




# Superficial brachioulnar artery in man

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*The individual arterial pattern of the upper limb is considerably variable (11–24%) and relevant for intraarterial interventions performed by cardiologists, plastic and vascular surgeons, radiologists, anaesthesiologists, transplant specialists, orthopaedists and neurosurgeons. Arterial variants in the upper limb result from modifications in the maintenance and regression of the initial capillary plexus, which forms dominant arterial channels and gradually expands into the growing upper limb bud between stages 12 and 21. In this case report we present the superficial brachioulnar artery with its external diameter of 3 mm and length of 525 mm, and of relevant course in the left upper limb of a 78-year-old male Caucasian formalin-fixed cadaver. The superficial brachioulnar artery unusually started with the superior part of axillary artery, presented the following five parts: axillary, brachial, cubital, antebrachial and palmar, and was finally continuous with the superficial palmar arch. The typical ulnar artery was somewhat hypoplastic and limited to the forearm. To the best of our knowledge, this is the first report in the professional literature to describe the start of the superficial brachioulnar artery with the superior part of axillary artery. We conclude the individual arterial pattern of the upper limb to be indispensably recognised preoperatively, so as to circumvent any unwanted injuries to the superficial brachioulnar artery that is considerably large, overlies the antebrachial fascia and supplies the superficial palmar arch. (Folia Morphol 2023; 82, 4: 936–942)*

**Key words:** superficial brachioulnar artery, superficial ulnar artery, axial artery, arterial variants, variant origin of ulnar artery, upper limb, Rodriguez-Niedenführ classification

## INTRODUCTION

The arterial supply to the upper limb is derived from the subclavian artery and consecutively comprises the following arteries: the axillary artery in the axillary cavity, the brachial artery in the arm that bifurcates in the cubital fossa into the ulnar and radial arteries. Both the ulnar and radial arteries traverse the forearm and enter the hand to end in the superficial and deep palmar arches, respectively. The boundaries between

the subclavian and axillary arteries, the axillary and brachial arteries, and the brachial and both antebrachial arteries refer to the following levels: the outer border of rib I, the inferior border of teres major muscle and the neck of radius, respectively [1–4, 6, 22–25, 29].

Rodriguez-Niedenführ et al. [22–25] proposed the comprehensive terminology for arterial variants in the upper limb. An atypical origin of the radial artery from either the axillary artery in the axillary cavity or the

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brachial artery in the arm used to be called a “high origin of the radial artery” or “high bifurcation of the brachial artery”, and now is referred to as the brachioradial artery, with the reported incidence of 4.67% to 15.6% [4, 22–25]. On the other hand, an ulnar artery with a high origin that courses over the superficial forearm flexor muscles and displays a kind of relevant aberrant artery in the arm and forearm is defined as the superficial brachioulnar artery (SBUA) [22–25]. The incidence of the SBUA ranges from 0.67% to 9.38%, with only 0.17% to 2% starting with the axillary artery [19]. It may originate from either the axillary artery [6, 10, 11, 14, 16, 18, 19, 22–25, 30, 31] or the brachial artery [3, 17, 28, 30, 31], passes deeply in the arm, mostly traverses subcutaneously in the forearm or rarely underlies the antebrachial fascia, and finally ends in the superficial palmar arch.

The arterial arrangement of the upper limb is undoubtedly relevant for intraarterial interventions performed by cardiologists, plastic and vascular surgeons, radiologists, anaesthesiologists, transplant specialists, orthopaedists and neurosurgeons [1–8, 11, 12, 17, 18, 21, 26, 27]. The incidence of anatomic variations of the major arteries of the upper limb ranges from 11% to 24% [19]. Failure to recognize or appropriately manage the SBUA may result in a compromised surgical outcome [8]. Since the SBUA usually arches and overlies the antebrachial fascia it may inadvertently be mistaken for either a superficial antebrachial vein or superficial phlebitis, and so be injured by presumptive venipuncture [9, 11, 15, 25, 26, 30]. Such a large subcutaneous artery in the forearm is prone to unwanted injury and brings an elevated risk of bleeding complications in unexpected situations [3, 5, 6, 9, 11, 13, 14].

In the present case report we have described the unique SBUA — with its external diameter of 3 mm and length of 525 mm — which unusually originated from the superior part of axillary artery, in the arm passed superficially to the median nerve, overlay the antebrachial fascia, reached the distal one-fourth of the ulnar antebrachial groove, and finally ended in the superficial palmar arch. To the best of our knowledge, this is the first report in the professional literature to describe the origin of the SBUA from the superior part of axillary artery.

## CASE REPORT

We report on the SBUA, arising from the superior part of axillary artery, which was encountered in the

left upper limb of a 78-year-old male Caucasian embalmed cadaver during a routine didactic dissection at Department of Normal Anatomy of Ludwik Rydygier Collegium Medicum in Bydgoszcz of Nicolaus Copernicus University in Torun in the academic year 2021/2022. The consecutive course of SBUA was then carefully dissected and documented (Fig. 1A–E).

The SBUA passed transitionally throughout its course in the arm and forearm, without giving off any branches. In the hand it was continuous with the superficial palmar arch. In terms of topography, the SBUA presented the following five parts: axillary, brachial, cubital, antebrachial and palmar. The external diameter of the SBUA was 3 mm throughout its course.

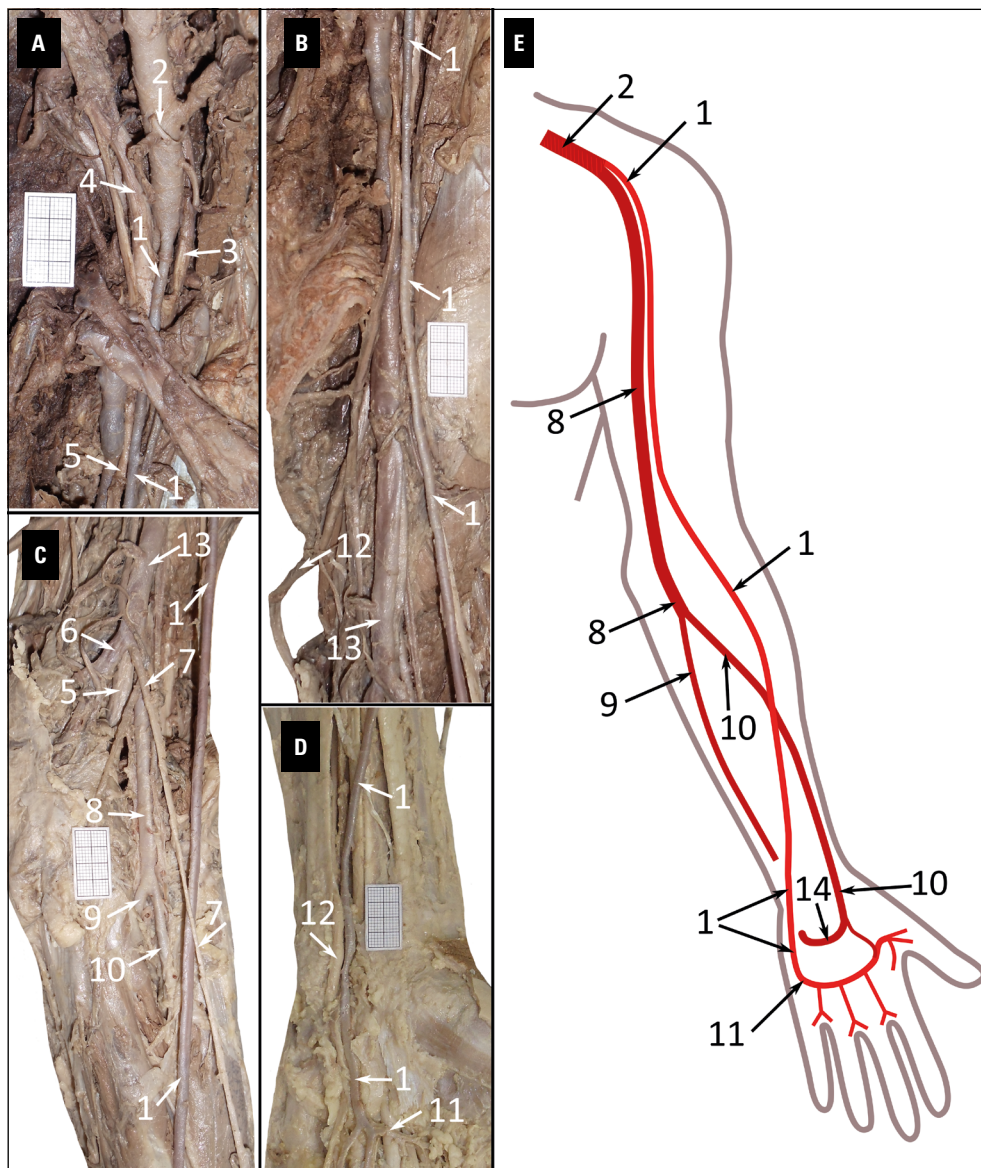
The axillary part of SBUA with its length of 73 mm stemmed anteriorly from the superior part of axillary artery, some 35 mm proximally to the pectoralis minor muscle, just between the medial and lateral roots of median nerve. It passed deeply in the axillary cavity, as an anterolateral relation of the median nerve. On exiting the axilla, the SBUA entered the medial bicipital groove.

The brachial part of SBUA with its length of 121 mm traversed the medial bicipital groove subjacent to the brachial fascia and was positioned both superficial to the brachial artery and lateral to the median nerve. While descending in the arm, the SBUA gradually deviated laterally from the brachial artery.

The cubital part of SBUA with its length of 79 mm assumed the most lateral and superficial position in the cubital fossa. It was crossed anteriorly by the hypoplastic cephalic vein; the latter together with the basilic vein formed the brachial vein.

The antebrachial part of SBUA with its length of 192 mm proceeded superficially since it overlay the antebrachial fascia, and followed from radial to ulnar, without any concomitant structures. Before approaching the ulnar nerve in the distal one-fourth of the ulnar antebrachial groove, the SBUA through the antebrachial fascia crossed anteriorly the three antebrachial flexors: pronator teres muscle, flexor carpi radialis muscle and palmaris longus muscle. After reaching the end of ulnar antebrachial groove the SBUA adopted the course of a typical ulnar artery.

The palmar part of SBUA with its length of 73 mm overlay the carpal tunnel, by passing through the ulnar canal of Guyon, along the radial side of the pisiform bone. After crossing the ulnar side of the hook of hamate bone it directed radially, so as to be continuous with the superficial palmar arch.



**Figure 1. A–E.** The consecutive course of the superficial brachioulnar artery through the axillary cavity, arm, cubital fossa, forearm and palm: 1 — superficial brachioulnar artery; 2 — axillary artery; 3 — lateral root of median nerve; 4 — medial root of median nerve; 5 — median nerve; 6 — basilic vein; 7 — hypoplastic cephalic vein; 8 — brachial artery; 9 — ulnar artery; 10 — radial artery; 11 — superficial palmar arch; 12 — ulnar nerve; 13 — brachial vein; 14 — deep palmar arch.

It is noteworthy that in the present case both the ulnar and radial arteries started typically at the brachial artery bifurcation, but the former was somewhat hypoplastic. The course of the hypoplastic ulnar artery was limited to the forearm alone. Consequently, the ulnar artery did not reach the hand, being completely excluded from the formation of the superficial palmar arch.

### DISCUSSION

In order to comprehensively discuss the SBUA its following three aspects will successfully be emphasized: the embryology, variability and clinical aspects.

### Embryology of the SBUA

In terms of embryology, at stage 12 the upper limb bud is solely supplied by an initial capillary plexus, which is a derivative of the dorsal aorta. The maturation, enlargement and remodelling of this initial capillary plexus extends in a proximal to distal sequence as the bud of upper limb grows, finally resulting in formation of a single vessel, called the axial artery [2–4, 23, 29]. The axial artery consecutively differentiates into its following four segments: subclavian and axillary arteries by stage 15, the brachial artery extending until the elbow by

stage 17 and the anterior interosseous artery by stage 18 [23, 27].

Formation of the subclavian artery indicates bilateral differences: the left subclavian artery is wholly derived from the left seventh intersegmental artery, while the right subclavian artery is a derivative of three arteries: the right fourth aortic arch, a segment of the right dorsal aorta and the right seventh intersegmental artery [27, 30]. The axillary, brachial and anterior interosseous arteries traverse the shoulder, the arm and the forearm, respectively. The anterior interosseous artery ends in the palmar plexus, i.e. the primitive deep palmar arch. Due to both an angiogenic sprouting mechanism and remodelling of the initial capillary plexus by stage 18 develop the proximal part of the radial artery arising from the brachial artery, and antebrachial arteries: the median and posterior interosseous arteries, followed by the ulnar artery. The posterior interosseous artery is destined for the extensor compartment of forearm, while the median artery accompanies the median nerve and ends in the primitive superficial palmar arch. It should be emphasized that the radial artery is “youngest”, being definitively formed as late as stage 21.

Regression of the distal part of the median artery results in its disconnection from the primitive superficial palmar arch, which by stage 18 is joined by the ulnar artery, a branch of the primary anterior interosseous artery. Afterwards, regression of the distal part of the anterior interosseous artery results in its disconnection from the primitive deep palmar arch, which is soon joined by the distal part of the primitive radial artery, arising in the middle of the brachial artery. After the proximal part of the primitive radial artery — referring to the inferior half of arm — atrophies, the brachial artery somewhat above the ulnar artery origin gives off a short stem of the radial artery, which joins the primitive radial artery in the cubital fossa and together form the radial artery by stage 21. The proximal segment of the primary anterior interosseous artery between origins of the radial and ulnar arteries is finally involved into the ulnar artery. It is noteworthy that the ulnar artery was primarily a branch of the anterior interosseous artery, but after the proximal segment of the anterior interosseous artery was incorporated in the ulnar artery, the anterior interosseous artery became a branch of the ulnar artery. The definitive arterial pattern of the upper limb is organized by stage 21.

Unlike the modified sprouting theory developed by Poteat [20], according to Rodriguez-Niedenführ et al. [23], certain capillary vessels maintain, enlarge and differentiate into arteries, while the others regress, resulting in dominant arterial channels, which form the final individual arterial pattern, including anomalous arteries. The SBUA results from the embryological abnormality, called the superficial brachial artery [2, 18, 23]. The superficial brachial artery probably develops from branches of the sixth and seventh cervical intersegmental arteries, finally stems from either the axillary artery or the brachial artery, passes deeply in the arm — but superficial to the median nerve — and superficially in the forearm. Its superficial course with relation to the median nerve may result in its entrapment neuropathy [2]. In the forearm the superficial brachial artery may end in a four-fold manner. Firstly, it may substitute for the hypoplastic ulnar artery and adopts its distal course as the SBUA [11, 14, 16–19, 22–25, 30, 31], described in the present case report. Secondly, the superficial brachial artery adopts a typical radial artery as the superficial brachioradial artery [13]. Thirdly, the superficial brachial artery may bifurcate and contribute to the superficial brachioulnoradial artery [23]. Fourthly, the superficial brachial artery adopts the superficial brachiomedian artery [23].

#### Variability of the SBUA

The variability of the arterial tree in the upper limb was unequivocally unified by the Rodriguez-Niedenführ classification [23]. Anomalous arteries are named after a combination of their topography and ending, and their deep or superficial position as superficial brachial, superficial brachioradial, superficial brachioulnar, superficial brachioulnoradial and superficial brachiomedian arteries. All these anomalous arteries are formed as late as the arrangement of the brachial artery is definitively achieved, i.e. stage 17 onwards [4, 23].

In the professional literature, the SBUA was precisely described in human cadavers by anatomical dissection [3, 5, 6, 16, 17, 22, 24] and in a minority in embryos by three-dimensional reconstruction [23, 25] and in living subjects by angiography [30], Doppler ultrasound [16] and raising of antebrachial flaps [5, 21]. Typically, the SBUA originates from either the inferior part of axillary artery just below the subscapular artery [9, 11, 14, 16, 18, 19, 22–25, 30, 31] or from the proximal half of brachial artery [3, 10, 17, 31].

Sporadically, the SBUA may stem from the middle part of axillary artery [7, 10, 19]. After reviewing the professional literature, we failed to find the SBUA arising from the superior part of axillary artery, as presented in this case report. Thus, to the best of our knowledge, this is the first report in the professional literature to present the SBUA, which originates from the superior part of axillary artery.

After originating from the axillary artery, the SBUA underlies the brachial fascia, crosses in front the medial and lateral roots of median nerve, and afterwards descends superficially to the median nerve, as does the SBUA originating from the brachial artery [25]. It is usually subjacent to the bicipital aponeurosis, less commonly overlies it, and sporadically perforates it to assume an epifascial position in the forearm [25]. The SBUA crosses superficially the common flexor tendon, usually overlies the antebrachial fascia and sporadically underlies it to eventually adopt its typical position in the inferior half of ulnar antebrachial groove [25].

Because the SBUA is of great variability, its blood supply territory may consequently be highly variable [3]. The reported overall incidence of the SBUA ranges from 1% [30] to 9.38% [5]. As emphasized by Rodriguez-Niedenführ et al. [25], the SBUA more commonly originated from the brachial artery when compared to the axillary artery. The origin of SBUA from the axillary artery changed from 0.17% to 2% [11, 18, 22–25, 30, 31], while from the brachial artery was found in 4.2% [25]. The combination of bilateral SBUA originating from the axillary arteries appears to be extremely rare [6, 10, 11]. Gupta et al. [10] found the bilateral SBUA, in both upper limbs originating from the middle part of axillary artery. The left SBUA unusually underlay the antebrachial fascia and sent off a few muscular branches to superficial antebrachial flexors, while the right one overlay the antebrachial fascia; bilateral arteries were continuous with the superficial palmar arch.

#### Clinical aspects of the SBUA

Vascular anomalies in the arm and forearm tend to increase the likelihood of damaging the superficial anomalous arteries during surgery [21]. Thus, awareness of numerous arterial variations in the upper limb is of great interest to clinicians of different specialties: cardiologists, plastic and vascular surgeons, and radiologists for successful interventional and surgical procedures — including native arteriovenous fistulae

for dialysis — anaesthesiologists for monitoring vital signs during invasive procedures and in the intensive care unit, orthopaedists and neurosurgeons while performing surgery in the carpal tunnel or the ulnar canal of Guyon. The use of antebrachial arteries for coronary artery bypass grafting indispensably requires accurate knowledge of the pattern and extent of anomalous vessels, including the SBUA [10]. As a pulsatile vessel, the SBUA may easily be diagnosed preoperatively by careful palpation, and its course may precisely be confirmed by vascular Doppler ultrasound [3, 5]. The SBUA in the forearm gives off several adequate fasciocutaneous branches, on which a fasciocutaneous flap, similar to a radial forearm flap, may be raised with safety [5, 9, 11, 21]. Otherwise, when raising forearm flaps in reconstructive surgery any accidental damage to the SBUA can seriously jeopardize hand circulation [5]. The usefulness of the flap with the SBUA lies in its uncomplicated dissection, preservation of both antebrachial arteries, and thus circumventing any vascular compromise to the upper limb [22]. An understanding of anomalous antebrachial arteries prerequisites the creation of autogenous fistulae in patients undergoing haemodialysis [10, 12]. During the surgical creation of another arteriovenous fistula from a transposed basilic vein in a patient with the radial artery occluded due to thrombosis of a previously performed radiocephalic fistula Frunze et al. [7] found the SBUA to be closely related to the course of the basilic vein. Had these authors ligated the SBUA during preparation of the basilic vein, a blood flow to the palmar arches would have been stopped completely, causing hand ischaemia. The presence of the SBUA may lead to accidental intraarterial injection or misinterpretation of angiographic images during surgical procedures in the upper limb [10].

#### CONCLUSIONS

While surgery in the upper limb is required, the individual arterial pattern should indispensably be recognised, so as to circumvent any unwanted injuries to the main supplying artery of unusual course like the SBUA.

The SBUA is a transitional vessel in the arm and forearm that substitutes for the distal part of the typical ulnar artery and is continuous with the superficial palmar arch.

**Conflict of interest:** None declared

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