Institute of Experimental Morphology, Pathology and Anthropology with Museum
Bulgarian Anatomical Society

Acta morphologica et anthropologica, 28 (1-2)
Sofia ● 2021

Rare Anatomic Variation of the Upper Limb Blood Supply: Case Report and Literature Review

Viktor Stoykov[1], Atanas Mitev[1], Ivan Maslarski[1]*

Department of Anatomy, Histology, Pathology and Forensic Medicine, Faculty of Medicine, SU "St. Kliment Ohridski", Sofia, Bulgaria

* Corresponding author e-mail: atanas.vl.mitev@abv.bg

Variations in vasculature of the upper extremity are fairly common and have been extensively studied throughout the years. During standard anatomical dissection of an upper extremity, multiple variations of vasculature were noted. Presence of a brachial artery (BA) with two main arterial stems was noted, with the superficial branch giving two main forearm arteries - a. radialis and a. medioulnaris – and the deep branch continuing in the forearm as the common interosseous artery. Furthermore, an open superficial palmar arch was discovered, with two common palmar digital arteries originating from a. radialis, and the other two from a. ulnaris (a. medioulnaris). To our knowledge, this is the first case report presenting these exact variations simultaneously in a single limb. Larger scale trials are still needed to determine the frequency of similar, multiple variations and to revise and improve existing classifications and terminology.

Key words: deep proper brachial artery (DPBA), superficial brachial artery (SBA), superficial brachioulnoradial artery (SBURA), incomplete arcus palmaris superficialis

Introduction

Variations of the arterial patterns in the upper limb have been the subject of many anatomical studies due to their high incidence. Knowing all the normal anatomical variations and their prevalence is important in clinical practice and crucial for numerous medical procedures like arterial and venous catheterization, creating skin flaps with a consistent vascular pedicle for resurfacing defects, used commonly in reconstructive surgery, surgical management of fractures, compartment syndrome, etc. The presence of a rare vascular pattern can increase the risk of an injury to the blood supply of a superficially located variant artery, or of an accidental injection.

In the course of a routine dissection of upper limb, according to the guidelines prescribed in *"Gray's Clinical Photographic Dissector of the Human Body"* [10], a rare variant of the vasculature pattern was discovered and carefully studied. A presence of a brachial artery (BA) with two main arterial stems was found, with the superficial branch artery giving two main forearm arteries - a. radialis and a. medioulnaris – and the deep

branch continuing in the forearm as the common interosseous artery. Furthermore, an open superficial palmar arch was discovered, with the two common palmar digital arteries originating from a. radialis, and the other two from a. ulnaris (a. medioulnaris).

Materials and Methods

In the past ten years 33 embalmed human bodies were assessed, that included 19 males and 14 females. The variation has been discovered in a routine dissection of a female, right upper limb with medical students in the Medical Faculty of University of Sofia "St. Kliment Ohridski". The cadaver has been fixed with standard solution containing formalin. Three anatomical significant arterial variations were noted. The purpose of this case report is to describe them as a rare, simultaneously occurring variation.

Results

The blood supply of the brachium region begins in a normal fashion, with the axillary artery giving rise to the brachial artery at the distal border of the teres major muscle. The brachial artery then traverses distally in its normal anatomical location and, as noted during performed measurements, has a diameter of around 0,8 cm. As seen in **Fig. 1**, the artery first gives rise to the profunda brachii artery, 4 cm after its emergence. This branch, as noted during examination, has no notable variability, traverses backwards to the posterior region of the brachium where it gives non-variable branches and is accompanied by the radial nerve. After this initial branching, the brachial artery soon bifurcates at the 7,5 cm mark, around the level of origination of the brachialis muscle, into two large vessels of similar size and caliber. Their relation regarding the median nerve was noted, with the anterior branch positioned in front, and the posterior branch positioned behind the nerve.

The superficial brachial artery (SBA) was found to have a fairly convoluted course through the brachium and was positioned similarly to a normal brachial artery regarding surrounding structures. It was found to give muscular branches before entering the cubital fossa at the level of a normal, non-variable brachial artery. Around the elbow the artery was found to pass through the medial portion of the cubital fossa after which it branched into two large vessels – the radial artery (RA) laterally, and a very superficially positioned branch medially, which was later named as the medioulnar (MU) or superficial ulnar (SU) [1, 3] artery of the forearm.

Fig. 1. Demonstration of the origin of the deep brachial artery and the division of the brachial artery into superficial brachial artery and deep proper brachial artery.

The deep proper brachial artery (DPBA) traverses distally behind the median nerve and gives four

branches, all arising from its medial aspect. The two larger branches were identified as the superior collateral ulnar and the inferior collateral ulnar arteries (**Fig. 2**). The smaller ones were muscular branches. The artery then passes immediately under the superficial brachial artery in the cubital fossa at the level of the elbow, after which it leaves the elbow region and angles posteriorly where it lies deep between the forearm muscles and gives rise to the common interosseous artery, which terminates into its two main branches: the anterior and posterior interosseous arteries.

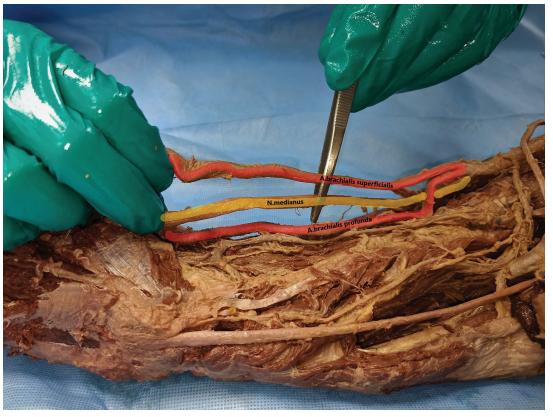


Fig. 2. The brachial artery divides into two main stems, one running behind and the other in front of the median nerve: superficial brachial artery and the deep proper brachial artery

At the level of the forearm (antebrachium), the radial artery was found to have a non-variable course, structure and branching. It travels down from the medial aspect of the neck of the radius to the styloid process of the anterior surface of the radius. In its proximal part it lays deep to the brachioradialis muscle, while distally it was covered only by fascia and skin. During its course in the forearm it was found to give off standard arterial branches as follows: the recurrent radial artery, palmar carpal branches and the superficial carpal branch. The medioulnar artery branches off from the superficial brachial artery at the lower border of the cubital fossa (**Fig. 3**). From its beginning it travels distally in an oblique fashion and is positioned above the muscles of the anterior group of the forearm. In the proximal half of the forearm the artery crosses above the muscle bodies of the pronator teres and flexor carpi radialis muscle. In the distal part of the forearm the artery navigates to the typical anatomical position of the ulnar artery (UA), and lays between the flexor carpi ulnaris and flexor digitorum superficialis. In the wrist it is situated in a similar fashion to the non-variable ulnar artery and passes through Guyon's channel. After passing the lower border of the cubital fossa, the deep proper brachial travels distally and posteriorly between the muscles of the anterior compartment of the hand where it gives of several arterial branches. Here we identified the anterior and posterior ulnar recurrent branches, after which the deep proper brachial artery continues as the common interosseous artery. This artery then gives its two main terminal branches in the anterior and posterior interosseous arteries, which on the cadaver showed no variations.

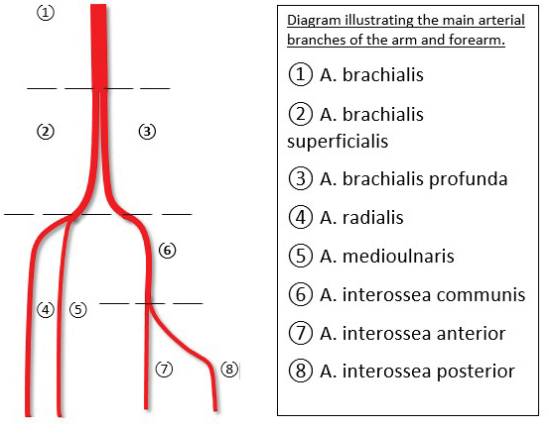


Fig. 3. Illustration of the main arterial branches of the arm and forearm by Stoykov V., Mitev A., Maslarski I.

In the palmar region, an incomplete SPA was visualized. The superficial palmar branch of the radial artery entered the hand deep to the abductor pollicis brevis muscle, giving off two common digital arteries and a digital artery to the thumb. The first common digital artery gave two proper digital arteries for the blood supply of the thumb and index finger, and the second common digital artery gave two proper digital arteries for the blood supply of the ulnar side of index finger and radial side of the middle finger. On the ulnar side, we found a superficial branch of ulnar artery entering the hand, superficial to the flexor retinaculum. After giving off a deep palmar branch (*r. palmaris profundus*), two common palmar digital arteries and a proper palmar digital artery for the ulnar side of the little finger were observed. The two common palmar digital arteries gave off two proper digital arteries each. One for the radial side of the little finger and the ulnar side of the ring finger, and the other for the radial side of ring finger and ulnar side of middle finger.

Discussion

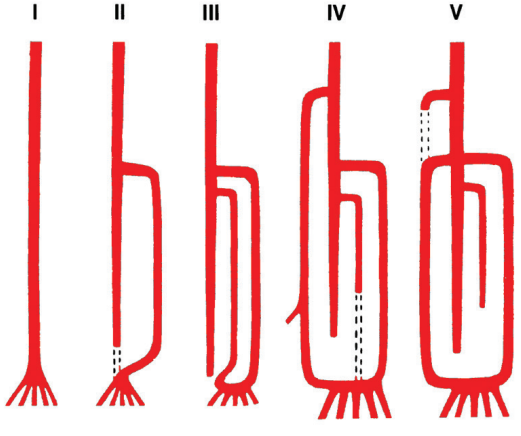
To understand the different patterns of blood supply of the upper extremity, a complete knowledge of the embryological development of the vascular system is required. As a detailed description of the embryological development is beyond the scope of this article, this chapter is restricted only to a brief explanation and illustration of the embryology of the arteries of the upper extremity.

According to *Senior* [14], in the embryonic development of the arteries of the upper limb, five stages can be recognized **(Fig. 4).**

Stage I: The axial artery of the arm develops from the sixth cervical segmental artery, recognized for the first time in an embryo of 4-7 mm. The proximal part of the axial artery becomes the brachial artery (BA) and the distal portion becomes the interosseous artery.

Stage II: At this stage, a median artery develops as a main artery which runs with the median nerve. The interosseous artery subsequently undergoes atrophy.

Stage III: Observed in human embryos of approximately 18 mm in length. The ulnar artery arises from the BA, which anastomoses with the median artery to form the superficial palmar arch, which supplies the arteries of the fingers.



Stage IV: Observed in human embryos of app. 21 mm in length. The key point of the stage is the development of a superficial brachial artery (SBA).

Stage V: Three consecutive changes occur: the median artery undergoes atrophy, the SBA gives off

Fig. 4. Diagram illustrating the five stages of development of the arteries of the arm by Stoykov V., Mitev A., Maslarski I.

a distal branch anastomosing with the superficial arch, and, at the level of the elbow, an anastomotic branch between the BA and the SBA hypertrophies, becoming the radial artery.

After performing a literature review, such variation was noted in a number of sources [1, 5, 6], and the arteries were deemed to be the superficial brachial artery and the deep brachial artery. This posed a problem, because in Anglo-Saxon literature this artery is also called the "deep brachial artery". To avoid confusion, for the purpose of this article, we will refer to the deep laying branch relative to the median nerve as the deep proper brachial artery. A frequency of up to 14% of this variation was described in cited literature [1, 9, 11]. Both arteries continued distally in the anterior region of the brachium and medially regarding the long head of the biceps. The diameter of the arteries after the point of bifurcation was noted to be 0,6 cm (SBA) and 0,5 cm (DPBA).

Singular arterial variations of the upper extremity are frequent occurrences that have been extensively researched through the years. A widely accepted general classification still doesn't exist, which makes comparing data and individual cases difficult. That is particularly true in cases where multiple, concurrent variations exist. Regarding the currently presented case, a literature review was performed, which aimed to establish the novelty (or lack thereof) of the observed multiple variations, and to try to classify them as accurately as possible.

The presence of a superficial brachial artery has been frequently described [1, 5]. Extensive studies on the topic have been performed in the past using a large number of cadavers, which have reported a very variable frequency ranging from 3% to 22%. Some of these authors [3, 4, 12] have proposed terminology (mostly based on the topographical approach) which is still widely accepted today. The term superficial brachial artery stems from the position of the structure regarding the median nerve. As per McCormack et al. [11] the superficial brachial artery "lies superficial to the median nerve in an abnormal site and forms a common stem of origin for the radial and ulnar arteries". This explanation could lead to oversimplification and confusion because of different reasons. For example the superficial brachial artery can be a singular large arterial entity arising in the arm, and continuing in forearm, but it can also be an accessory artery, accompanied by another large arterial vessel following bifurcation at some point in the arm (as in this case report).

Furthermore, during the literature review, it was noted that not only structures that continue in the forearm as the radial and ulnar arteries were named as the *SBA*, but also structures which had a variable course in the forearm (i.e. SBA continuing as only the radial orulnar arteries) [9, 11, 13]. For these reasons, authors of newer studies have attempted to propose a different approach regarding terminology **(Fig. 5)**. For example Rodríguez-Niedenführ et al. [13, 15] have proposed different terms for an accessory artery situated in front of the median nerve, based on its continuation in the forearm, which are as follows:

Fig. 5. A. *brachialis superficialis* (SBA) dividing into *a. radialis* and *a. medioulnaris* (MUA).

- brachioradial artery – when it continues as the radial artery in the forearm
- superficial ulnar artery – for ulnar artery with a high origin, which courses over the superficial forearm flexor muscles
- superficial brachioulnoradial artery (SBURA) – for an accessory, superficial brachial artery dividing at elbow level into radial and ulnar arteries and coexisting with a "normal" brachial artery that continues as the common interosseous trunk in the forearm

In accordance to the described classification, the authors have revised the previously described definition of a superficial brachial artery given by McCormack et al., [9] to become the following "The superficial brachial artery represents a brachial artery, which instead of coursing deep to the median nerve runs in front of it after adopting its superficial course. This variation does not present any further deviation from the norm and at the elbow it branches into the forearm arteries". In such, they have attempted to preserve the specificity of the term and to give further, more complex description of different variations. For the purpose of this case report we find the term superficial brachioulnoradial artery appropriate, as it describes fully the observed variation on our cadaver.

Following the bifurcation at the arm, the deep artery, relative to the median nerve, passes through the cubital fossa to enter the forearm and continue as the common interosseous branch. A frequency of occurrence was difficult to determine, as most articles focused on examining the superficial branch, but incidence of two main arterial stems was noted as around 8-14% [13, 14]. In existing literature this vessel was named as the brachial artery [1, 7, 11]. This seemed to imply a logic that the structure is a direct continuation of the brachial artery before the point of bifurcation, with which in this presented case we don't agree, because the distal course of the artery does not follow the path of a non-variable brachial artery, and continues as the common interosseous artery in the forearm **(Fig. 6)**. As stated previously in the article, we propose the secondary brachial branch, positioned deep to the median nerve to be called the deep proper brachial artery, which in our opinion is an accurate topographic description that avoids confusion with the brachial artery (*a.brachialis*) before the point of bifurcation,the deep brachialartery (*a.profunda brachii)*.

At the level of the proximal forearm the SBA bifurcates into two branches: the radial artery (RA) and the medioulnar (MUA) or superficial artery (SUA). The term MUA was found in one source [2], while SUA was more frequently noted [1, 11, 13]**.** The frequency of this variation was found to be between 0.7% and 7% [1, 5]. The artery was found to give only muscular branches on its course through the forearm. Only one more such case was noted during the literature review [13, 16]. This particular variation presents an interesting clinical significance because of its superficial position in the proximal and middle third of the

Fig. 6. Incomplete (open) superficial palmar arch, first two common palmar digital arteries originate from *a. radialis*, the other to originate form a. ulnaris (*a. medioulnaris*, MUA).

forearm, which makes it vulnerable to trauma, accidental intra-arterial injections and accidental intraoperative lacerations.

According to a meta-analysis performed by Zarzecki et al. [16] an incomplete SPA was observed in 18.7% of all cases. The most common pattern observed was a complete arch with radio-ulnar anastomosis (72%), the variant included in most anatomical textbooks or atlases. As reported by Janevski [5], this variant is classified as type D and is seen as a very uncommon pattern, observed in only 2% of the cases. According to Coleman's classification [4], based on a study on 650 specimens, the variation observed in our cadaver is described as type A incomplete SPA, with a frequency of 3.2%.

Plenty of medical procedures are affected by the above mentioned arterial variations. Some of them include RA harvesting for coronary artery bypass grafting, RA cannulation and RA arterio-venous fistulas used for hemodialysis. The RA graft, in particular, is seen as a reliable source because of the diameter of the artery, its thickness and resistance are all appropriate for myocardial revascularization. RA cannulation is also performed for continuous monitoring of blood pressure and arterial blood gas analysis in major surgeries and intensive care units. There is increased risk of ischemia of the hand in incomplete SPA, therefore it should be checked if possible prior to any major procedures.

Conclusion

To the best of our knowledge, this is the first case report describing simultaneously occurring double brachial arteries, medioulnar artery and an incomplete superficial palmar arch in a cadaver. Although this, most likely, is a very rare multiple variation in a single limb, it again emphasizes the need for clinicians to be vigilant of possible typical and atypical vascular variations. This report should be of great interest to reconstructive hand surgeons, where the described variation of a very superficially lying MU artery continues into an incomplete SPA. The MU artery in this case, which is of similar caliber as the RA, can be easily injured during various surgical approaches to the forearm. Potential injury to this artery could lead to tissue ischemia of the ulnar side of the hand and the fourth and fifth digit.

Although this is not the target of this case report, we feel that it is important to research multiple simultaneously occurring vascular variations and their possible clinical consequences. There is a need for large scale population studies which examine the incidence rates of concomitant variations and the correlation between them. We feel that a byproduct of such research could be the creation of a new, improved and unified classification system, which would better suit further research and clinical needs.

References

1. **Adachi, B.** *The artery system of Japanese*. Kyoto, Maruzen Press, **1**, 1928, 285-356. [In German].
2. **Al-Fayez, M., Z. KaimkhanI, M. Zafar, H. Darwish, A. Aldahmash, A. Al-Ahaideb**. Multiple arterial variations in the right upper limb of a Caucasian male cadaver. – *Int. J. Morphol.* **28**, 2010, 659-665.
3. **Chin, K., K. Sing**. The superficial ulnar artery - a potential hazard in patients with difficult venous access. – *British Journal of Anaesthesia,* **94**, 2005, 692-693.
4. **Coleman, S., B. Anson**. Arterial patterns in the hand based upon a study of 650 specimens. – *Plastic and Reconstructive Surgery*, **29**, 1961, 85-86.

5. **Janevski, B.** Anatomy of the arterial system of the upper extremities. Angiography of the upper extremity. – *Series in Radiology*, **7**, 1982, 41-122.
6. **Kachlic D. V. Musil, V. Baca.** Contribution to the anatomical nomenclature concerning upper limb anatomy. – *Surg. Radiol. Anat*., **4,** 2017, 405-417.
7. **Keen, J**. A study of the arterial variations in the limbs with special reference to symmetry of vascular patterns. – *Am. J. Anat.,* **61**, 1961, 245-261.
8. **Konarik M, V. Musil, V. Baca, D. Kachlik.** Upper limb principal arteries variations: A cadaveric study with terminological implication. – *Bosn. J. Basic. Med. Sci*., **4**, 2020, 502-513.
9. **Lippert, H., R. Pabst**. *Arterial variations in man*, J.F.Bergmann-Verlag 2011, pp.128.
10. **Loukas, M., B. Benninger, R. Tubbs**. *Gray's clinical photographic dissector of the human body*. 2nd edition, 2018, pp.480.
11. **McCormack, L., E. Cauldwell. B. Anson**. Brachial and antebrachial arterial patterns. – *Surg. Gynae. Obs*., **96**, 1953, 43–44.
12. **Miller, E.** Observations upon the arrangement of the axillary artery and brachial plexus. – *American Journal of Anatomy*, 64, 1939, 143-163.
13. **Rodriguez-Niedenfuhr M., T. Vazquez, L. Nearn, B. Ferreira, I. Parkin, J. Sanudo.** Variations of the arterial pattern in the upper limb revisited: a morphological and statistical study, with a review of the literature. – *J. Anat.,* **199**(5), 2001, 547-566.
14. **Senior, H.** A note on the development of the radial artery. - *Anat. Rec*., **32**, 1926, 214-220.
15. **Sharma, T., R. Singla, K. Sachdeva.** Bilateral superficial brachial artery. – *Kathmandu University Medical Journal,* **7**, 1970, 426-428.
16. **Zarzecki, M., P. Popieluszko, A. Zayachkowski, P. Pekala, B. Henry, K. Tomaszewski.** The surgical anatomy of the superficial and deep palmar arches: a meta-analysis. – *J. Plast. Reconstr. Aesthet. Surg*., **71**, 2018, 1577-1592.