (72%). The common trunk for both brachiocephalic trunk and left common carotid artery was present in 10 specimens (20%). In 2 specimens (4%), the arch gives four branches, left vertebral artery being additional branch. In 1 specimen (2%), the arch gives three branches namely; common trunk for brachiocephalic trunk and left common carotid artery, left vertebral artery and left subclavian artery. In 1 specimen (2%), the arch gives three branches namely; brachiocephalic trunk, left common carotid artery and common trunk for left vertebral artery and left subclavian artery. **Conclusion:** The results in this study provide significant information vital for anatomists, cardiovascular surgeons and radiologists.

**Keywords:** Arch of Aorta, Common Trunk, Brachiocephalic Trunk, Left Common Carotid Artery, Left Subclavian Artery, Left Vertebral Artery

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## Introduction

The aorta is the main arterial trunk of systemic circulation. For descriptive purposes it is divided into the ascending aorta, the arch of aorta, and the descending aorta, 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.<sup>[1]</sup>

Study of the branching pattern of arch of aorta is of considerable significance, due to repeated intervention by intervention cardiologists and cardiothoracic surgeons.<sup>[2]</sup> The arch of aorta is also an important site of endovascular repair.<sup>[2,3]</sup> The anomalous origins and distribution of the large branches of the arch can result in change in the cerebral hemodynamics that might lead to cerebrovascular catastrophes.<sup>[4]</sup> The aim of present study was to observe the branching pattern of arch of aorta, incidence of its variations and its clinical significance.

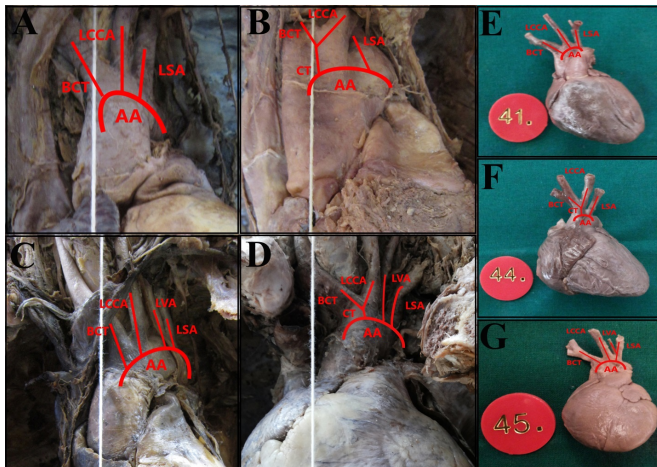
## Subjects and Methods

Fifty properly embalmed human cadaver specimens (40 adult cadavers and 10 still born fetuses) belonging to south Indian origin were dissected to expose structures in superior mediastinum. The arch of aorta was dissected with proper care to identify its branches namely; brachiocephalic trunk, left common carotid artery and left subclavian artery.

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. The statistical analysis of collected data was done using the SPSS program.

## Results

**Anatomical variations in branching pattern of arch of aorta [Chart 1]**



**Figure 1: Photographs showing variations in branching pattern of the arch of aorta. A: Usual pattern of 3 major branches arising from the arch. B: 2 branches arising from arch with common trunk for BCT and LCCA. C: 4 branches arising from the arch, LVA being additional branch between LCCA and LSA. D: 3 branches arising from arch with common trunk for BCT and LCCA and origin of LVA from arch. E: Fetal specimen with usual pattern of 3 major branches arising from the arch. F: Fetal specimen with 2 branches arising directly from arch; a common trunk for BCT and LCCA, LSA as second branch. G: Fetal specimen with 3 branches arising directly from arch; BCT, LCCA and a common trunk for LVA and LSA.**

In 10 cadavers (20%), the arch had two branches namely; a common trunk for BCT and LCCA with LSA as second branch [Figure 1B, 1F]. In 2 cadavers (4%), four branches originated independently from the arch namely; BCT, LCCA, LVA and LSA [Figure 1C]. In 1 cadaver (2%), the arch had three branches namely; common trunk for BCT and LCCA with LVA and LSA as second and third branch respectively [Figure 1D]. In 1 cadaver (2%), the arch had three branches namely; BCT, LCCA and a common trunk for LVA and LSA as third branch [Figure 1G].

**Distance from the median plane to the origin of the branches of arch of aorta [Table 1]**

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

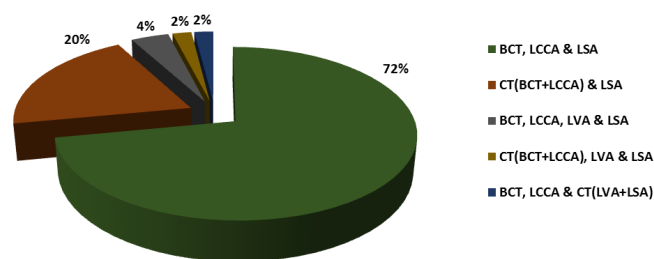
**Diameter of branches of the arch of aorta at site of origin [Table 2]**

The mean diameter of BCT was  $13.57 \pm 1.59$  mm. The mean diameter of LCCA was  $8.27 \pm 0.89$  mm. The mean diameter of LSA was  $11.46 \pm 1.20$  mm. The mean diameter of CT (BCT+LCCA) was  $21.59 \pm 1.98$  mm. The mean diameter of LVA was  $4.54 \pm 1.02$  mm.

**Discussion**

Among the most important concerns in the study of the vascular system are its major variations. Although many of them do not cause disturbance in the functions of the body, they may be of great importance to the surgeon. Many of the variations are due to different modes of change of the primary vessels of the branchial arches, during embryonic period of gestation. [5-7]

An analysis of variation in branches from 1000 aortic arches by Anson in 1963, showed 65% with usual pattern; in 27% left common carotid and the brachiocephalic trunk had a common trunk; in 2.5% the four arteries branched separately from the arch. The remaining 5% showed a great variety of patterns. [1] In present study usual branching pattern was seen in 72%, with 28% variant branching pattern. This finding was nearly comparable to that of Alsaif HA and Ramdan WS, Gupta and Sodhi where 70% had usual branching pattern. [10,15] Various studies have documented different frequencies of this variation in different population [Table 3].



**Chart 1: Variations in the branching pattern of Arch of Aorta**

The usual pattern of three major branches; BCT, LCCA and LSA arising independently from the arch were observed in 36 cadavers (72%) [Figure 1A, 1E]. Four types of variations were observed in 14 cadavers (28%), either in the form of increase or decrease in number of branches arising from the arch and common origin of two branches.

**Table 1: Distance from the median plane to the origin of the branches of arch of aorta in mm**

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	24.29	±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 2: Diameter of its branches at site of origin.**

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	21.59	±1.98	18.38	24.88	6.50
LVA	3	4.54	±1.02	3.68	5.66	1.98

The present study on South Indian population may provide acceptable information on branching pattern of arch of aorta and morphometric data about the branches for safely performing endovascular surgery. These variations have to be taken into concern by surgeons when they are planning surgical or diagnostic interventions involving arch of aorta and its branches. Surgeons must be conscious of possible variations of the major arteries and be able to identify them. Correct identification of these vessels is very important for suitable invasive techniques in order to achieve desired objectives and to avoid major complications especially during vascular surgery. The anatomic and morphologic variations of the arch of aorta and its branches are significant for diagnostic and surgical procedures in the thorax and neck. [6,7]

## Conclusion

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

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**Table 3: Incidence of variant branching pattern of arch of aorta in different populations.**

Study	Year	Population	% of usual	% of	Types of variation in %			
					CT LCCA) & LSA	(BCT+ BCT, LVA & LSA	LCCA,	Other types
Adachi, <sup>[8]</sup>	1928	Japanese	80	20	11	5	4	
Nelson and Sparks, <sup>[9]</sup>	2001	Japanese	94.3	5.7	1.1	4.1	0.5	
Gupta Sodhi, <sup>[10]</sup>	2003	Indian	77.5	22.5	7.5	5	10.5	
Nayak, Pai, Prabhu et al. <sup>[11]</sup>	2006	Indian	90.4	9.6	4.8	1.6	3.2	
Suresh, Ovchinnikov and Mc Rae, <sup>[12]</sup>	2006	Trinidadian	75	25	16.6	8.3	0.1	
Shin, Chung, Shin et al. <sup>[2]</sup>	2008	Korean	84	16	8	8	-	
Ogengo, Olabu et al. <sup>[13]</sup>	2009	Kenyan	67.3	32.7	25.7	6.2	0.8	
Natsis, Tsi-touridis, Didage-los et al. <sup>[14]</sup>	2009	Greek	83	17	15	1.7	0.3	
Haifa A. Alsaif and Wafaa S. Ramadan, <sup>[15]</sup>	2010	Saudi Ara-bia	75	25	17	6	2	
Bhattarai and Poudel, <sup>[16]</sup>	2010	Nepalese	80	20	11	7	3	
Present study	2014	South Indian	72	28	20	4	4	

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