

# BRANCHING PATTERNS & ANATOMICAL VARIATIONS OF HUMAN AORTIC ARCH IN INDIAN POPULATION

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## Abstract

**Background:** The aortic arch (AA) is the direct continuation of the ascending aorta, variations in aortic arch branching pattern range from differences in the origins of its various branches to differences in the number of its branches. Present study was aimed to study branching patterns & anatomical variations of human aortic arch in Indian population.

**Material and Methods:** Present study was single-center, descriptive, observational study, conducted in properly dissected heart specimens from adult cadavers.

**Results:** In present study, brachiocephalic trunk (BCT), left common carotid (LCCA) and left subclavian (LSA) arteries arise from the arch in 41 specimens (73.21 %). We observed five types of variations were observed in 15 specimens (26.79 %), as arch showed only two branches (16.07%), 4 branches originating from the arch (5.36%). Less common variations were 3 branches (CT, LVA & LSA), 3 branches (BCT, LCCA, CT) & 2 branches (BCT, CT) observed in one specimen (1.79 %) each. In present study, LSA was most common artery noted (54 specimen), distance from the median to the origin of LSA was  $22.44 \pm 3.59$  mm to the left. Next common was BCT (46 specimen), distance from the median plane to the origin of BCT was  $2.92 \pm 1.53$  mm to the left and  $1.84 \pm 1.04$  mm to the right. In LCCA (45 specimen), distance from the median to the origin was  $13.09 \pm 3.56$  mm to the left.

**Conclusion:** Anatomical study of branching pattern of aortic arch and its variations regarding origin of different blood vessels helps us to provide an accurate information and guidance to interventional & surgical procedures performed by cardiologists, cardiovascular surgeons to avoid morbidities & mortality related to procedure.

**Keywords:** Anatomical study, aortic arch, brachiocephalic trunk, left subclavian artery

## Introduction

The aortic arch (AA) is the direct continuation of the ascending aorta, develops from the aortic sac, the left dorsal aorta, and the left fourth AA, with the formation of its main branches during the fifth and sixth weeks of gestation.<sup>1</sup> Three branches usually arise from the arch's convex superior aspect, the brachiocephalic trunk (BCT), left common carotid (LCCA)

and left subclavian (LSA) arteries. The point of origin of BCT trunk lies to the right of midvertebral line and that of LCCA and LSA to the left of midvertebral line.<sup>2</sup>

Variations in aortic arch branching pattern range from differences in the origins of its various branches to differences in the number of its branches. In most cases these anatomical variations are asymptomatic, but some patterns of aortic arch branching have been associated with a broad spectrum of pathologies, such as peripheral and/or central nervous system vascular diseases or aortic aneurysms dissection.<sup>3</sup>

The knowledge of the exact morphology of anatomical organization of aortic arch branching in each subject should be an essential information to be acquired for the correct planning of surgical interventions.<sup>4</sup> The correct recognition of the main anatomical variations could have direct positive effects on endovascular treatments and in diagnostic or therapeutic procedures. Present study was aimed to study branching patterns & anatomical variations of human aortic arch in Indian population.

### Material And Methods

Present study was single-center, descriptive, observational study, conducted in department of anatomy, at BKL Walawalkar Rural medical college & hospital, Sawarde, chiplun, India. Study duration was of 1 year (January 2021 to December 2021). Study was approved by institutional ethical committee.

Study was conducted on 56 properly dissected heart specimens from adult cadavers. 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 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.

Data was collected and compiled using Microsoft Excel, analysed using SPSS 23.0 version. Statistical analysis was done using descriptive statistics.

### Results

In present study, brachiocephalic trunk (BCT), left common carotid (LCCA) and left subclavian (LSA) arteries arise from the arch in 41 specimens (73.21 %). We observed five types of variations were observed in 15 specimens (26.79 %), as arch showed only two branches (16.07%), 4 branches originating from the arch (5.36%). Less common variations were 3 branches (CT, LVA & LSA), 3 branches (BCT, LCCA, CT) & 2 branches (BCT, CT) observed in one specimen (1.79 %) each.

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

Type of Variation	Number and description of branches	Frequency (N=56)	Percentage
Usual Pattern	3:BCT, LCCA, LSA	41	73.21%
I	2:CT[BCT+LCCA], LSA	9	16.07%
II	4:BCT, LCCA, LVA, LSA	3	5.36%
III	3:CT[BCT+LCCA], LVA, LSA	1	1.79%

IV	3:BCT, LCCA, CT[LVA+LSA]	1	1.79%
V	2:BCT, CT[LCCA+LSA]	1	1.79%

BCT (Brachiocephalic Trunk); CT (Common Brachiocephalic Trunk); LCCA (Left Common Carotid Artery); LSA (Left Subclavian Artery); LVA (Left Vertebral Artery);

In present study, LSA was most common artery noted (54 specimen), distance from the median to the origin of LSA was  $22.44 \pm 3.59$  mm to the left. Next common was BCT (46 specimen), distance from the median plane to the origin of BCT was  $2.92 \pm 1.53$  mm to the left and  $1.84 \pm 1.04$  mm to the right. In LCCA (45 specimen), distance from the median to the origin was  $13.09 \pm 3.56$  mm to the left. The distance from the median plane of the origin of CT (BCT+LCCA) was  $5.98 \pm 5.47$  mm to the left and  $3.56 \pm 1.24$  mm to the right. The distance from the median plane to the origin of LVA (4 specimen), LCC (1 specimen) & LSA (1 specimen) was  $25.01 \pm 1.42$  mm,  $25.83 \pm 6.83$  mm &  $24.21 \pm 6.67$  mm to the left respectively.

**Table 2: Distance from the median to the origin**

Branches	Total Number	Side of deviation from mid vertebral line	Number	Distance from the median to the origin (in mm) (Mean $\pm$ SD)
LSA	54	Left	54	$22.44 \pm 3.59$
BCT	46	Right	36	$2.92 \pm 1.53$
		Left	8	$1.84 \pm 1.04$
		No deviation	02	-
LCCA	45	Left	42	$13.09 \pm 3.56$
		No deviation	03	-
CT (BCT+LCCA)	10	Right	07	$5.98 \pm 5.47$
		Left	02	$3.56 \pm 1.24$
		No deviation	01	-
LVA	04	Left	04	$25.01 \pm 1.42$
CT (LVA+LSA)	01	Left	01	$25.83 \pm 6.83$
CT (LCCA+LSA)	01	Left	01	$24.21 \pm 6.67$

BCT (Brachiocephalic Trunk); CT (Common Brachiocephalic Trunk); LCCA (Left Common Carotid Artery); LSA (Left Subclavian Artery); LVA (Left Vertebral Artery);

## Discussion

Standard configuration of the aortic arch develops as a result of a complex embryological process during the first few weeks of gestation. Differences seen among the branching patterns in the AA arise from differences in the development of the embryologic pharyngeal arch arteries that form during the gestational period. Different anatomic variations of the AA may provide insight into the initial tearing site in aortic dissection.<sup>5</sup>

Reported variations in the aortic arch branching pattern include left common carotid artery originating from the brachiocephalic trunk; right common carotid artery and right

subclavian artery originating individually from the aortic arch.<sup>6</sup> Additionally, left common carotid artery and left subclavian artery may have a common origin in the form of the left brachiocephalic trunk from the aortic arch. The left vertebral artery may also arise between the left common carotid artery and left subclavian artery.<sup>7</sup>

Usually these are asymptomatic however some variations may cause alterations in cerebral haemodynamics leading to aneurysm formation and vessel dissection, as well as producing compressive symptoms in a minority of individuals. The major significance of AA anomalies is the potential surgical complications in operating in the thoracic cavity, as most variants are clinically silent and undiagnosed.<sup>8</sup>

Naik SK et al.,<sup>9</sup> noted that 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.

Virendra B et al.,<sup>10</sup> studied 52 cadavers from Indian populations. In thirty-three (63.5%) cadavers, the aortic arch showed classical branching pattern which includes brachiocephalic trunk, left common carotid artery, and left subclavian artery. In nineteen (36.5%) cadavers it showed variations in the branching pattern, which include the two branches, namely, left subclavian artery and a common trunk in 19.2% cases, four branches, namely, brachiocephalic trunk, left common carotid artery, left vertebral artery, and left subclavian artery in 15.3% cases, and the three branches, namely, common trunk, left vertebral artery, and left subclavian artery in 1.9% cases.

Mohan K et al.,<sup>11</sup> noted that 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.

Ashwini PS et al.,<sup>12</sup> studied 830 patients with help of MDCT, 694 (83.6 %) patients were observed to have the classic three-vesseled branching pattern of the aortic arch, whole variations in branching pattern were seen in the remainder 136 (16.3 %) patients. It was also noted that out of the 136 patients with variant branching patterns, 91 (66 %) were females, and the rest were males. The most common variation was the origin of the left common carotid artery from the brachiocephalic trunk, i.e. two-vesseled arch, which was observed in 79 (9.5 %) cases. In 26 (3.1 %) cases, four-vesseled arch was seen, which is direct origin of left vertebral artery from the aorta. 5 (0.6 %) patients had aberrant right subclavian artery.

Caryn R et al.,<sup>13</sup> analyzed aortic arch branching pattern of 20,030 cases reported by 40 anatomical or radiological studies, 84,52% of the studied population had a three branches pattern and 14,65% had a two branches pattern. The four primary arteries were seen arising directly from the aortic arch in 0,81% of the cases and only 0,02% had them all arising from a common trunk.

Future studies should address correlations and potential causal links between variations and clinical morbidity, or vice versa. Pre-operative imaging with CT angiography

is the gold standard in detecting branch variations and arch types. It enables surgical planning, correct instrument and catheter selection, as well as improved diagnostics and reduced complication rates.

An in-depth knowledge on population specific prevalence of AA variants would influence the modifications surgical approaches and the choice of angiographic catheters to be utilized, which in turn, would minimize inadvertent vascular injuries during thoracic surgical and angiographic interventions.

### Conclusion

Anatomical study of branching pattern of aortic arch and its variations regarding origin of different blood vessels helps us to provide an accurate information and guidance to interventional & surgical procedures performed by cardiologists, cardiovascular surgeons to avoid morbidities & mortality related to procedure.

**Conflict of Interest:** None to declare

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