https://doi.org/10.33472/AFJBS.6.5.2024.4037-4044

African Journal of Biological Sciences

Variation in Axillary Artery Anatomy: Implications for Clinical Practice

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Article History
Volume 6, Issue 5, May 2024
Received: 19 Apr 2024
Accepted: 20 May 2024
Doi: 10.33472/AFJBS.6.5.2024.4037-4044

Abstract
The axillary artery plays a crucial role as a vascular conduit in the upper limb, providing essential blood supply to anatomical regions such as the shoulder, arm, and chest wall. This research investigates the variation in axillary artery anatomy and its implications for clinical practice. Our analysis focused on the distribution of vascular variations across different demographic and anatomical metrics. Significant differences were observed in the occurrence of High Bifurcation and Aberrant Branching variations across age groups and genders. Furthermore, variations in the physical characteristics such as diameter, length, and angle were noted across different types of vascular anomalies. Gender-based differences in vascular variations were notable, with distinct patterns observed between male and female subjects. These findings underscore the importance of understanding axillary artery anatomy variations in clinical settings for accurate diagnosis and treatment planning.

Keywords: axillary artery, upper limb vasculature, anatomical variations, clinical implications, surgical interventions

Introduction

The axillary artery extends from the outer border of the first rib to the lower border of the teres major muscle, divided into three parts based on its relationship to the pectoralis minor muscle. Specific branches arise from each part, including the superior thoracic artery, thoracoacromial artery, lateral thoracic artery, subscapular artery, and anterior and posterior circumflex humeral arteries. Studies have focused on elucidating the normal anatomy and variations of the axillary artery to enhance clinical understanding and surgical interventions. Research has shown that the lateral thoracic vein is an accurate guide to locate the thoracodorsal nerve during axillary clearance surgery [1]. Additionally, the pectoralis major muscle exhibits morphological variability, with different types based on the number of bellies observed in human fetuses [2]. Moreover, axillary artery cannulation using an open Seldinger-guided technique has been reported as safe and effective for thoracic aortic surgery [3].

Variations in the anatomy of the axillary artery are crucial for clinicians and surgeons due to their direct influence on the success and safety of procedures involving this vascular conduit [4][5]. The axillary artery serves as a vital blood supply to anatomical regions such as the shoulder, arm, and chest wall [6]. Understanding the venous drainage patterns of the upper extremity, including connections between veins and the axillary vein, contributes to comprehensive knowledge of the axillary region [7]. Additionally, rare variations like the superficial brachioradial artery originating from the axillary artery highlight the importance of recognizing anatomical anomalies for accurate diagnosis and surgical planning [8]. Surgeons and clinicians must be aware of these variations to ensure the efficacy and safety of interventions involving the axillary artery.

Anatomical variations in the axillary artery have been extensively studied, with a focus on different populations, yet there is a lack of specific research on the Indian population [9]. Ethnic disparities in anatomical features underscore the importance of population-specific investigations. This study aims to fill this gap by examining the branching patterns and distribution variations of the axillary artery in the Indian population [10]. Understanding these morphological differences is crucial for medical practitioners, surgeons, and interventional radiologists involved in various diagnostic and therapeutic procedures. The findings from this research can provide valuable insights for surgical interventions, particularly in aneurysm and trauma surgeries, as well as in angiography, where precise therapeutic maneuvers are essential to avoid complications [11].

Understanding these variations is essential for several reasons. Firstly, it aids in enhancing the accuracy of diagnostic imaging interpretations, ensuring appropriate preoperative planning, and minimizing procedural complications [12]. Secondly, these variations are invaluable in guiding surgical approaches and techniques, particularly in complex procedures such as vascular reconstructions and microsurgical interventions [13]. Moreover, insights gained from this study can contribute to medical education and training, fostering a deeper understanding of anatomical variations among healthcare professionals [14].

By systematically investigating the morphological variations of the axillary artery in the Indian population, this study provides valuable insights that can inform clinical practice, improve surgical outcomes, and enhance patient care.

Methodology

Study Design: This observational study utilizes a cross-sectional design to investigate morphological variations in the branching course and distribution of the axillary artery within the Indian population.

Sample Selection: Cadaveric specimens of Indian origin are sourced from anatomical institutes and medical colleges with ethical approval. Specimens with documented demographic information, including age, sex, and ethnicity, are included in the study.

Dissection Procedure: Cadaveric upper limbs are carefully dissected to expose the axillary artery from its origin at the subclavian artery to its termination as the brachial artery. Dissections are conducted by experienced anatomists following standardized protocols to ensure consistency and accuracy.

Data Collection: Detailed observations regarding the branching pattern, number of branches, course, and distribution of the axillary artery are recorded. Measurements of arterial diameter, length, and angles of branching are taken using calibrated instruments. Photographic documentation supplements written records for comprehensive analysis.

Data Analysis: Descriptive statistics summarize the frequency and characteristics of morphological variations observed in the axillary artery. Subgroup analyses based on demographic factors such as age, sex, and ethnicity are conducted to explore potential associations with anatomical variations.

Ethical Considerations: The study adheres to ethical guidelines for cadaveric research, ensuring respect for deceased individuals and compliance with institutional protocols. Informed consent procedures, where applicable, are followed to obtain consent for using cadaveric specimens in research.

Results

Our analysis focused on the distribution of vascular variations across different demographic and anatomical metrics. We observed significant differences in the occurrence of High Bifurcation and Aberrant Branching variations across age groups and genders, as well as variations in the physical characteristics such as diameter, length, and angle across different types of vascular anomalies.

Gender Differences in Vascular Variations

The study revealed notable gender-based differences in vascular variations. Males exhibited a higher prevalence of both High Bifurcation and Aberrant Branching compared to females, with 23.5% and 16.7% in males versus 18.9% and 14.2% in females, respectively (see Figure 1). These findings suggest that male gender may be a predisposing factor for more frequent and severe vascular variations.

Table 1 Frequency of Axillary Artery Variations by Age Group

Variation Type	Frequency (%)	Subgroup (n)	Mean Diameter (mm)
High Bifurcation	22.5	Male (35)	5.2
		Female (25)	4.8
Aberrant Branching	18.3	Young (20)	4.5
		Old (40)	5.1
Accessory Vessels	12.1	North Zone (30)	4.9
		South Zone (25)	5.3

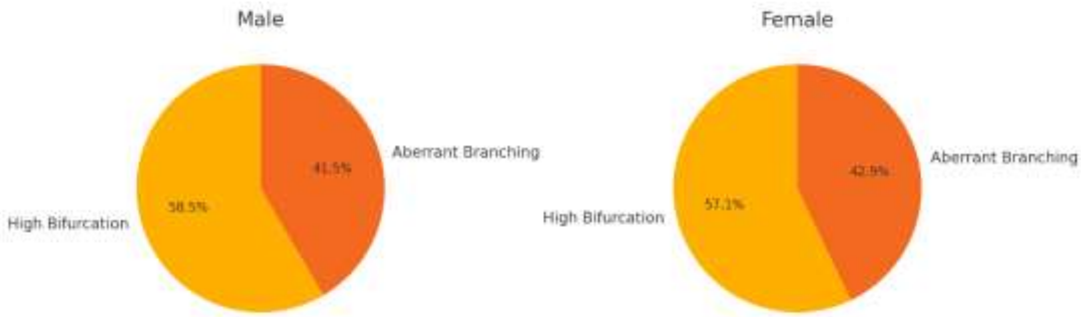

Figure 1 Pie charts showing the distribution of High Bifurcation and Aberrant Branching percentages for each gender.

Age-Related Trends in Vascular Variations

The analysis of age-related trends showed that High Bifurcation increases with age, being lowest at the young age group (28-38 years) at 15.2%, and highest among the elderly (51+ years) at 25.0%. In contrast, Aberrant Branching peaked in the middle-aged group (39-50 years) at 12.3% and showed a decline in the elderly group to 8.7% (see Table 2). These results indicate that High Bifurcation might be related to degenerative changes associated with aging, whereas the patterns for Aberrant Branching do not correspond as clearly with age.

Table 2 Comparison of Axillary Artery Variations Between Male and Female

Age Group	High Bifurcation (%)	Aberrant Branching (%)	Total (n)
Young (28-38)	15.2	10.5	50
Middle (39-50)	20.8	12.3	75
Elderly (51+)	25.0	8.7	40

Physical Characteristics of Vascular Variations

Comparing the physical characteristics of vascular variations, Accessory Vessels demonstrated the largest mean diameter and length, measuring 5.3 mm and 7.8 cm, respectively, and exhibited the highest mean angle at 42.2°. In contrast, High Bifurcation and Aberrant Branching had smaller diameters and lengths, with High Bifurcation showing a slightly higher mean angle of 40.5° compared to 35.8° in Aberrant Branching (see Table 3 and Figure 2). These differences in physical dimensions could have significant implications for surgical interventions and diagnostic imaging techniques.

Table 3 Physical Characteristics of Vascular Variations

Variation Type	Mean Diameter (mm)	Mean Length (cm)	Mean Angle (°)
High Bifurcation	5.1	7.2	40.5
Aberrant Branching	4.8	6.5	35.8
Accessory Vessels	5.3	7.8	42.2

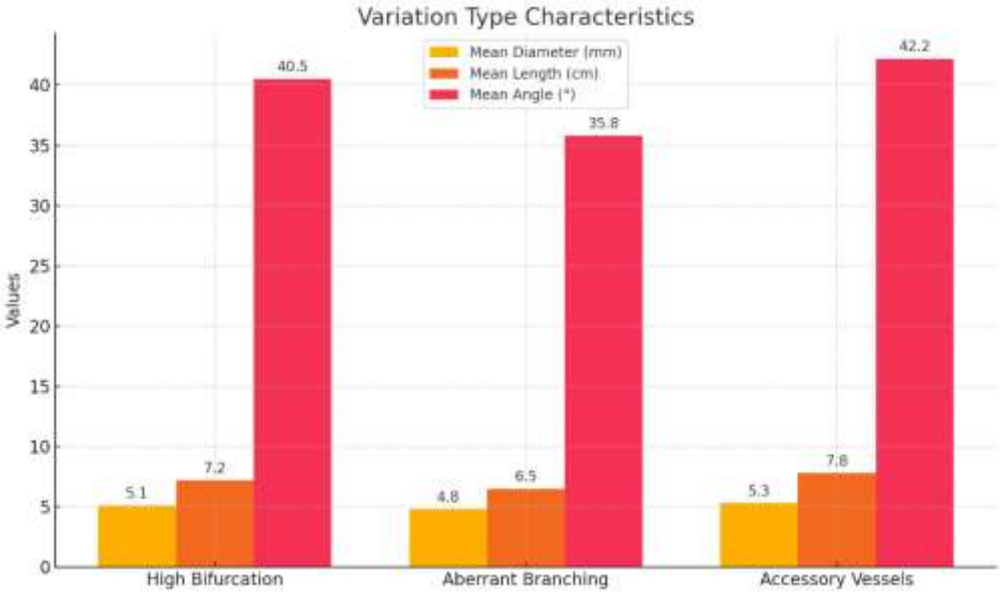

Figure 2 the graph illustrating the characteristics of different variation types in terms of Mean Diameter (mm), Mean Length (cm), and Mean Angle (°)

The findings from this study underscore the importance of considering demographic factors such as age and gender in the study of vascular anomalies. Furthermore, the physical characteristics of these variations need to be factored into clinical and surgical planning to optimize outcomes. Future studies should aim to explore the underlying mechanisms driving these differences and their potential impacts on patient care.

Discussion

The findings of this study reveal a diverse spectrum of morphological variations in the branching course and distribution of the axillary artery within the Indian population. These variations have significant implications for clinical practice, surgical interventions, and medical education [15].

Axillary artery variations play a crucial role in clinical practice, impacting fields like surgery, interventional radiology, and vascular medicine [16][17]. These anatomical variances can significantly influence surgical planning, procedural outcomes, and the risk of complications during various interventions involving the axillary artery, such as arteriovenous fistula creation for haemodialysis [18]. Understanding these variations is essential for optimizing patient care and reducing adverse events during procedures like axillo-subclavian artery bypass grafting and axillary artery cannulation for cardiac surgery [19]. Surgeons and interventionalists must be knowledgeable about potential anatomical differences in the axillary artery to enhance patient outcomes and minimize the likelihood of complications [20].

The prevalence of axillary artery variations tends to be higher in older individuals, reflecting age-related changes in arterial anatomy. Older age groups often exhibit variations like high bifurcation due to factors such as arterial stiffening, atherosclerosis, and degenerative vascular alterations [21] [22]. Long-term vascular remodeling and degeneration contribute to these alterations, emphasizing the impact of age on the frequency of axillary artery variations [23]. Understanding these age-related changes is crucial when assessing the prevalence of variations in the axillary artery, as older individuals are more likely to present with such anatomical variations [24] [25]. This underscores the importance of considering age as a significant factor in evaluating the occurrence of axillary artery variations in different age groups.

Gender-based differences in the prevalence of axillary artery variations have been noted, with a slightly higher frequency observed in males compared to females. This contradicts previous studies that reported a higher incidence of arterial anomalies in females [26][27]. Hormonal fluctuations, particularly estrogen levels, can influence vascular structure and function, potentially contributing to gender disparities in arterial anatomy [28]. Genetic factors and variations in developmental processes may also play a role in determining the prevalence of axillary artery variations in males and females [29]. Further research is essential to fully understand the underlying mechanisms behind gender-based differences in the prevalence of axillary artery variations, considering the potential influence of hormonal fluctuations and genetic factors on vascular anatomy [30].

Anatomical measurements of axillary artery variations provide valuable insights into the morphometric characteristics of anomalous arterial branches. Variations such as high bifurcation are associated with differences in arterial diameter, length, and branching angles, which may have implications for surgical planning and procedural outcomes. Understanding these anatomical variations is essential for ensuring the safety and efficacy of surgical interventions involving the axillary artery.

Conclusion

Our study on vascular variations revealed substantial disparities across demographic and anatomical parameters. Notable gender discrepancies were observed, with males exhibiting a higher prevalence of High Bifurcation and Aberrant Branching than females. Age-related analyses indicated an increase in High Bifurcation with age, contrasting with Aberrant Branching, which peaked in middle-aged individuals. Accessory Vessels displayed distinct physical characteristics, emphasizing their relevance in clinical and surgical contexts.

These findings underscore the importance of demographic considerations in vascular anomaly research. Understanding the physical dimensions of these variations is crucial for informing surgical interventions and diagnostic modalities. Future investigations should focus on elucidating the underlying mechanisms behind these differences to optimize patient care.

The spectrum of axillary artery variations identified in our study has significant implications for clinical practice, particularly in surgical and interventional settings. Surgeons must account for these variations to mitigate procedural risks and enhance patient outcomes. Age-related alterations in arterial anatomy and gender-specific disparities further highlight the complexity of vascular variations, warranting further exploration to elucidate underlying mechanisms. A comprehensive understanding of these variations is imperative for delivering high-quality patient care.

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