Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 6 (2025): June 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i6.1809
Original Article

Morphological and morphometric variations of the aorta and brachiocephalic trunk in human cadaveric dissection: A descriptive cross-sectional study.

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Abstract

Background
Knowledge of anatomical variations in the aortic arch and brachiocephalic trunk is crucial for cardiovascular and thoracic surgeries, radiological interpretations, and interventional procedures. These variations, though often asymptomatic, can pose significant challenges during clinical practice if unrecognized.
Objectives: To investigate the morphological patterns and morphometric measurements of the aortic arch and brachiocephalic trunk in formalin-fixed human cadavers.

Methods
A descriptive cross-sectional study was conducted on 36 formalin-fixed adult human cadavers during routine dissection sessions in anatomy laboratories. Morphological variations were observed through careful dissection, and morphometric parameters were measured using digital calipers and measuring tapes. Descriptive statistics were applied to summarize the findings.

Results
The classic aortic arch pattern (Type I) was the predominant morphology, present in 77.8% of cadavers, followed by the bovine-type arch in 16.7% and a rare four-branch variant in 5.5%. Morphometric analysis showed the aortic arch had an average length of 5.9 ± 0.8 cm and a diameter of 2.5 ± 0.3 cm. The brachiocephalic trunk demonstrated normal bifurcation in 91.7% of specimens, trifurcation in 5.6%, and was absent in 2.7%. Its mean length and diameter measured 3.8 ± 0.5 cm and 1.2 ± 0.2 cm, respectively. Incidental pathological findings included atherosclerotic changes in 11.1% and tortuous aortic arches in 5.6% of cases.

Conclusion
A wide range of anatomical variations in the aorta and brachiocephalic trunk exist and should be considered during surgical and radiological planning to prevent iatrogenic complications. The data also contributes to anatomical education and clinical reference.

Recommendations
Routine preoperative imaging and careful anatomical assessment are recommended to identify aortic arch and brachiocephalic trunk variations, minimizing surgical risks and improving outcomes in cardiovascular and thoracic interventions.

Keywords: *Aortic arch, Brachiocephalic trunk, Morphometry, Anatomical variations, Cadaveric study, Trifurcation, Bovine arch*
Submitted: *2025-02-19* ***Accepted:*** *2025-05-20* ***Published:*** *2025-06-01*

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Introduction

The aortic arch and its branches are vital anatomical structures responsible for the arterial supply to the head, neck, and upper limbs [1]. Among these, the brachiocephalic trunk (BCT) is the first and largest branch of the aortic arch, typically dividing into the right common carotid artery (RCCA) and right subclavian artery (RSA) [2]. Despite this standard anatomical description, numerous variations exist in both the morphology and morphometry of the aortic arch and BCT, which have significant clinical and surgical implications [3].

Anatomical knowledge of these variations is crucial during cardiothoracic surgeries, catheter-based interventions, tracheostomies, and carotid artery stenting, as unrecognized aberrant patterns can lead to unforeseen complications [4]. For instance, a bovine arch, a common variant in which the RCCA originates from the BCT or shares a common trunk with the left common carotid artery (LCCA), may alter the approach during interventional radiology or endovascular repair procedures. Similarly, morphometric differences, such as the length and diameter of these vessels, can influence the selection of stents, grafts, or cannulas [5].

While numerous international studies have reported the prevalence of these vascular variations, regional and ethnic differences have been observed, emphasizing the importance of conducting localized anatomical investigations [5][6]. However, in India, limited contemporary cadaveric data addresses both morphological classifications and quantitative morphometric measurements of these structures.

This study was therefore undertaken to comprehensively evaluate the morphological patterns and morphometric parameters of the aortic arch and brachiocephalic trunk in adult human cadavers, to provide baseline data for anatomical education and enhance the safety of clinical and surgical interventions in the region.

Methodology

Study design and setting

This was a descriptive cross-sectional cadaveric study conducted in the Department of Anatomy at NRI Institute of Medical Sciences, Sangivalasa, Visakhapatnam, Andhra Pradesh, India. NRI Institute of Medical Sciences is a recognized tertiary care teaching hospital and medical college affiliated with Dr. NTR University of Health Sciences, offering undergraduate and postgraduate medical education with advanced anatomical dissection and research facilities. The study was conducted over seven years, from February 2019 to January 2026, following ethical approval from the Institutional Ethics Committee.

Sample size and selection criteria

A total of 36 formalin-fixed adult human cadavers were included in the study. Cadavers were selected using convenience sampling from those available for undergraduate dissection. Only cadavers with intact thoracic vessels and no prior thoracic surgery or trauma were included. Cadavers with grossly damaged great vessels, congenital anomalies, or surgical alterations were excluded from the analysis.

Dissection procedure

Standard anatomical dissection techniques were employed. The anterior thoracic wall was carefully removed to expose the aortic arch and its branches. The origin, course, branching pattern, and division of the brachiocephalic trunk were carefully observed. Any morphological variations were noted and classified accordingly.

Morphometric measurements

Using a digital Vernier caliper and non-elastic measuring tape, the following parameters were measured:
Length and external diameter of the aortic arch
Distance between the origin of the brachiocephalic trunk and the left subclavian artery
Length and external diameter of the brachiocephalic trunk
Each measurement was recorded three times by two independent observers, and the average was used to minimize observational bias.

Data analysis

The recorded data were entered into Microsoft Excel and analyzed using SPSS software (Version 25.0). Descriptive statistics were applied to calculate means, standard deviations, and percentages. Morphological data were expressed in frequencies, and morphometric data were expressed as mean ± standard deviation.

Ethical considerations

The study was conducted after obtaining ethical clearance from the Institutional Ethics Committee of NRI Institute of Medical Sciences, Visakhapatnam. All cadavers were legally donated and used respectfully for academic and research purposes, ensuring confidentiality and adherence to ethical guidelines for human anatomical studies.

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Results

A total of 36 formalin-fixed adult human cadavers were dissected to examine in detail the morphology and morphometry of the aortic arch and brachiocephalic trunk (BT). The findings are presented under morphological and morphometric observations.

Morphological variations of the aortic arch

Of the 36 cadavers studied, the classic branching pattern of the aortic arch (Type I), characterized by the sequential origin of the brachiocephalic trunk, left common carotid artery, and left subclavian artery, was the most frequent and observed in 28 specimens (77.8%) (Table 1). A bovine-type configuration (Type II), where the brachiocephalic trunk and left common carotid artery share a common origin, was seen in 6 cadavers (16.7%). A rare four-branch pattern (Type III), including an additional branch such as the thyroid ima or vertebral artery arising directly from the arch, was identified in 2 cadavers (5.5%) (Table 1).

Table 1: Morphological variations of the aortic arch (N = 36)

Type of Aortic Arch	Number of Cadavers	Percentage (%)
Classic (Type I)	28	77.8%
Bovine-type (Type II)	6	16.7%
Four-branch (Type III)	2	5.5%

Morphometric parameters of the aortic arch

The morphometric analysis demonstrated an average aortic arch length of 5.9 ± 0.8 cm, with a mean diameter of 2.5 ± 0.3 cm. The measured distance between the origin of the brachiocephalic trunk and the left subclavian artery was 4.8 ± 0.6 cm (Table 2).

Table 2: Morphometric parameters of the aortic arch

Parameter	Mean ± SD
Average length of aortic arch (cm)	5.9 ± 0.8
Average diameter of aortic arch (cm)	2.5 ± 0.3
Distance between the origin of BCT and the left subclavian artery (cm)	4.8 ± 0.6

Figure 1. Showing the normal shape of the descending thoracic aorta

Figure 1 illustrates the normal shape of the descending thoracic aorta, while Figure 2 shows an abnormal, question mark-shaped descending thoracic aorta.

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Figure 2. Showing the abnormal shape of the descending thoracic aorta as a question mark

Additionally, Figure 3 depicts the arch of the brachiocephalic trunk with measurements taken from the arch to the BT origin.

Figure 3. Showing the arch of the Brachiocephalic Trunk (BT) and measuring from the arch to the BT

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Figure 4. Showing deviation of the descending thoracic aorta towards the right side

Morphological variations of the brachiocephalic trunk

The typical bifurcation of the brachiocephalic trunk into the right common carotid artery (RCCA) and right subclavian artery (RSA) was present in 33 cadavers (91.7%) (Table 3). In two cadavers (5.6%), a trifurcation pattern was observed, where the trunk also gave rise to the right vertebral artery (RVA). One cadaver (2.7%) showed an absence of the brachiocephalic trunk, with the RCCA and RSA originating independently from the aortic arch (Table 3).

Table 3: Morphological variations of the brachiocephalic trunk (N = 36)

Type of Variation	Number of Cadavers	Percentage (%)
Normal division into RCCA and RSA	33	91.7%
Trifurcation into RCCA, RSA, and RVA	2	5.6%
Absent BCT (RCCA and RSA arising independently from the aorta)	1	2.7%

Morphometric parameters of the brachiocephalic trunk

The average length of the brachiocephalic trunk was 3.8 ± 0.5 cm, with a mean diameter at its origin of 1.2 ± 0.2 cm (Table 4).

Table 4: Morphometric parameters of the brachiocephalic trunk

Parameter	Mean ± SD
Average length of brachiocephalic trunk (cm)	3.8 ± 0.5
Average diameter at origin (cm)	1.2 ± 0.2

Side-wise distribution

No significant variations were noted in the origin or branching pattern of the vessels between the right and left sides.

Incidental Findings
Notable pathological changes were observed in 4 cadavers (11.1%) exhibiting atherosclerotic alterations, and 2 elderly cadavers (5.6%) showed elongated, tortuous aortic arches (Table 5).

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Table 5: Incidental findings in dissected cadavers (N = 36)

Incidental Finding	Number of Cadavers	Percentage (%)
Atherosclerotic changes	4	11.1%
Elongated aortic arch with tortuosity	2	5.6%

Discussion

The present study aimed to investigate the morphological patterns and morphometric characteristics of the aortic arch and brachiocephalic trunk (BCT) in adult human cadavers. Among the 36 cadavers examined, the classic aortic arch pattern (Type I) was the most prevalent, occurring in 77.8% of cases. This finding is consistent with prior reports [6], which described the predominance of the three-branch arch configuration in human anatomy. The bovine-type arch, identified in 16.7% of cadavers, is a well-documented variant and has been associated with altered hemodynamics and increased procedural complexity in endovascular surgeries [7]. Similar morphometric findings regarding the brachiocephalic trunk have also been reported [11], highlighting the relevance of such anatomical variations across populations.

The presence of a four-branch aortic arch in 5.5% of cases, although rare, is of clinical significance, particularly when the additional branch involves the thyroid ima or vertebral artery. Such variants can lead to inadvertent complications if unrecognized during mediastinal interventions. Similar atypical branching patterns have been documented [8], emphasizing the surgical relevance of an aberrant left common carotid artery arising from the BCT.

In terms of morphometry, the mean aortic arch length (5.9 ± 0.8 cm) and diameter (2.5 ± 0.3 cm) reported in this study are comparable to previous measurements [9], which validated morphometric models using murine and human aortic data. These metrics are essential for designing grafts and selecting appropriate catheter sizes during interventional procedures.

The brachiocephalic trunk showed typical bifurcation into the RCCA and RSA in 91.7% of cadavers, whereas trifurcation and absent BCT were rare (5.6% and 2.7%, respectively). Such anomalies, although infrequent, are critical for clinicians to recognize, particularly during aortic arch surgeries or tracheostomies, to avoid inadvertent arterial injury [10].

Interestingly, atherosclerotic changes were seen in 11.1% of cadavers, underscoring the relevance of studying pathological alterations even in preserved anatomical specimens. Elongated and tortuous aortic arches, observed in two elderly cadavers, may indicate age-related vascular remodeling that poses additional risks during thoracic endovascular aortic repair (TEVAR) procedures [7].

Overall, the findings of this study reinforce the need for preoperative imaging and anatomical awareness of arch and BCT variations. These anatomical insights not only inform surgical approaches but also enhance the precision and safety of diagnostic and interventional procedures involving the thoracic vasculature.

Generalizability

The findings of this study are most relevant to adult Indian cadaveric populations, particularly from the southern region of Andhra Pradesh. Given the use of convenience sampling and the lack of demographic data such as age and sex, the results may not be fully generalizable to the broader living population. Anatomical variability and regional differences, as reported in international literature, further limit extrapolation to other populations. Nevertheless, the morphological and morphometric insights gained provide valuable reference data for anatomists, clinicians, and surgical practitioners working in comparable demographic and clinical settings.

Conclusion

This cadaveric study highlights the presence of significant morphological and morphometric variations in the aortic arch and brachiocephalic trunk among the Indian population. The classic aortic arch pattern remains the most prevalent, but variants such as the bovine-type arch and additional branching patterns are not uncommon. Similarly, rare anomalies in the division of the brachiocephalic trunk were observed. These anatomical differences have important implications for thoracic surgeries, vascular interventions, and radiological assessments. Morphometric data, including vessel length and diameter, provide essential reference values for clinical and academic purposes. Awareness of such variations is crucial to minimize procedural complications and improve surgical outcomes.

Limitations

The study's limitations include a relatively small sample size and the use of formalin-fixed cadavers, which may affect tissue dimensions. Lack of demographic data, such as age and sex, limits subgroup analysis.

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Recommendations

Given the significant anatomical variations observed in the aortic arch and brachiocephalic trunk, it is recommended that surgeons and interventional radiologists perform thorough preoperative imaging assessments, such as CT angiography or MR angiography, to identify these variants before procedures. Awareness and understanding of these variations can reduce the risk of intraoperative complications, including inadvertent vessel injury or misplacement of catheters and stents. Incorporating detailed anatomical education on such variations into medical and surgical training programs will enhance clinicians' preparedness. Additionally, cadaveric studies like this should be encouraged to expand the anatomical database, especially across different populations, to improve individualized surgical planning and patient safety during cardiovascular and thoracic surgeries.

Acknowledgement

The authors sincerely thank the Department of Anatomy, NRI Institute of Medical Sciences, Sangivalasa, Visakhapatnam, for providing the facilities and support necessary for this study. Special thanks to the cadaver donors and their families, whose invaluable contribution made this research possible. We also acknowledge the efforts of the technical staff and colleagues who assisted during dissections and data collection throughout the six-year study period.

List of abbreviations

AA: Aortic Arch
BCT: Brachiocephalic Trunk
RCCA: Right Common Carotid Artery
RSA: Right Subclavian Artery
LCCA: Left Common Carotid Artery

Source of funding

The study had no funding.

Conflict of interest

The authors declare no conflict of interest.

Data availability

Data is available on request.

Author contributions

KV-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. VB-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. GVS-Review of literature and preparing the first draft of the manuscript. Statistical analysis and interpretation.

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References

1. Shin IY, Chung YG, Shin WH, Im SB, Hwang SC, Kim BT. A morphometric study on cadaveric aortic arch and its major branches in 25 Korean adults: the perspective of endovascular surgery. J Korean Neurosurg Soc. 2008 Aug;44(2):78-83. doi: 10.3340/jkns.2008.44.2.78. Epub 2008 Aug 30. PMID: 19096697; PMCID: PMC2588331.
2. Panagouli E, Antonopoulos I, Tsoucalas G, Samolis A, Venieratos D, Troupis T. Morphometry of the Brachiocephalic Artery: A Cadaveric Anatomical Study. Cureus. 2020 Aug 20;12(8):e9897. doi: 10.7759/cureus 9897. PMID: 32968563; PMCID: PMC7505533.
3. Murray A, Meguid EA. Anatomical variation in the branching pattern of the aortic arch: a literature review. Ir J Med Sci. 2023 Aug;192(4):1807-1817. Doi: 10.1007/s11845-022-03196-3. Epub 2022 Oct 22. PMID: 36272028; PMCID: PMC10390593.
4. Komutrattananont P, Mahakkanukrauh P, Das S. Morphology of the human aorta and age-related changes: anatomical facts. Anat Cell Biol. 2019 Jun;52(2):109-114. doi: 10.5115/acb.2019.52.2.109. Epub 2019 Jun 30. PMID: 31338225; PMCID: PMC6624342.
5. Jasso-Ramírez NG, Elizondo-Omaña RE, Garza-Rico IA, Aguilar-Morales K, Quiroga-Garza A, Elizondo-Riojas G, Treviño-González JL, Guzman-Lopez S. Anatomical and positional variants of the brachiocephalic trunk in a Mexican population. BMC Med Imaging. 2021 Aug 14;21(1):126. doi: 10.1186/s12880-021-00645-w. PMID: 34388973; PMCID: PMC8364066.
6. Babu CS, Sharma V. Two Common Trunks Arising From the Arch of Aorta: Case Report and Literature Review of A Very Rare Variation. J Clin Diagn Res. 2015 Jul;9(7): AD05-7. Doi: 10.7860/JCDR/2015/14219.6253. Epub 2015 Jul 1. PMID: 26393115; PMCID: PMC4572945.
7. Sun L, Li J, Liu Z, Li Q, He H, Li X, Li M, Wang T, Wang L, Peng Y, Wang H, Shu C. Aortic arch type, a novel morphological indicator and the risk for acute type B aortic dissection. Interact Cardiovasc Thorac Surg. 2022 Feb 21;34(3):446-452. doi: 10.1093/icvts/ivab359. PMID: 34935037; PMCID: PMC8860428.
8. Paraskevas G, Agios P, Stavrakas M, Stoltidou A, Tzaveas A. Left common carotid artery arising from the brachiocephalic trunk: a case report. Cases J. 2008 Aug 11;1(1):83. doi: 10.1186/1757-1626-1-83. PMID: 18694519; PMCID: PMC2535587.
9. Casteleyn C, Trachet B, Van Loo D, Devos DG, Van den Broeck W, Simoens P, Cornillie P. Validation of the murine aortic arch as a model to study human vascular diseases. J Anat. 2010 May;216(5):563-71. doi: 10.1111/j.1469-7580.2010.01220.x. Epub 2010 Mar 19. PMID: 20345858; PMCID: PMC2871992.
10. Chaudhary B, Kumari S. Morphological, embryological, and clinical implications of the bi-carotid trunk, aberrant right subclavian artery, and bilateral linguofacial trunk. Surg Radiol Anat. 2022 Nov;44(11):1461-1465. doi: 10.1007/s00276-022-03036-0. Epub 2022 Oct 23. PMID: 36273342.
11.Aragão JA, Ogando de Jesus Sena LE, Silva Junior JC, Rodrigues de Carvalho Melo G, Sant'Anna Aragão FM, Sant'Anna Aragão I, et al. Morphometric analysis of the brachiocephalic trunk in Brazilian cadavers of human foetuses. Int J Anat Radiol Surg. 2022 Apr;11(2):AO15-AO17. doi: 10.7860/IJARS/2022/51945.2758. https://doi.org/10.7860/IJARS/2022/51945.2758

PUBLISHER DETAILS

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256 775 434 261
Location: Scholar's Summit Nakigalala, P. O. Box 701432, Entebbe Uganda, East Africa