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Original Research Article

AN OBSERVATIONAL CROSS-SECTIONAL CADAVERIC STUDY OF ACCESSORY BRACHIAL ARTERIES ASSOCIATED WITH PERSISTENT MEDIAN ARTERY AND INCOMPLETE SUPERFICIAL PALMAR ARCH

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ABSTRACT

Background: Variations in the upper limb arteries are clinically significant due to their implications in surgical, radiological, and interventional procedures. The accessory brachial artery (ABA) is a rare vascular anomaly resulting from persistence of embryonic arterial channels. The aim is to identify and document ABAs and associate arterial variations in the forearm and hand and discuss their embryological and clinical significance. **Materials and Methods:** A descriptive observational cross sectional cadaveric study was done on 30 upper limb specimens from 15 embalmed cadavers. Standard dissection techniques were employed to trace the origin, course, branching pattern, and termination of the arteries. Observations during dissection were documented and compared with existing literature. **Result:** ABA was observed in 2 specimens (6.66%), each occurring unilaterally. In one case (3.33%), it originated from the axillary artery in the left upper limb, while in another (3.33%), it originated from the brachial artery in the right upper limb. In both cases, the artery continued as the radial artery, with variations in its relation to the median nerve. Associated findings included persistent median artery and alterations in the branching pattern of the brachial artery. A complete superficial palmar arch was observed in 93.33% of specimens, while incomplete arches (6.67%) corresponded to cases with vascular variations. According to Coleman and Anson classification, these were identified as Type B and Type C arches. **Conclusion:** The presence of (ABA), persistent median artery(PMA), and incomplete palmar arches highlights the complexity of upper limb vascular anatomy. Awareness of these variations is essential for clinicians to prevent iatrogenic injury and ensure safe surgical and interventional procedures. Preoperative vascular assessment is recommended in suspected cases.

INTRODUCTION

The upper limb arterial anatomy demonstrates considerable variability which is clinically important in modern medicine. Minimally invasive vascular procedures have been done very frequently, such as trans radial coronary angiography, arterial cannulation, vascular graft harvesting, reconstructive microsurgery, and endovascular interventions. Hence precise knowledge of arterial patterns has become very essential.

Variations involving the origin, course and branching pattern of upper limb artery are of major anatomical and clinical importance as they may influence the procedural outcomes and can cause complications such as arterial injury, thrombosis, or failure of vascular access if unrecognized.[1,2] Among these, accessory brachial artery (ABA) is an uncommon vascular variation characterized by the presence of an additional arterial channel accompanying the normal brachial artery.[2]

Typically, the brachial artery begins at the lower border of teres major muscle as a continuation of the

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axillary artery, descends along the medial aspect of arm and terminates in the cubital fossa at the level of the neck of radius by dividing into radial and ulnar arteries.[1] Developmental alterations during embryogenesis may produce abnormal branching patterns, persistence of embryonic vessels, and altered arterial communications.[3,4]

During limb development, the axis artery serves as the primary vascular supply and gives rise to the axillary, brachial, and anterior interosseous arteries, along with the median artery. Subsequent remodeling involves regression of certain embryonic vessels and persistence of others. Failure of this process may result in variations such as accessory brachial arteries, persistent median arteries, or altered branching patterns.[3,4]

Several anatomical studies have documented the variability of upper limb arterial patterns. McCormack et al. analyzed 750 upper limbs and reported variations in the brachial and antebrachial arterial patterns, highlighting that deviations from the normal branching pattern are not uncommon.[2] Similarly, Keen described variations in arterial symmetry and emphasized the presence of accessory arterial channels, although most cases were unilateral.[5] More recent embryological studies by Rodríguez Niedenführ et al. have provided a developmental basis for these variations, explaining them as persistence or regression anomalies of the embryonic vascular plexus.[4]

The persistent median artery is an important variation represents persistence of the embryonic median artery, which usually regresses after the development of definitive radial and ulnar arteries.[4] When present, this artery may contribute significantly to the vascularity of the hand and alter the formation of superficial palmar arches.[5]

Furthermore, the presence of superficially located anomalous arteries may lead to accidental intra-arterial injections during routine venipuncture as they may be mistaken for veins.[2]

Although individual arterial variations have been widely reported, the coexistence of multiple variations, especially on a bilateral basis, remains rare. Therefore, the present study was undertaken to identify and document accessory brachial arteries, analyze associated arterial variations in the forearm and hand, and compare the findings with existing literature, with the aim of highlighting their embryological basis and clinical significance.

MATERIALS AND METHODS

The present study was designed as a descriptive observational cross sectional cadaveric study and was conducted in the Department of Anatomy over a period of two years during routine undergraduate dissection.

A total of thirty upper limb specimens obtained from fifteen embalmed human cadavers were included in the study. The sample size was determined based on a convenience sampling method, as the study utilized cadaveric material available for routine undergraduate dissection.

The cadavers were preserved using standard formalin based embalming techniques, ensuring adequate preservation of vascular and soft tissue structures for detailed anatomical examination. Only well preserved upper limbs of either sex with intact vascular anatomy were included, while damaged, mutilated, surgically altered, or poorly preserved specimens were excluded from the study.

The present study was conducted in accordance with institutional and ethical guidelines. Ethical approval was obtained from the Institutional Ethics Committee.

The cadavers used in this study were obtained through the body donation program of the institution. All specimens were handled with due respect, dignity, and confidentiality, in accordance with standard ethical principles for the use of human cadaveric material in medical education and research.

Dissection was carried out according to the guidelines outlined in Cunningham's Manual of Practical Anatomy. The skin and superficial fascia were carefully removed to expose the deeper structures, followed by meticulous dissection of the deep fascia. The flexor compartments of the arm, cubital fossa, forearm, and palm were systematically explored. The brachial artery and its branches were identified and traced throughout their course, noting their anatomical relations, particularly with the median nerve. Special attention was given to identifying the origin, course, branching pattern, and termination of the brachial artery and any accessory vessels. Distally, the radial, ulnar, and interosseous arteries were followed into the palm, and the palmar aponeurosis was carefully dissected to study the formation and completeness of the superficial and deep palmar arches.

All observed variations were carefully documented and photographed for accuracy and record keeping. The morphological findings were systematically recorded and compared with standard anatomical descriptions and previously published literature. The observed variations were analyzed with emphasis on their embryological basis and clinical significance.

RESULTS

A total of 30 upper limb specimens obtained from 15 cadavers were studied. Accessory brachial artery (ABA) was observed in 2 specimens (6.66%), each occurring unilaterally.

Case 1: Left Upper Limb

An accessory brachial artery was found arising from the second part of the axillary artery. It passed between the two roots of the median nerve, descended superficial to it, and in the mid arm lay lateral to the median nerve. In the lower arm, it continued as the radial artery [Figure 1].

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At the level of the cubital fossa, the accessory brachioradial artery communicated with the main brachial artery via a well defined anastomotic channel. The radial artery gave an ascending recurrent branch, which anastomosed with the profunda brachii artery. Distally, the main brachial artery terminated unusually by dividing into the ulnar artery and a persistent median artery (PMA) [Figure 2].

In the forearm, the radial artery coursed superficially over the brachioradialis muscle, passed through the anatomical snuff box, and entered the dorsum of the hand. The persistent median artery pierced the median nerve in the upper forearm, accompanied it in the mid forearm, and was crossed by the flexor carpi radialis tendon in the distal forearm.

In the hand, the persistent median artery supplied the lateral digits, including the ulnar side of the thumb, index finger, and radial side of the middle finger. The ulnar artery gave superficial and deep branches, with the superficial branch supplying the medial two and a half digits. There was no communication between the ulnar artery and the persistent median artery, resulting in an incomplete superficial palmar arch. The radial artery contributed to the deep palmar circulation by anastomosing with the deep branch of the ulnar artery [Figure 3].

Figure 1: Accessory brachial artery arising from the axillary artery and descending in relation to the median nerve in the arm.

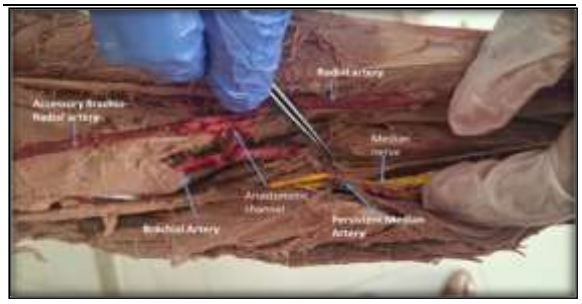

Figure 2: Arterial pattern at the cubital fossa showing communication between accessory and main brachial arteries and division into Radial artery and persistent median artery.

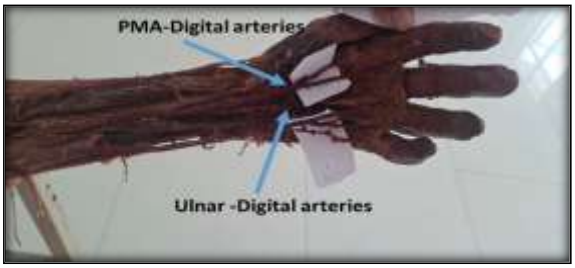

Figure 3: Palmar arterial pattern showing contribution of the persistent median artery (PMA) and incomplete superficial palmar arch.

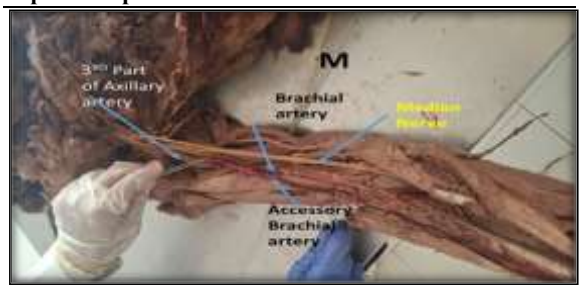

Figure 4: Accessory brachial artery in the right arm arising from the main brachial artery and continuing as the radial artery.

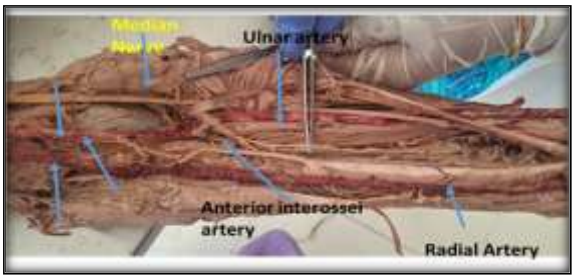

Figure 5: Forearm arterial pattern showing division of the brachial artery into Ulnar, Radial and Anterior interosseous arteries.

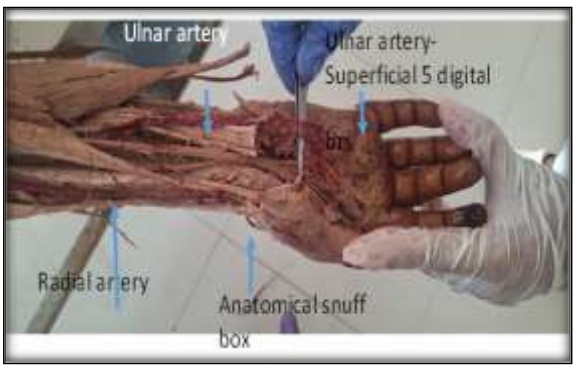

Figure 6: Palmar arterial pattern in the right hand shows incomplete superficial palmar arch and radial artery contribution to deep circulation.

Case 2: Right Upper Limb

In the right upper limb, an accessory brachial artery arose from the main brachial artery in the proximal arm [Figure 4]. It ran lateral to the parent vessel and remained deep to the median nerve. At the level of the cubital fossa, it continued as the radial artery without any anastomotic communication [Figure 5]. The main brachial artery terminated by dividing into the ulnar artery and the common interosseous artery.

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The common interosseous artery further divided into the anterior and posterior interosseous arteries. The anterior interosseous artery descended along the anterior interosseous membrane, accompanied by the anterior interosseous nerve.

Distally, the radial artery passed through the anatomical snuff box and entered the dorsum of the hand. In the hand, the ulnar artery gave superficial and deep branches, with the superficial branch forming an incomplete superficial palmar arch and giving off five digital branches supplying the medial four and a half digits, sparing the radial side of the thumb.

The radial artery passed through the first dorsal interosseous space into the palm and contributed to the deep palmar circulation by anastomosing with the deep branch of the ulnar artery [Figure 6].

Table 1: Origin and Distribution of Accessory Brachial Artery in Present Study

Origin	Sample Size (n=30)	Female	Male	Unilateral	Right Arm	Left Arm
From Axillary Artery	1 (3.33%)	-	Observed	Yes	-	Observed
From Brachial Artery	1 (3.33%)	Observed	-	Yes	Observed	-

Table 2: Combined Observations of Accessory Brachial Artery and Palmar Arterial Patterns (Coleman & Anson Classification)

Case	Origin of Accessory Brachial Artery	Relation to Median Nerve	Termination as Radial Artery	Palmar Arch Pattern (Coleman & Anson Classification)
Case 1	Axillary artery	Superficial to median nerve	Yes	Type C: Median–ulnar superficial palmar arch (incomplete)
Case 2	Brachial artery	Deep to median nerve	Yes	Type B: Ulnar type superficial palmar arch (incomplete)
Total (n = 30 limbs)	2 cases observed	—	2/30 limbs (6.66%)	Type C: 1 (3.33%); Type B: 1 (3.33%)

The present study identified accessory brachial artery in 2 out of 30 upper limb specimens (6.66%), each occurring unilaterally. One variation involved origin from the axillary artery in the left upper limb of a male cadaver, while the other arose from the brachial artery in the right upper limb of a female cadaver [Table 2]. In both cases, the accessory artery continued as the radial artery but differed in its relation to the median nerve, being superficial in Case 1 and deep in Case 2 [Table 1]. These proximal variations were associated with distal arterial anomalies, including altered termination of the brachial artery and variations in palmar circulation. A complete superficial palmar arch was observed in 93.33% of specimens, whereas an incomplete arch was present in 6.67%, corresponding to the cases with accessory brachial artery variations. According to Coleman and Anson classification, the palmar arch patterns were classified as Type C (median–ulnar incomplete) and Type B (ulnar incomplete) [Table 1]. These findings highlight the association between proximal arterial variations and atypical palmar arch configurations, emphasizing their clinical importance in surgical and interventional procedures.

DISCUSSION

Variations in the arterial pattern of the upper limb are frequently encountered during cadaveric dissections and radiological investigations. These anomalies possess significant anatomical and clinical relevance, particularly in surgical and interventional procedures involving the limb.[6,9] Among these, the accessory brachial artery (ABA) is relatively uncommon and is typically attributed to persistence of embryonic arterial channels during development.[6,7]

Several studies have documented variations in the origin and course of the brachial artery. Chakravarthi et al. reported multiple variations in branching patterns, emphasizing their clinical significance.[6] Similarly, Haldaj et al. described accessory brachial arteries and their surgical implications.[7] Yang et al. observed that accessory brachial arteries may arise at different levels with variable courses,[8] while Zlotolow et al. highlighted their relevance in reconstructive and hand surgeries.[9]

In the present study, ABA originated from the axillary artery in one case and from the brachial artery in another, demonstrating variability comparable to earlier reports.[8,10] Lalit and Piplani described accessory arteries continuing as radial artery, similar to the present findings.[10] More complex patterns, including bifurcation and trifurcation, have been reported by Vollala et al., further illustrating developmental variability.[11]

The relationship of ABA to the median nerve is clinically significant. In this study, one artery was superficial while the other was deep to the median nerve. Such variations have been reported in previous studies and are important in surgical procedures involving the cubital fossa.[6,7] These variations may lead to complications during fracture fixation, nerve decompression, and vascular reconstruction.

In both cases, ABA continued as the radial artery, which has direct clinical implications. As noted by Doyle and Gilbert, anomalous radial arteries may complicate transradial catheterization and coronary angiography, leading to arterial spasm, thrombosis, or procedural failure.[12]

The presence of a persistent median artery (PMA) represents persistence of embryonic arterial supply. Natsis et al. described the PMA as antebrachial or palmar type, with the palmar type contributing to

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hand vascularity.[13] Prajapati et al. also emphasized its clinical relevance.[15] Lucas and Henneberg suggested that the prevalence of PMA may be increasing, possibly reflecting microevolutionary changes.[14] Imaging studies have further highlighted its importance in diagnostic practice.[21]

Clinically, PMA is significant due to its association with median nerve compression and carpal tunnel syndrome.[13,15] Its presence may also complicate surgical procedures in the wrist and hand.

The superficial palmar arch (SPA) exhibits considerable variation. Coleman and Anson classified SPA into complete and incomplete types, which remains the standard classification.[16] In the present study, incomplete SPA was observed in 6.67% of cases, including Type B and Type C patterns. Similar findings have been reported by Patnaik et al,[17] and Chimmalgi et al,[18] Ruengsakulrach et al. also highlighted the surgical importance of palmar arch variations.[19]

Incomplete arches are clinically important because they compromise collateral circulation and may predispose to ischemia during arterial injury or surgical procedures.[16,20] Hence, preoperative evaluation of vascular integrity is essential.

Embryologically, these variations arise due to disturbances in the development of the axis artery and primitive vascular plexus, resulting in persistence or regression failure of embryonic vessels.[22,23] As noted by Bergman et al., anatomical variations are common due to developmental modifications,[24] and classical descriptions in Gray's Anatomy reinforce this variability.[25]

From a clinical perspective, these variations are highly significant. Superficial arteries may be mistaken for veins during intravenous procedures, leading to accidental intra arterial injection and complications such as thrombosis, ischemia, and tissue necrosis.[6,9] Radiologists should be aware of these anomalies to avoid diagnostic errors, while surgeons must carefully evaluate vascular anatomy to prevent intraoperative complications.

Table 3: Comparative Analysis of Present Study with Previous Literature

Parameter	Present Study	Previous Studies (Literature)
Incidence of ABA	6.66%	Variable incidence (Chakravarthi [6]; Haldaj [7]; Yang [8])
Origin of ABA	Axillary and brachial artery	Variable origins (Yang [8]; Lalit [10])
Relation to Median Nerve	Superficial & deep	Mostly superficial, some deep (Chakravarthi [6])
Termination	Radial artery	Variable patterns incl. trifurcation (Vollala [11])
Laterality	Unilateral	Both unilateral & bilateral (Haldaj [7])
Sex Distribution	Both sexes	No sex predilection (literature)
Persistent Median Artery	Present	Reported embryonic remnant (Natsis [13])
Palmar Arch Pattern	Incomplete 6.67%	Variable (Patnaik [17]; Chimmalgi [18])
Classification	Type B, C	Coleman & Anson [16]
Embryological Basis	Persistence of vessels	Supported (Lucas [14]; Bergman [24])
Clinical Significance	Surgical risk	Reported widely (Doyle [12])

In [Table 3], a comparative analysis of the present findings with previous literature is summarized, which clearly demonstrates overall consistency with earlier studies and also highlighting the rare coexistence of multiple vascular variations in upper limb.

The rare but clinically significant coexistence of accessory brachial artery, persistent median artery, and incomplete superficial palmar arch observed in the present study emphasizing the complexity of upper limb vascular anatomy and the need for detailed anatomical knowledge for safe clinical practice.

CONCLUSION

It's very essential to have a profound knowledge of variations in the accessory brachial artery and persistent median artery for safe surgical and interventional procedures involving the upper limb. Superficial or anomalous arteries may be mistaken for veins, leading to inadvertent intra arterial injections and vascular injury. Variations in the relationship of the accessory brachial artery to the median nerve may predispose nerve compression and complicate surgical approaches around the arm and cubital fossa.

In procedures such as carpal tunnel surgery, vascular grafting, flap surgeries, and angiographic interventions, the presence of persistent median artery and incomplete superficial palmar arch have important implications due to altered arterial supply to the hand.

A thorough preoperative evaluation has to be done to recognize such rare coexistence of accessory brachial artery, persistent median artery, and incomplete superficial palmar arch, which is crucial for anatomists, radiologists, surgeons, and interventional specialists to prevent complications and ensure accurate diagnosis and safe clinical practice.

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