

# A Study of Anatomical Variations in the Branching Pattern of Aortic Arch in South Indian Population of Mid Karnataka Region

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**Abstract:** *The Perfect Anatomical knowledge of branching pattern of Aortic Arch is very important in avoiding fatal surgical complications during Aortic instrumentation, Thoracic surgeries, Neck surgeries and also in accidental injuries of Thorax & Neck. This study is based on meticulous dissection of Aortic arch in properly embalmed hundred human cadavers. The anatomical variations in the branching pattern of Aortic arch, the distance between the mid vertebral line and point of origin of each branch and diameter of its varies branches at the point of their origin were measured. The normal branching pattern of Aortic arch was observed in 82 specimens (82%). In 12 specimens (12%), Aortic arch gives two branches: the first branch is a common stem for brachiocephalic trunk and left common carotid artery and a second branch is left subclavian artery arising independently from aortic arch. In 3 specimens (3%) Aortic arch gives 4 branches namely Brachiocephalic trunk, Left common carotid artery, Left subclavian artery and Left vertebral artery and in 2 specimens (2%), Aortic arch gives three branches, first branch is a common stem for brachiocephalic and Left common carotid artery, a second branch is Left vertebral artery and third branch is Left subclavian artery. In one specimen (1%), Aortic arch gives three branches first branch is brachiocephalic trunk, a second branch is Left common carotid artery and a third branch is common stem for Left vertebral artery and Left subclavian artery, Brachiocephalic trunk and Left common carotid artery. **Back ground:** The Perfect Anatomical knowledge of branching pattern of Aortic Arch is very important in avoiding fatal surgical complications during Aortic instrumentation, Thoracic surgeries, Neck surgeries and also in accidental injuries of Thorax & Neck. **Methods:** This study is based on meticulous dissection of Aortic arch in properly embalmed Hundred human cadavers. The anatomical variations in branching pattern, the distance between the mid vertebral line and the point of origin of each branch and diameter of various branches at the point of origin were measured. **Results:** The normal branching pattern of Aortic arch was found in 82 specimens (82%), in 12 specimens (12%) Aortic arch gives only 2 branches, first branch is a common stem for Brachiocephalic trunk and Left common carotid artery and a second branch is Left subclavian artery. In three specimens (3%) Aortic arch gives four branches, usual three branches and an additional fourth branch being Left vertebral artery. In 2 specimens (2%) Aortic arch gives unusual three branches; first branch is a common stem for Brachiocephalic trunk and Left common carotid artery, a second branch is Left vertebral artery and a third branch is Left subclavian artery. In 1 specimen (1%) Aortic arch gives unusual three branches; first branch is brachiocephalic trunk, a second branch is Left common carotid artery and a third branch is a common stem for Left vertebral artery and Left subclavian artery. **Conclusion:** The observations and the results in this study provide basic anatomical information which is very much significant to intervention cardiologists, Endovascular surgeons and cardiothoracic surgeons*

**Keywords:** Aortic arch, common stem, mid vertebral line, Brachiocephalic trunk, variation.

## 1. Introduction

The Aortic arch continues from the Ascending aorta. Three branches arise from the superior aspect of the arch: the brachiocephalic trunk, left common carotid and left subclavian arteries. Primary branches from the aortic arch may be reduced to one but more commonly two.<sup>1</sup>

The most common branching pattern of aortic arch in human's comprises of three great vessels; first the brachiocephalic trunk, then the left common carotid artery and finally the left subclavian artery.<sup>2</sup> The study of the branching pattern of aortic arch is of considerable significance due to repeated intervention by intervention cardiologists and cardiothoracic surgeons.<sup>3</sup> In performing endovascular surgeries, the most common technique is to puncture the femoral artery and advance a catheter towards aortic arch through abdominal aorta. However despite the improvement catheter quality and the rapid development of fluoroscopy imagine, this usual technique may be very difficult to perform in some cases due to anatomical variation of the aortic arch and its major branches. Also serious complication may develop due to these procedures.<sup>4</sup>

The aim of the present study was to observe the normal branching pattern of aortic arch and incidence of its variation to provide an accurate information and guidance to intervention cardiologists and endovascular surgeons to avoid fatal surgical complications

## 2. Materials and Methods

Hundred properly embalmed human cadaver specimens belonging to mid Karnataka region of South India population are selected from J.J.M Medical College, Davangere, Karnataka, were meticulously dissected to expose the Aortic arch. The various branches of aortic arch carefully identified and traced.

Variations in the branching pattern, the distance between mid vertebral line and point of origin of each branch and diameter of various branches at the point of origin were noted. The vernier calipers and digital camera were used for the measurements and photographs respectively.

### 3. Results

(A) Variations in the branching pattern of arch of aorta (Figure 1 & Chart 1)

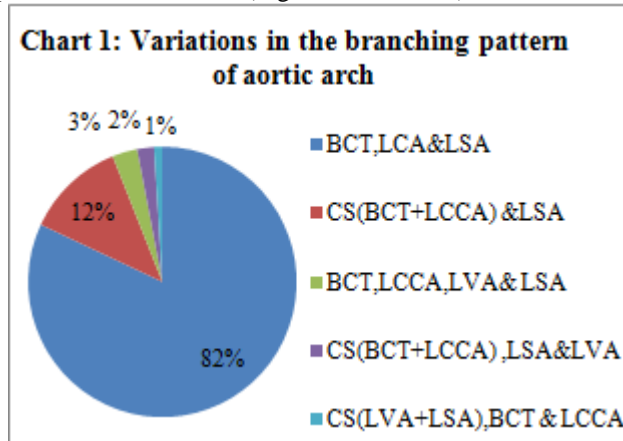


Figure 1a

Figure 1b

Figure 1c



Figure 1c

Figure 1d

**Figure 1:** Photograph showing variations in the branching pattern of aortic arch (AA)

1a. Normal branching pattern of 3 major branches arising from AA

1b. AA gives 2 branches; first branch is a common stem for BCT and LCCA, a second branch is LSA arising separately from aortic arch.

1c. The AA gives 4 branches namely BCT, LCCA, LSA & LVA

1d. AA gives 3 branches; one branch is a common stem for BCT & LCCA,

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a 2nd branch is LVA and 3rd branch is LSA.

1e. AA gives 3 branches; first branch is BCT, a second branch is LCCA and third branch is a common stem for LVA and LSA.



**Figure 2:** Photograph showing Vernier Calipers measuring diameter of the aortic arch branches.

The normal branching pattern of aortic arch was observed in 82 cadaveric specimens (82%) ; Brachiocephalic trunk, left common carotid artery and left subclavian artery arising

independently from the aortic arch (Fig. 1a). In remaining 18specimens four types of variations were observed either in the form of decrease or increase in the number of branches arising form aortic arch as follows

**Variation no.1:** In 12 specimens (12%), the aortic arch gives two branches ; one branch is a common stem for BCT and LCCA and second branch is LSA (Fig. 1b).

**Variation no.2:** In 3 specimens (3%), the aortic arch gives four branches namely BCT, LCCA, LVA and LSA (Fig.1c).

**Variation no.3:**In 2 specimens (2%) the aortic arch gives three branches; one branch is a common stem for BCT and LCCA , a second branch is LVA and third branch is LSA (Fig. 1d).

**Variation no.4:** In 1 specimen (1%) the aortic arch gives three branches; one branch is BCT, the second branch is LCCA and a third branch is a common stem for LVA and LSA.

**(B)Distance between the mid vertebral line and point of origin of each branch of aortic arch**

**Table 1:** Distance between the mid vertebral line and point of origin (in mm)

Sl. no	Branches	Total Number	Side of deviation from mid vertebral line	Number	Mean	Min.	Max.	Range
1	BCT	86	Right	74	2.79	2.36	8.56	6.20
			Left	10	1.98	1.68	3.96	2.28
			No deviation	02	-	-	-	-
2	LCCA	86	Left	82	12.98	8.54	17.98	9.44
			No deviation	04	-	-	-	-
3	LSA	99	Left	99	25.04	18.46	34.38	15.92
4	CS (BCT+LCCA)	14	Right	10	5.98	2.80	12.58	9.78
			Left	02	3.56	1.88	5.26	3.38
			No deviation	02	-	-	-	-
5	CS (LVA+LSA)	01	Left	1	26.18	26.18	26.18	0
6	LVA	02	Left	02	24.98	24.98	25.58	0.6

An average distance between the mid vertebral line and point of origin of BCT is 2.79mm to the right and 1.98mm to the left. An average distance between the mid vertebral line and point of origin of LCCA is 12.98mm to the left. An average distance between the mid vertebral line and point of origin of LSA is 25.04mm to the left. An average distance between the mid vertebral line and point of origin of CS (BCT +LCCA) is 5.98 to the right and 3.56mm to the left. An average distance between the mid vertebral line and point of origin of CS (LVA+LSA) is 26.18mm to the left. An average distance between the mid vertebral line and point of origin of LVA is 24.98 mm to the left.

**(C)Inner diameter of each branch of aortic arch at the point of orgin (in mm).**

Sl. no	Branches	Total Number	Mean	Min.	Max.	Range
1	BCT	86	15.98	9.48	17.02	7.54
2	LCCA	86	8.42	5.96	9.99	4.03
3	LSA	99	11.02	8.76	13.96	5.20
4	CS (BCT+LCCA)	14	20.96	17.94	25.04	7.10
5	CS (LVA+LSA)	01	16.22	10.46	22.98	12.52
6	LVA	02	4.76	3.72	6.01	2.29

The mean diameter of BCT at its point of origin is 15.98mm. The mean diameter LCCA at its point of origin 8.42mm. The mean diameter of LSA at its point of origin is 11.02mm. The mean diameter of CS for BCT & LCCA at its point of origin is 20.96mm. The mean diameter of CS for LVA & LSA at its point of origin is 16.22mm. The mean diameter of LVA at its point of origin is 4.76mm.

**4. Discussion**

In the present study, the normal branching pattern arising independently from AA is found in 82%. A common stem

for BCT & LCCA and left subclavian artery arising as an independent branch is found in 12% of the specimens. In 3% of specimens AA gives four branches, the usual 3 branches and an additional branch being left vertebral artery.

This finding is nearly similar to that of Bergman RA<sup>4</sup>, where in about 80% of persons, the branching order is right brachiocephalic, left common carotid and left subclavian artery; in 11% a common stem exit for brachiocephalic and left common carotid with left subclavian arising independently from the arch. In 5% left vertebral artery arises from the aortic arch independently along with usual three branches. This study is also near to the study of Young Shin et al<sup>5</sup>. Where the three major branches ; BCT, LCCA and LSA independently originated AA in 84%, In 8% of the cadavers the BCT and LCCA originated together from AA. In the remaining 8% the three major branches and left vertebral artery arises as an independent branch directly from AA

The anomalous origin and distribution of large Aortic arch vessels can cause changes in cerebral haemodynamics that may lead to cerebral abnormalities.<sup>6</sup> Detection of anomalous origins of the branches of AA is attributed to the altered development of certain branchial arch arteries during embryonic period of development.<sup>7</sup>

The variations of branches arising from AA are well known and documented by several Authors in different races such as Adachi<sup>8</sup> in Japanese, Gupta and Sodhi<sup>9</sup> in Indians, Ogengo, Olabu et al<sup>10</sup> in Kenyan, Natsis, Tsitouridis et al<sup>11</sup> in Greek, Bhattarai and Poudel<sup>12</sup> in Nepalese the present study is of South Indian population.

In the present study, the average distance between mid vertebral line and point of origin of BCT, LCCA and LSA is 2.79mm to the right, 12.98mm to the left and 25.04mm to the left respectively. This study is almost nearer to the study of Young Shin et al<sup>5</sup>, in which the average distance of BCT, LCCA and LSA from mid vertebrate line is 0.92mm to the right, 12.33mm to the left and 22.8mm to the left respectively.

In the present study the inner diameter of BCT, LCCA and LSA at the point of origin is 15.98mm, 8.42mm and 11.02mm respectively. This study is nearly similar to the study of Young Shin et al<sup>5</sup>, who measured the inner diameter of the major branches at their origin and found the measurement on an average of 18.3mm, 9.8mm, and 10.6mm for BT, LC and LS respectively. This study is also comparable with the study of H AAlsaifa et al<sup>2</sup>, which the inner diameter of the three major vessels of AA at their origin was 17.97mm, 9.77mm and 14.33mm for BT, LC & LS respectively.

## 5. Conclusion

An accurate information about the anomalous origins of aortic arch branches is vital in endovascular surgeries and in intervention cardiology. The different branching pattern observed in this study and measurements taken can assist endovascular surgeons and intervention cardiologists.

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