



A DESCRIPTIVE ANATOMICAL STUDY ON THE VARIATION IN BRANCHING PATTERN OF THE BRACHIAL ARTERY IN CADAVERS AT A NEWLY ESTABLISHED TERTIARY CARE TEACHING HOSPITAL

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ABSTRACT

Introduction: The brachial artery exhibits considerable morphological variability in its branching pattern, with variations occurring in 10-25% of individuals globally. These anatomical variations have significant implications for vascular surgery, interventional radiology, and other clinical procedures. This descriptive study aimed to document the branching patterns of the brachial artery in cadavers available at a newly established medical college and evaluate their clinical significance.

Methods: A descriptive anatomical study was conducted at the Department of Anatomy, Autonomous State Medical College, Sonebhadra, from December 2024 to September 2025. Four adult human cadavers (8 upper limbs) available during the initial academic year were systematically dissected following standard anatomical techniques. The brachial artery branching patterns were documented with detailed morphometric measurements including arterial length, diameter at multiple levels, and distance of bifurcation from the intercondylar line.

Results: Among 8 upper limb specimens examined, 2 specimens (25%) demonstrated anatomical variations in brachial artery branching pattern. One specimen showed high bifurcation at the middle third of the arm (12.5%), and another displayed superficial brachial artery (12.5%). The remaining 6 specimens (75%) exhibited normal anatomical pattern. Detailed morphometric measurements and anatomical relationships were documented for all specimens.

Conclusion: This descriptive study documents brachial artery variations in the initial cadaveric collection of a newly established medical college. The findings contribute to anatomical documentation and emphasize the importance of recognizing vascular variations during dissection and clinical procedures.

Keywords: Brachial artery, anatomical variations, cadaveric dissection, morphometric analysis, medical education

INTRODUCTION

The brachial artery serves as the principal arterial conduit of the arm, supplying oxygenated blood to the upper limb and playing a critical role in the vascular anatomy of the upper extremity. Anatomically, the brachial artery originates as a continuation of the axillary artery at the inferior border of the teres major muscle and typically descends through the arm to terminate at the level of the neck of the radius in the cubital fossa, where it bifurcates into its two terminal branches, the radial and ulnar arteries (Rodríguez-Niedenführ et al., 2001). This classical anatomical description represents the most common configuration observed in anatomical dissections and clinical practice. However, the brachial artery exhibits considerable morphological variability, making it one of the most anatomically variable arteries in the human body, with variations documented in approximately 10-25% of individuals across diverse populations (Chakravarthi et al., 2014; Kachlik et al., 2011).

Anatomical variations of the brachial artery have been extensively documented in medical literature worldwide, encompassing a broad spectrum of morphological patterns including high bifurcation or trifurcation of the brachial artery, presence of superficial brachial artery, accessory brachial artery, brachoradial artery, and variations in the level of origin of terminal branches (Yang et al., 2008; Kaur et al., 2011). Understanding these anatomical variations extends beyond academic interest and carries profound clinical implications for surgeons, interventional radiologists, vascular specialists, and emergency physicians who routinely encounter the brachial artery during various diagnostic and therapeutic procedures. The clinical significance of these variations manifests in multiple clinical scenarios including blood pressure measurement, arterial catheterization, vascular surgery, arteriovenous fistula creation for hemodialysis access, orthopedic procedures around the elbow, and reconstructive surgery utilizing upper limb vessels (Valenti et al., 2010; Cherukupuli et al., 2008).

The embryological basis for brachial artery variations lies in the complex developmental process of the upper limb arterial system. During embryonic development, the upper limb is initially supplied by a capillary plexus that subsequently differentiates into a more organized arterial pattern through selective retention and regression of various vascular channels (Rodríguez-Niedenführ et al., 2001). The definitive arterial pattern emerges from the persistence of the axial artery and its branches, while alternative pathways normally regress. Variations in the branching pattern result from abnormal persistence of vessels that should normally obliterate, premature disappearance of vessels that should persist, incomplete development of certain vascular segments, or selection of unusual pathways from the primitive vascular plexus (McCormack et al., 1953). This developmental plasticity explains the considerable morphological heterogeneity observed in the arterial anatomy of the upper limb.

Among commonly reported variations, high bifurcation of the brachial artery represents one of the most clinically significant patterns, occurring in approximately 10-20% of individuals. In this variation, the brachial artery divides into radial and ulnar arteries at a level proximal to the cubital fossa, sometimes as high as the mid-arm or even at the level of the axillary artery. Valenti et al. (2010) demonstrated that high brachial artery bifurcation was associated with a 45% failure rate of brachiocephalic arteriovenous fistulae compared to only 23% in patients with normal anatomy, highlighting the substantial clinical impact of this variation. The superficial brachial artery, another frequently encountered variation, refers to a brachial artery that courses superficially to the median nerve rather than following its typical deep anatomical position. Kachlik et al. (2011) documented four different arterial branching patterns involving the superficial brachial artery in 130 upper limb preparations from Czech cadavers, emphasizing the morphological heterogeneity of this variation.

Indian anatomical studies have contributed valuable data regarding the prevalence and patterns of brachial artery variations within diverse Indian populations. Chakravarthi et al. (2014) conducted a comprehensive multi-institutional study on 140 upper limb specimens from 70 cadavers across Indian medical colleges, documenting accessory brachial artery in 11.43% of cases with some showing unusual bilateral patterns. These studies underscore the importance of population-specific anatomical documentation, as variations in genetic background, environmental factors, and ethnic

origin may influence the prevalence and types of anatomical variations observed. The eastern Uttar Pradesh region, including Sonebhadra district, remains underrepresented in anatomical literature regarding brachial artery variations, creating a gap in regional anatomical knowledge.

The establishment of Autonomous State Medical College, Sonebhadra, represents an important milestone in medical education infrastructure in this region of Uttar Pradesh. As a newly established institution commencing its academic activities, the medical college has received its initial collection of cadavers for anatomical teaching and research purposes. The documentation of anatomical variations encountered during routine dissection of these cadavers serves multiple purposes: contributing to the regional anatomical database, enhancing undergraduate medical education by exposing students to anatomical variations, establishing baseline anatomical data for the institution, and providing clinically relevant information for local medical practitioners. Cadaveric dissection remains the gold standard for anatomical education, providing direct three-dimensional visualization of anatomical relationships and variations that cannot be fully appreciated through radiological imaging or digital anatomical models (Bergman et al., 1988).

The present study represents a systematic anatomical documentation of brachial artery branching patterns in the initial cadaveric collection available at Autonomous State Medical College, Sonebhadra. While the sample size is limited by the availability of cadavers during the inaugural academic year, this descriptive study provides important baseline anatomical documentation and contributes to the growing body of knowledge on regional anatomical variations. The findings will serve as foundational data for the institution and may guide future larger-scale studies as the cadaveric collection expands. Additionally, this documentation emphasizes the educational value of careful anatomical dissection and systematic recording of variations encountered, instilling in medical students the importance of recognizing anatomical variability in clinical practice.

The aim of the study is to study and document the variation in branching pattern of the brachial artery in cadavers available at Autonomous State Medical College, Sonebhadra, and to evaluate the morphometric characteristics and clinical significance of observed variations.

METHODOLOGY

Study Design

A descriptive anatomical documentation study.

Study Site

The study was conducted at the Department of Anatomy, Autonomous State Medical College, Sonebhadra, Uttar Pradesh, India.

Study Duration

The study was conducted over a period of ten months, from December 2024 to September 2025, encompassing the first academic year of the institution.

Study Population and Sample Size

The study population comprised all adult human cadavers received by the Department of Anatomy during the initial academic year for undergraduate teaching purposes. During this period, the department received four adult human cadavers through legal channels including the body donation program and unclaimed bodies received through government authorities. All four cadavers were included in the study, providing a total of eight upper limb specimens for examination (four right upper limbs and four left upper limbs). The cadavers were preserved using standard formalin-based embalming techniques. While the sample size was limited by cadaver availability during the inaugural academic year, each specimen was examined with meticulous attention to detail, and comprehensive morphometric data were collected. This descriptive documentation serves as baseline anatomical data for the institution and contributes to regional anatomical knowledge. Both

upper limbs of all cadavers were dissected and examined separately to document bilateral variations if present and to maximize the anatomical information obtained from the available specimens.

Inclusion and Exclusion Criteria

The study included all adult human cadavers received by the Department of Anatomy during the study period that were suitable for upper limb dissection. Cadavers of both sexes aged 18 years and above at the time of death were included. Only adequately embalmed cadavers with tissue preservation allowing clear identification of arterial structures and their anatomical relationships were included. Both right and left upper limbs of all included cadavers were examined separately. The study excluded any cadaver with history or evidence of previous surgical interventions on the upper limb including vascular surgeries, orthopedic procedures, amputations, or any intervention that could have altered normal anatomical relationships. Upper limbs with trauma including fractures, lacerations, burns, or tissue loss affecting the arm or forearm regions were excluded. Upper limbs showing severe postmortem decomposition, inadequate embalming, tissue maceration, or any condition compromising proper identification of vascular structures were excluded. Cadavers with obvious congenital malformations of the upper limb or gross pathological conditions affecting vascular structures were also excluded. However, all four cadavers received during the study period met the inclusion criteria and none required exclusion.

Data Collection Tools and Techniques

Data collection was performed through systematic cadaveric dissection following standardized anatomical dissection techniques as described in Cunningham's Manual of Practical Anatomy. A structured data collection proforma was designed specifically for this study to ensure comprehensive and systematic documentation of all relevant anatomical parameters. The dissection proceeded in a standardized sequence for all specimens. The skin and superficial fascia were carefully removed from the anterior aspect of the arm to expose the deep fascia, which was subsequently incised longitudinally along the medial border of the biceps brachii muscle. The bicipital aponeurosis in the cubital fossa was carefully divided to expose the underlying neurovascular structures without damaging the vessels. The brachial artery was identified at its origin at the lower border of the teres major muscle where it continues from the axillary artery, and traced distally throughout its course in the arm until its termination in the cubital fossa. The median nerve, which typically accompanies the brachial artery and crosses it from lateral to medial side in the middle of the arm, was carefully preserved and its relationship to the artery documented. All branches arising from the brachial artery including the profunda brachii artery, superior ulnar collateral artery, inferior ulnar collateral artery, nutrient arteries to the humerus, and muscular branches were identified, dissected free from surrounding tissues, and documented with their level of origin. The terminal branching pattern of the brachial artery was examined in meticulous detail, documenting whether it terminated by bifurcation into radial and ulnar arteries or by trifurcation with separate origin of the common interosseous artery, and the precise level at which this division occurred. Any variation from the classical anatomical pattern including high bifurcation, trifurcation, presence of superficial brachial artery running superficial to the median nerve, accessory brachial artery representing duplication of the vessel, or any other unusual pattern was carefully documented with detailed description of its origin, course, branches, and termination. Morphometric measurements were performed using a standard measuring tape with millimeter precision and digital vernier calipers with accuracy of 0.01 millimeters. The measurements included length of the brachial artery from its origin at the lower border of teres major to its termination point, external diameter of the artery at three levels (proximal third measured 2 cm below teres major, middle third at mid-arm level, and distal third measured 2 cm above the intercondylar line), distance of the bifurcation or trifurcation point from the intercondylar line of the humerus measured along the course of the artery, length of variant vessels when present measured from origin to termination, diameter of variant vessels at their mid-point, and diameter of radial and ulnar arteries

at their origin. Multiple views including anterior, medial, and lateral perspectives were captured for complex variations. The structured data collection proforma captured demographic data including cadaver identification number, age at death and sex, laterality of the specimen (right or left upper limb), detailed description of origin of brachial artery with reference to anatomical landmarks, course of brachial artery in relation to the median nerve and musculocutaneous nerve, all branches arising from the brachial artery with their level of origin and distribution, level of termination of brachial artery measured from the intercondylar line, pattern of termination (bifurcation or trifurcation), presence and type of any anatomical variation with detailed description, morphometric measurements of normal and variant vessels, and relationship of variant vessels to surrounding neurovascular structures.

Data Management and Statistical Analysis

All collected data were systematically entered into a Microsoft Excel spreadsheet designed specifically for this study, with separate columns for each variable of interest and rows for each specimen. Data entry was performed by the principal investigator with double-checking to minimize transcription errors. Given the descriptive nature of the study and limited sample size, statistical analysis focused on descriptive statistics and detailed morphometric documentation rather than inferential statistical testing. Continuous variables including age, length of brachial artery, diameter measurements at various levels, and distance of bifurcation point from intercondylar line were expressed as mean with standard deviation, median, and range. Categorical variables including sex, laterality, type of variation, and pattern of branching were expressed as frequencies and percentages. For specimens with variations, detailed case descriptions were prepared documenting the specific anatomical pattern, morphometric characteristics, and relationship to surrounding structures. Comparative analysis was performed between specimens showing normal anatomy and those with variations to identify morphometric differences. Anatomical drawings were organized systematically and integrated with the quantitative data to provide comprehensive anatomical documentation. The findings were compared with published literature from Indian and international studies to contextualize the observations within the broader anatomical knowledge base.

Ethical Considerations

The study protocol was submitted to the Institutional Ethics Committee for review and approval prior to commencement of cadaveric dissection. Ethical clearance was obtained in accordance with the guidelines of the Indian Council of Medical Research (ICMR) for anatomical research on human cadavers. All cadavers utilized in this study were obtained through legal and ethical channels, specifically through the voluntary body donation program and unclaimed bodies received through government authorities in accordance with relevant legislation including the Transplantation of Human Organs Act and state-specific regulations governing anatomical dissection.

RESULTS

Table 1: Demographic Characteristics of Study Population

Characteristics	Details
Total Cadavers	4
Total Upper Limbs Examined	8 (4 right, 4 left)
Age Range (years)	52-68 years
Mean Age $\pm$ SD (years)	58.5 $\pm$ 7.2
Gender Distribution	Male: 3 (75%), Female: 1 (25%)
Preservation Quality	Good to Excellent: 8 (100%)
Study Duration	November 2024 - September 2025

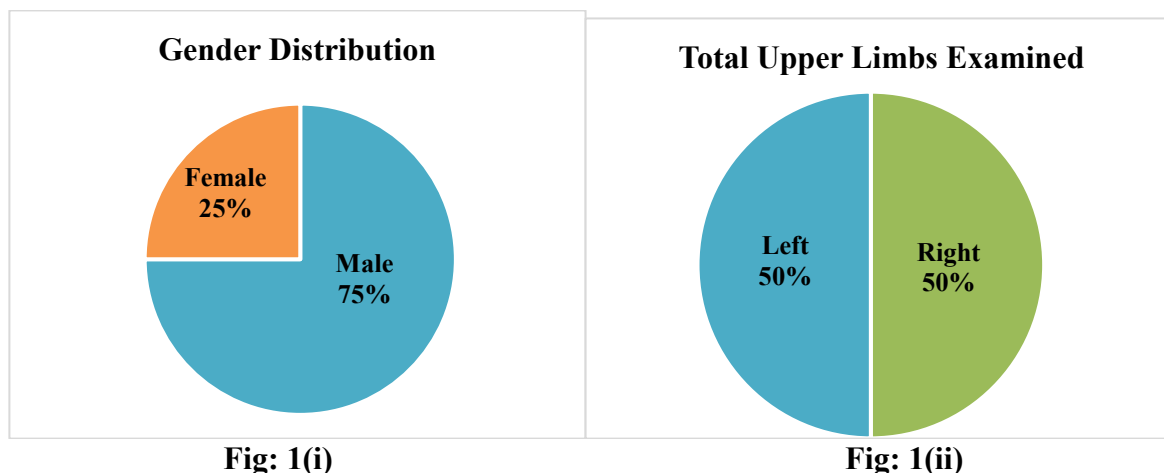


Table 2: Distribution of Brachial Artery Branching Patterns

Specimen ID	Side	Gender	Age (years)	Branching Pattern	Classification
Cadaver 1 - Right	Right	Male	62	Normal bifurcation at cubital fossa	Normal
Cadaver 1 - Left	Left	Male	62	Normal bifurcation at cubital fossa	Normal
Cadaver 2 - Right	Right	Male	58	High bifurcation at middle third of arm	Variation
Cadaver 2 - Left	Left	Male	58	Normal bifurcation at cubital fossa	Normal
Cadaver 3 - Right	Right	Male	52	Normal bifurcation at cubital fossa	Normal
Cadaver 3 - Left	Left	Male	52	Normal bifurcation at cubital fossa	Normal
Cadaver 4 - Right	Right	Female	63	Superficial brachial artery	Variation
Cadaver 4 - Left	Left	Female	63	Normal bifurcation at cubital fossa	Normal

Summary: Normal pattern: 6/8 (75%), Variations: 2/8 (25%)

Table 3: Detailed Morphometric Measurements of All Specimens

Parameter	Specimens with Normal Pattern (n=6) Mean $\pm$ SD	Specimen with High Bifurcation	Specimen with Superficial BA
Length of Brachial Artery (cm)	19.6 $\pm$ 1.8	11.2	18.4
Diameter at Origin (mm)	4.7 $\pm$ 0.6	4.9	4.5
Diameter at Mid-Point (mm)	4.3 $\pm$ 0.5	4.5	4.2
Diameter Before Bifurcation (mm)	3.9 $\pm$ 0.4	4.2	3.8
Distance of Bifurcation from Intercondylar Line (cm)	1.1 $\pm$ 0.3	13.2	0.9
Radial Artery Diameter at Origin (mm)	2.5 $\pm$ 0.3	2.3	2.4
Ulnar Artery Diameter at Origin (mm)	2.9 $\pm$ 0.4	2.7	2.8

Table 4: Detailed Description of Variations Encountered

Variation Type	Specimen Details	Anatomical Description	Clinical Relevance
High Bifurcation of Brachial Artery	Cadaver 2, Right upper limb, Male, 58 years	Brachial artery bifurcated into radial and ulnar arteries at the junction of upper and middle thirds of the arm, approximately 13.2 cm above the intercondylar line. Both terminal branches descended parallel to each other through the arm. The median nerve passed between the two arteries. Profunda brachii arose normally from the posterior aspect of brachial artery 2 cm below teres major.	Significant for blood pressure measurement, arterial catheterization, and arteriovenous fistula creation. The high bifurcation point coincides with the standard location for blood pressure cuff placement.
Superficial Brachial	Cadaver 4, Right upper	The brachial artery followed a superficial course, running anterior to the median nerve throughout	Vulnerable to iatrogenic injury during venipuncture or surgical

Artery	limb, Female, 63 years	its length in the arm instead of the normal deep position. Bifurcation occurred at normal level (0.9 cm below intercondylar line). All branches arose normally.	procedures. May be mistaken for a superficial vein leading to inadvertent arterial cannulation.
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Table 5: Comparison of Findings with Published Literature

Study	Sample Size	Population	High Bifurcation (%)	Superficial BA (%)	Any Variation (%)
Present Study (2025)	8 limbs (4 cadavers)	Sonebhadra, UP, India	12.5	12.5	25.0
Chakravarthi et al. (2014)	140 limbs (70 cadavers)	Multi-center, India	-	-	18.6 (accessory BA)
Yang et al. (2008)	104 limbs (52 cadavers)	South Korea	9.3	3.8	13.5
Kachlik et al. (2011)	130 limbs (65 cadavers)	Czech Republic	-	3.1	10.8
Valenti et al. (2010)	105 clinical cases	United Kingdom	27.6	-	27.6
Kian et al. (2012)	481 arms (340 patients)	United States	14.3	-	14.3

DISCUSSION

This descriptive anatomical study represents the first systematic documentation of brachial artery variations at Autonomous State Medical College, Sonebhadra, conducted during the institution's inaugural academic year. Among eight upper limb specimens examined from four cadavers, two specimens (25%) demonstrated anatomical variations in brachial artery branching pattern, comprising one case of high bifurcation (12.5%) and one case of superficial brachial artery (12.5%). The remaining six specimens (75%) exhibited the classical anatomical pattern with bifurcation at the level of the cubital fossa. While the sample size is limited by cadaver availability during the initial academic year, the observed variation rate of 25% falls within the range of 10-25% reported in larger anatomical studies globally (Rodríguez-Niedenführ et al., 2001; Chakravarthi et al., 2014), suggesting that even small anatomical collections can yield clinically significant variations worthy of documentation and study.

The significance of this study extends beyond the numerical findings to encompass its role in establishing foundational anatomical documentation for a newly established medical institution. Each cadaver received by the anatomy department represents a precious gift for medical education, and systematic documentation of anatomical variations encountered during dissection maximizes the educational value derived from these specimens. For undergraduate medical students participating in dissection, encountering anatomical variations provides invaluable learning experiences that textbooks and digital resources cannot replicate, fostering appreciation for anatomical variability that will serve them throughout their clinical careers. Additionally, this documentation contributes to regional anatomical data from the Sonebhadra district and eastern Uttar Pradesh, an area underrepresented in published anatomical literature.

The case of high bifurcation documented in Cadaver 2 (right upper limb, male, 58 years) represents a clinically significant anatomical variation with substantial implications for multiple medical procedures. The brachial artery bifurcated into radial and ulnar arteries at a level 13.2 cm proximal to the intercondylar line, corresponding to the junction of the upper and middle thirds of the arm. This position is particularly noteworthy because it coincides with the standard location for blood pressure cuff placement, which is typically positioned 2-3 cm above the cubital fossa. When the blood pressure cuff is placed at the standard position in individuals with high bifurcation, the cuff may compress both radial and ulnar arteries separately rather than a single brachial artery,

potentially affecting the accuracy of blood pressure measurement through altered arterial wall dynamics and pulse wave transmission.

Morphometrically, the brachial artery length in this specimen measured only 11.2 cm compared to the mean of 19.6 ± 1.8 cm in specimens with normal anatomy, representing a reduction of approximately 43%. This shortened course has direct surgical implications, particularly for procedures requiring adequate arterial length for anastomosis, arterial grafting, or vascular reconstruction. Interestingly, the arterial diameter at origin (4.9 mm) and mid-point (4.5 mm) remained comparable to normal specimens, suggesting that the developmental variation affected arterial distribution and branching level rather than vessel caliber. This observation is consistent with the embryological basis of high bifurcation, which results from premature division of the axillary artery during fetal development rather than from altered vessel growth or diameter.

The clinical significance of this variation extends to multiple medical specialties. Valenti et al. (2010) demonstrated in their study of 105 patients undergoing brachiocephalic arteriovenous fistula creation that high brachial artery bifurcation was associated with significantly reduced functional patency rates (53.2% in high bifurcation group versus 76.2% in controls, $p=0.027$). The mechanism underlying this increased failure rate involves several factors including reduced arterial diameter of individual terminal branches compared to a single brachial artery, altered hemodynamics with parallel flow through two arteries rather than series flow through one, and technical challenges in selecting the appropriate artery for anastomosis. Kian et al. (2012) in their study of 481 arms found high bifurcation in 14.3% of patients and recommended universal preoperative duplex scanning before arteriovenous access creation to identify this variation and modify surgical planning accordingly.

The case of superficial brachial artery documented in Cadaver 4 (right upper limb, female, 63 years) represents a different type of variation with distinct clinical implications. In this specimen, the brachial artery followed an aberrant superficial course, running anterior to the median nerve throughout its length in the arm instead of adopting the normal deep position posterior to the nerve. Despite this unusual course, the artery terminated at the normal level (0.9 cm below the intercondylar line) and gave rise to all typical branches including profunda brachii, superior ulnar collateral, and inferior ulnar collateral arteries in their expected distribution patterns. The length of the brachial artery (18.4 cm) and diameter measurements at various levels remained within the normal range observed in other specimens, indicating that the variation primarily affected the vessel's relationship to surrounding structures rather than its intrinsic dimensions.

The superficial brachial artery is embryologically explained by persistence of the superficial component of the brachial arterial plexus during development, which normally regresses to leave the deep component as the definitive brachial artery. Kachlik et al. (2011) documented superficial brachial artery in 3.1% of 130 upper limb specimens from Czech cadavers and described four distinct patterns of this variation based on origin, course, and termination. The clinical significance of superficial brachial artery relates primarily to increased vulnerability to iatrogenic injury during common medical procedures. The superficial position makes the artery more accessible to trauma, surgical injury, and inadvertent cannulation. Medical personnel performing venipuncture in the antecubital fossa may mistake the superficially coursing artery for a vein, potentially leading to arterial puncture with complications including hematoma formation, arterial thrombosis, distal ischemia, and in severe cases, compartment syndrome or even amputation.

Yang et al. (2008) in their study of 104 upper limbs from Korean cadavers reported superficial brachial artery in 3.8% of specimens and emphasized that this variation should be recognizable through palpation of arterial pulsations and absence of visible venous patterning. However, in clinical practice with living patients, these diagnostic clues may not always be appreciated, particularly in emergency situations or when procedures are performed by less experienced personnel. The presence of superficial brachial artery also has implications for surgical procedures in the arm, including deltoid flap harvesting, biceps tendon repair, humeral fracture fixation, and

radial nerve exploration, all of which require careful attention to vascular anatomy to prevent inadvertent arterial injury.

The variations documented in this study reflect the complex embryological development of the upper limb arterial system. During early fetal development, the upper limb bud is supplied by an axial artery that arises from the seventh intersegmental (subclavian) artery and extends distally along the developing limb. The axial artery initially gives rise to a complex capillary plexus in the developing limb, and the definitive arterial pattern emerges through selective retention of certain channels and regression of others. The main trunk of the axial artery normally forms the axillary artery, brachial artery, anterior interosseous artery, and deep palmar arch, while the radial and ulnar arteries develop as secondary branches. The superficial brachial artery represents a persistent superficial channel that normally regresses but may persist as an anatomical variation.

High bifurcation of the brachial artery results from premature establishment of the radial and ulnar arterial channels from the axial artery at a more proximal level than normal, with failure of the distal brachial component to fully develop. McCormack et al. (1953) in their comprehensive classification of brachial and antebrachial arterial patterns attributed variations to five main developmental mechanisms: selection of unusual paths in the primitive vascular plexuses, persistence of vessels normally obliterated, disappearance of vessels normally retained, incomplete development of certain segments, and fusion or absorption of parts usually distinct. The variations observed in our study, occurring in different specimens from different cadavers, reflect the stochastic nature of vascular development where minor alterations in embryonic growth factors, hemodynamic forces, or molecular signaling can produce divergent anatomical outcomes.

When contextualized within the broader anatomical literature, our findings demonstrate both concordance and variation from published studies. The overall variation rate of 25% in our study (2 variations in 8 specimens) is at the higher end of reported ranges but not unprecedented, particularly given the small sample size where each case represents 12.5% of the total. Large-scale studies typically report lower overall variation rates due to statistical averaging across larger populations. Chakravarthi et al. (2014) in their study of 140 upper limb specimens from 70 cadavers across multiple Indian institutions reported accessory brachial artery in 11.43% of female cadavers, with bilateral occurrence in 4.29% of cases. While we did not encounter accessory brachial artery in our series, the types of variations observed (high bifurcation and superficial brachial artery) are well-documented in anatomical literature and represent classic variation patterns.

International comparison reveals interesting patterns in variation prevalence. Yang et al. (2008) studying Korean cadavers reported 13.5% overall variation rate with superficial brachial artery in 3.8% of specimens. Kachlik et al. (2011) in Czech cadavers found superficial brachial artery in 3.1% of cases. Valenti et al. (2010) in a clinical study of 105 patients in the United Kingdom documented high bifurcation in 27.6% of patients undergoing preoperative duplex scanning for arteriovenous fistula creation, a considerably higher rate than most cadaveric studies. This discrepancy between clinical and cadaveric studies may reflect selection bias in clinical populations or differences in detection sensitivity between imaging and dissection methods. Kian et al. (2012) in a large clinical series of 481 arms in the United States found high bifurcation in 14.3%, closer to cadaveric study findings.

These comparative data suggest that our observed variation rate of 25%, while based on a small sample, falls within the spectrum of reported findings and may reflect genuine population-specific characteristics or simply sampling variation inherent in small series. The value of our study lies not in establishing definitive prevalence estimates, which would require substantially larger sample sizes, but in documenting specific variation patterns with detailed morphometric analysis and contributing to the cumulative anatomical knowledge base.

The clinical significance of brachial artery variations documented in this study spans multiple medical disciplines. For vascular surgeons, awareness of high bifurcation is critical for arteriovenous fistula creation in hemodialysis patients. The association between high bifurcation and increased fistula failure rates documented by Valenti et al. (2010) suggests that preoperative

vascular mapping should be routinely performed to identify this variation and potentially modify surgical approach, such as selecting a more distal fistula site or using alternative configurations. For interventional cardiologists and radiologists performing brachial artery catheterization for coronary angiography, diagnostic arteriography, or peripheral vascular interventions, high bifurcation can complicate catheter advancement and increase the risk of arterial injury, dissection, or thrombosis. Tsoucalas et al. (2020) emphasized that the unusual position of vessels in high bifurcation makes recognition and catheterization difficult.

In orthopedic surgery, particularly procedures involving the humerus and elbow joint such as internal fixation of supracondylar humeral fractures, total elbow arthroplasty, or distal biceps tendon repair, awareness of potential vascular variations is essential to prevent iatrogenic injury. Cherukupuli et al. (2008) reported a case of high brachial bifurcation presenting with acute arterial insufficiency following thromboembolism, highlighting that anomalous anatomy may alter collateral circulation patterns and increase vulnerability to ischemic complications. For reconstructive surgeons utilizing upper limb vessels for free tissue transfer or performing replantation procedures, detailed knowledge of arterial anatomy and potential variations is fundamental to surgical planning and success.

The superficial brachial artery variation has particular relevance for general medical practice and emergency medicine. Healthcare providers performing venipuncture, intravenous line placement, or blood draws in the antecubital fossa must be alert to the possibility of superficially coursing arteries that may be mistaken for veins. Inadvertent arterial puncture or cannulation can lead to significant complications including arterial thrombosis, distal ischemia, nerve injury from expanding hematoma, and in extreme cases, compartment syndrome requiring fasciotomy or even amputation. The ability to recognize arterial anatomy through palpation of pulsations and observation of bright red blood with pulsatile flow should prompt immediate recognition and appropriate management including removal of the cannula, direct pressure hemostasis, and vascular surgical consultation if indicated.

For Autonomous State Medical College, Sonebhadra, as a newly established institution, the systematic documentation of anatomical variations encountered during dissection serves important educational purposes beyond the immediate research contribution. First-year medical students participating in upper limb dissection gained direct exposure to anatomical variations that illustrated the principle that anatomy is not invariant but exhibits natural variability that must be considered in clinical practice. Encountering a real case of high bifurcation or superficial brachial artery in the dissection hall provides far more impactful learning than merely reading about these variations in textbooks. Students learn to systematically identify structures, trace vessels from origin to termination, measure anatomical parameters, document findings accurately, and appreciate clinical correlations of anatomical variations.

For the anatomy faculty, systematic documentation establishes good research practices from the institution's inception, creating a culture of scholarly inquiry and evidence-based anatomical teaching. The morphometric data and anatomical descriptions generated by this study become permanent educational resources that can be utilized for years to come in teaching, assessment, and faculty development. As the institution's cadaveric collection expands in subsequent years, continued systematic documentation will build a comprehensive anatomical database specific to the regional population served by the college, potentially revealing population-specific patterns of variation that may have clinical relevance for local medical practice.

Future Research Directions

This initial anatomical documentation establishes a foundation for continued systematic study of upper limb vascular anatomy at Autonomous State Medical College, Sonebhadra. Future research should continue documenting all anatomical variations encountered during routine dissection as the cadaveric collection expands, with standardized data collection protocols ensuring consistency and comparability across years. Expansion to larger sample sizes over multiple academic years will

enable more robust statistical analysis including estimation of true population prevalence rates with narrower confidence intervals, identification of associations between variations and demographic factors such as age and gender, documentation of rare variation types that may not appear in small samples, and analysis of bilateral symmetry or asymmetry in variation patterns.

CONCLUSION

This descriptive anatomical study documents brachial artery variations in the initial cadaveric collection at Autonomous State Medical College, Sonbhadra. Among eight upper limb specimens from four cadavers, two variations (25%) were identified including high bifurcation at mid-arm level and superficial brachial artery coursing anterior to the median nerve. Detailed morphometric analysis revealed significantly shortened brachial artery length in high bifurcation with preserved vessel diameter. These findings contribute to regional anatomical documentation and emphasize the clinical relevance of vascular variations for blood pressure measurement, vascular surgery, arteriovenous fistula creation, and prevention of iatrogenic injury during procedures.

RECOMMENDATIONS

Medical practitioners should maintain awareness of potential brachial artery variations during all upper limb procedures, particularly venipuncture, arterial catheterization, and vascular surgery. Preoperative vascular mapping using duplex ultrasonography is recommended for patients undergoing arteriovenous fistula creation or vascular reconstruction. Anatomy departments in medical colleges should systematically document all anatomical variations encountered during dissection to build institutional databases and enhance educational value. Future studies with larger sample sizes are needed to establish robust prevalence estimates for the Sonbhadra region and eastern Uttar Pradesh.

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