Section: Anatomy

Original Research Article

VARIATIONS IN THE BRANCHING PATTERNS OF THE HUMAN AORTIC ARCH: A CADAVERIC STUDY

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Abstract

Background: The human aortic arch exhibits various branching patterns, which are crucial for clinical and surgical planning. Understanding these variations can assist in better diagnostic and intervention strategies. To classify and analyze the variations in the branching patterns of the human aortic arch in a cadaveric study and to assess the implications of these variations in medical practice. **Material and Methods:** This descriptive study examined the aortic arch branching patterns of 50 cadavers. The cadavers were dissected at Anatomy dissection hall, and the branching patterns were categorized into five types based on their anatomical configuration. Associated anomalies were also recorded, with attention to their potential clinical significance. **Results:** The study identified five primary branching patterns. The standard branching pattern was observed in 68% (34/50) of cases (Table 1). Variations included Bochdalek's Variant (12%, 6/50, Table 2), Common Trunk Variant (8%, 4/50, Table 3), Aberrant Right Subclavian Artery (10%, 5/50, Table 4), and other less common variants (2%, 1/50, Table 5). Age, sex distribution, and associated anomalies were detailed for each variant. The presence of anomalies like non-recurrent laryngeal nerve and partial anomalous pulmonary venous return were noted. **Conclusion:** Significant variability in the branching patterns of the aortic arch was observed. These anatomical nuances are critical for surgical planning and risk assessment. Awareness and detailed understanding of these variations can enhance surgical outcomes and educational methodologies.

INTRODUCTION

The aortic arch is a critical anatomical structure that gives rise to the major arteries supplying the upper part of the body. Its branching pattern, while typically following a common arrangement, can exhibit variations that are of significant clinical and surgical relevance.[1,2] The standard configuration consists of three major branches: the brachiocephalic trunk, left common carotid artery, and left subclavian artery. However, deviations from this norm, though less common, can influence both the approach and outcome of cardiovascular, thoracic, and neurosurgical procedures.[3]

Understanding the diversity of aortic arch branching patterns is essential not only for clinicians and surgeons but also for improving educational tools for medical students and residents.[4] Anomalies such as the aberrant right subclavian artery, Bochdalek's variant, and other less common configurations can complicate diagnostic procedures and surgical interventions.[5] For instance, an aberrant subclavian artery can lead to dysphagia lusoria—a rare dysphagia caused by esophageal compression—and misinterpretation of imaging studies if not recognized.[6]

Despite the significance of these anatomical variations, there is limited comprehensive data categorizing these differences and their potential impacts. This gap in knowledge highlights the need for detailed anatomical studies to better define the spectrum of aortic arch configurations. Accordingly, our study aimed to document and analyze the variations in the branching patterns observed in 50

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cadavers, providing detailed insights into their distribution and associated clinical implications.

By bridging these knowledge gaps, the study seeks to enhance the precision of clinical assessments and interventions involving the aortic arch, ultimately fostering improved patient care and educational practices.

Aim and Objectives

The aim of this study is to investigate and document the various branching patterns of the human aortic arch and their associated anomalies in a cadaveric sample, to provide detailed anatomical insights that can enhance surgical accuracy and educational content.

Objectives

To Document and Categorize the Branching Patterns of the Aortic Arch: Systematically identify and categorize the different branching patterns of the aortic arch observed in a sample of 50 cadavers, as recorded in your detailed results.

Provide comprehensive descriptions of each variant to aid in anatomical recognition and understanding.

To Analyze the Prevalence of Each Branching Pattern:

Determine the frequency of each identified branching pattern, such as the Standard Branching Pattern, Bochdalek's Variant, Common Trunk Variant, Aberrant Right Subclavian Artery, and Other Variants.

Compare these patterns with existing data to understand regional or demographic variations.

To Investigate the Association of Anomalies with Specific Branching Patterns: Identify and document any anatomical anomalies associated with each branching pattern, such as non-recurrent laryngeal nerves, isolated origins of vertebral arteries, and partial anomalous pulmonary venous return.

Assess the implications of these associations for surgical and diagnostic procedures.

To Enhance Clinical and Surgical Planning:

Utilize the findings to inform and improve preoperative planning, especially in cardiovascular and thoracic surgery, where knowledge of variant anatomy is crucial.

Recommend adjustments in diagnostic imaging techniques to better detect and plan for these variations.

MATERIALS AND METHODS

Study Design and Setting

This descriptive anatomical study was conducted to investigate the variations in the branching patterns of the human aortic arch. The research was carried out in the Anatomy dissection hall at the GMERS Medical College, Dharpur,Gujarat. The study spanned from January 2023 to December 2023, utilizing cadavers donated for educational and research purposes.

Sample Size: The study included a total of 50 cadavers, selected based on the availability and completeness of the thoracic structures. Both male and female cadavers, aged from 45 to 85 years, were included to provide a comprehensive analysis across different demographics. Exclusion criteria were set to omit cadavers with a history of thoracic surgery or trauma, to avoid anatomical discrepancies due to surgical alterations or injuries.

Dissection Procedure: Cadavers were systematically dissected to expose the thoracic cavity and the aortic arch. All dissections were performed by a team of experienced anatomists and medical students under supervision. Standard dissection tools and techniques were employed, ensuring meticulous exposure of the aortic arch and its branches.

Data Collection: Data on the branching patterns of the aortic arch were meticulously recorded, noting the sequence and origin of arterial branches. Each variant was categorized based on established anatomical classifications. Additional observations, such as associated anomalies or unusual findings, were also documented.

Data Analysis: The collected data were analyzed to determine the frequency and characteristics of each branching pattern variant. Descriptive statistics were used to summarize the demographic data and the prevalence of each anatomical variant. Results were tabulated and referenced according to their corresponding table in the results section.

Ethical Considerations: The study adhered to ethical standards concerning the use of cadaveric material for educational and research purposes. Approval was obtained from the Institutional Ethics Committee of GMERS Medical College, Dharpur, Gujarat and all procedures were conducted respecting the dignity and privacy of the donors.

RESULTS

Our anatomical study analyzed 50 cadavers to identify variations in the branching patterns of the human aortic arch. We classified these patterns based on distinct anatomical features, and the results are summarized across five tables.

The Standard Branching Pattern was the most common, observed in 34 of the 50 cadavers (68%). This pattern, which followed the typical anatomical sequence of the brachiocephalic trunk, left common carotid artery, and left subclavian artery, showed a broad age range of 45 to 85 years and an almost equal sex distribution. Notably, no associated anomalies were identified in this group (Table 1).

Bochdalek's Variant was identified in 6 cadavers (12%), characterized by the left common carotid artery arising from the brachiocephalic trunk. This variant occurred in individuals aged between 52 and 79 years and was equally distributed between males and females. Importantly, one cadaver presented with a right-sided aortic arch, indicating a potential clinical relevance of this variation (Table 2).

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The Common Trunk Variant, where a single trunk gives rise to both the brachiocephalic and left common carotid arteries before branching off to the left subclavian artery, was present in 4 cadavers (8%). This variant was noted in younger cadavers, with ages ranging from 49 to 76 years, and showed no gender predominance. An isolated origin of a vertebral artery was observed in one instance, underscoring the anatomical and potentially functional significance of this variant (Table 3).

Aberrant Right Subclavian Artery was detected in 5 cadavers (10%), with ages spanning from 55 to 82 years. This group had a slight male predominance. The clinical implications of this variant are underscored by the presence of a non-recurrent laryngeal nerve in one cadaver, which could affect surgical planning and risk management (Table 4).

Finally, the category Other Variants included one cadaver (2%) presenting with partial anomalous pulmonary venous return. This was a 69-year-old male, highlighting the diversity and rarity of some aortic arch variants which may have implications in specialized medical examinations and interventions (Table 5).

Table 1: Standard Branching Pattern

Parameter	Value
Frequency	34 cadavers (68%)
Age Range	45-85 years
Sex Distribution	18 males, 16 females
Associated Anomalies	None noted

Table 2: Bochdalek's Variant

Parameter	Value
Frequency	6 cadavers (12%)
Age Range	52-79 years
Sex Distribution	3 males, 3 females
Associated Anomalies	One case had a right-sided aortic arch

Table 3: Common Trunk Variant

Parameter	Value
Frequency	4 cadavers (8%)
Age Range	49-76 years
Sex Distribution	2 males, 2 females
Associated Anomalies	One case with isolated origin of vertebral artery

Table 4: Aberrant Right Subclavian Artery

Parameter	Value
Frequency	5 cadavers (10%)
Age Range	55-82 years
Sex Distribution	3 males, 2 females
Associated Anomalies	One case with non-recurrent laryngeal nerve

Table 5: Other Variants

Parameter	Value
Frequency	1 cadaver (2%)
Age Range	69 years
Sex Distribution	1 male
Associated Anomalies	Partial anomalous pulmonary venous return

DISCUSSION

The current study provides a detailed examination of the anatomical variations in the branching patterns of the human aortic arch within a sample of 50 cadavers. This research highlights the diversity and frequency of these variations, emphasizing their potential clinical significance.

Comparison with Previous Studies The prevalence of the standard branching pattern found in 68% of our sample is consistent with the findings of previous studies.[7,8,9] which report a typical prevalence ranging from 65% to 80%. However, our findings regarding the Bochdalek's variant and the aberrant right subclavian artery contribute to the ongoing discussion about their clinical implications.[10,11] The Bochdalek's variant, observed in 12% of our cadavers, aligns with the lower frequency, but it is slightly higher than the global average, suggesting possible regional variations.[12]

Clinical Implications The identification of these variants is crucial for clinical practice, particularly in surgical and radiographic planning. For instance, the aberrant right subclavian artery, which we found in 10% of cases, is a vital consideration during thoracic surgeries and can impact the approach to interventions such as stent placements and open

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thoracic surgeries.[13,14] Moreover, the non-recurrent laryngeal nerve associated with this variant presents a significant risk during thyroid and parathyroid surgeries.

Educational Implications From an educational standpoint, these findings underscore the importance of incorporating diverse anatomical representations into medical training programs. Understanding the range of normal and variant anatomy can enhance diagnostic accuracy and surgical precision, particularly in complex cardiovascular and thoracic procedures.

Study Limitations Our study does have limitations, including the relatively small sample size and the inherent biases associated with cadaver studies, such as the age of the cadavers and post-mortem changes that may affect anatomical structures. Furthermore, the study's focus on a single geographic region might limit the generalizability of the findings to other populations.

Future Research Future studies could aim to include a larger and more diverse sample size across different geographic regions to validate these findings further. Additionally, longitudinal studies involving imaging and surgical outcomes could provide more insight into the functional implications of these anatomical variations.

CONCLUSION

This study identified multiple branching patterns of the aortic arch in 50 cadavers, with 68% displaying the standard pattern. Notable variants like Bochdalek's and the aberrant right subclavian artery underscore the anatomical diversity significant for surgical planning and medical education. The association of specific anomalies with these variants highlights the need for meticulous preoperative imaging to enhance surgical safety and outcomes. Our findings advocate for enriched medical curricula and suggest continued research into anatomical variations to improve clinical practices.

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