

# A coincidental variation of the axillary artery: the brachioradial artery and the aberrant posterior humeral circumflex artery passing under the tendon of the latissimus dorsi muscle

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## ABSTRACT

A case of anomalous terminal branching of the axillary artery was encountered and described in a left upper limb of a male cadaver. A series of 214 upper limbs of Caucasian race was dissected. A variant artery, stemming from the very end of the axillary artery followed a superficial course distally. It passed the cubital fossa, ran on the lateral side of the forearm as usual radial artery, crossed ventrally to the palm and terminated in the deep palmar arch. This vessel is a case of the brachioradial artery (incorrectly termed as the "radial artery with high origin"). Moreover, it was associated with another variation, concerning the aberrant posterior humeral circumflex artery passing under the tendon of the latissimus dorsi muscle. The anatomical knowledge of the axillary region is essential for radiodiagnostic, surgical and traumatologic procedures. The superficially located artery brings an elevated danger of heavy bleeding in all unexpected situations, its variant branching can cause problems in radial catheterization procedures and the anomalously coursing other arterial variant poses an elevated danger in surgical procedures concerning the surgical neck of humerus.

KEYWORDS: anatomical variations, brachioradial artery, posterior humeral circumflex artery, upper limb; coincidental

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## INTRODUCTION

The development of the upper limb arteries is not a simple process and is closely related to the bone development [1]. The brachioradial artery (*arteria brachioradialis*, BrA) is the most common variation of the arteries of the upper limb. Anatomically, the BrA is the radial artery (*arteria radialis*, RA), featuring a „high origin“, which means that the RA originates not as a terminal branch of the brachial artery (*arteria brachialis*, BA) by bifurcation within the cubital fossa (*fossa cubitalis*), but more proximal, either from the BA anywhere along the course of the arm, or directly from the axillary artery (*arteria axillaris*, AA). The course of the BrA is then either similar to the BA, i.e. it descends along the

proper brachial artery, situated more ventrally and laterally, or more rarely, it can get more superficial and cross the median nerve (*nervus medianus*) ventrally; then it should be termed as the superficial brachioradial artery (*arteria brachioradialis superficialis*) [1,2]. The incidence of the BrA is reported to be 13.8% on average [3]. The posterior humeral circumflex artery (*arteria circumflexa humeri posterior*, PHCA) stems from the AA at the distal border of the subscapularis (*musculus subscapularis*) from the proximal segment of the infrapectoral (last, third) part of the AA and runs dorsally into the quadrangular space (*foramen humerotrici-pitale, spatium axillare laterale*) together with the axillary nerve (*nervus axillaris*). The PHCA curves around the surgical neck of humerus to supply the shoulder joint, the deltoid (*musculus deltoideus*), the teres major, the teres minor and the long and lateral head of triceps. The PHCA can anastomose with the deltoid branch of profunda brachii artery (*ramus deltoideus arteriae profundae brachii*), the largest branch from the BA, given off not far from the arbitrary beginning of the BA (at the level of the distal margin of the

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teres major) in the very proximal arm. The PHCA can further anastomose with the deltoid branch of thoracoacromial artery (*ramus deltoideus arteriae thoracoacromialis*) and the acromial branches of suprascapular artery (*rami acromiales arteriae suprascapularis*).

The terminology applied strictly follows the last revision of the Latin anatomical nomenclature, as analyzed in our previous papers [4-6]. The terms from variant anatomy follow the recommendation of *Rodriguez-Niedenführ* [3].

## MATERIALS AND METHODS

The body of a 68-years-old female donor, injected and fixed with the classical formaldehyde method, was routinely dissected at the Department of Anatomy, Third Faculty of Medicine, Charles University in Prague, Czech republic, as a part of larger study concerning 214 limbs. Both upper limbs were carefully dissected from the axillary fossa as far as the distal palm. Two arterial variations close to each other were observed and documented, present only unilaterally, in the left limb.

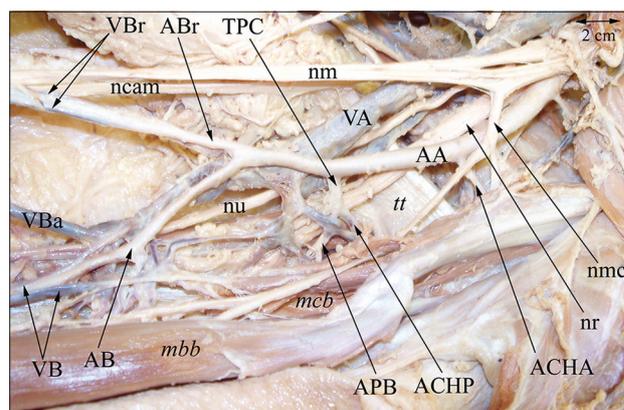
The project has been approved by a Ethics Commission of the Third Faculty of Medicine, Charles University in Prague and that it conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000) and all human subjects gave written informed consent and donors anonymity has been preserved.

## RESULTS

The proximal variant registered was the posterior humeral circumflex artery, stemming from an abnormal site (see Figure 1).

It originated from a trunk (profundocircumflex trunk; *truncus profundocircumflexus*), a short and thick vessel (caliber 6mm) which bifurcated into the proximally ascending PHCA (caliber 5mm) and distally descending PBA (caliber 5mm). The origin site for PHCA was shifted distally from the infrapectoral part of the AA to the very proximal part of the BA, immediately below the inferior margin of the insertion muscle tendons. The short profundocircumflex trunk ran horizontally and laterally. Thus, the PHCA could not pass through its usual topographical site – the quadrangular space (*foramen humerotricipitale*) – but after leaving the trunk, it coursed underneath the fused tendons of the proximal teres major and distal latissimus dorsi. Then it turned up and ascended behind the tendon to the usual position at the level of the quadrangular space, where it ramified and entered the deltoid.

The profunda brachii artery was given off from the trunk bifurcation distally, approached the radial nerve (*nervus*



**FIGURE 1.** Ventral aspect of the axilla and proximal arm with respect to the arteries and veins. Legend: AA – arteria axillaris, AB – arteria brachialis, ABr – arteria brachioradialis, ACHA – arteria circumflexa humeri anterior, ACHP – arteria circumflexa humeri posterior, APB – arteria profunda brachii, mbb – musculus biceps brachii, mcb – musculus coracobrachialis, ncam – nervus cutaneus antebrachii medialis, nm – nervus medianus, nmc – nervus musculocutaneus, nr – nervus radialis, nu – nervus ulnaris, TPC – truncus profundocircumflexus, tt – tendines musculi teretis minoris et musculi latissimi dorsi, VA – vena axillaris, VB – vena brachialis, VBa – vena basilica, VBr – vena brachioradialis.

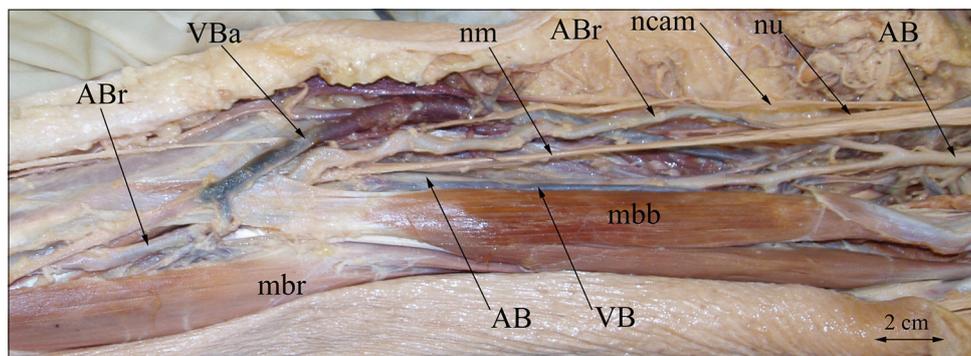
*radialis*), crossing the AA and BA dorsally, and together they entered the space between the heads of the triceps brachii.

All the arteries were accompanied by corresponding veins. The caliber of the axillary vein was 10mm, that of the venous profundocircumflex trunk was 8mm, and both tributaries (posterior humeral circumflex vein and profunda brachii vein) were 6mm wide.

The latter (distal) variant was the brachioradial artery stemming from the BA (caliber 6mm) shortly (3cm) after the origin of the profundocircumflex trunk (see Figure 2).

It followed the same course as the BA, 6mm wide, descended medially, passed under the median nerve and was situated between the median and ulnar nerve (*nervus ulnaris*). It approached the medial cutaneous nerve of forearm (*nervus cutaneus medialis antebrachii*) and the basilic vein (*vena basilica*) and together they coursed distally as far as the interepicondylar line. Here, the BrA entered the cubital fossa, left the basilic vein and the medial cutaneous nerve of forearm for the depth, where it immediately joined the median nerve and re-crossed it to the lateral side; in this case superficially, though. Then it passed under the whole tendon of the biceps brachii (*musculus biceps brachii*) and emerged on the lateral side of the forearm. From here, it ran as the usual radial artery as distal as the palm to from the deep palmar arch (*arcus palmaris profundus*). As for the veins, they followed the textbook pattern (except those accompanying the variations mentioned), i.e. they were doubled from periphery as far as the axillary vein and featured no principal derivation form usual arrangement.

Other arteries of the upper limb dissected featured no other variations.



**FIGURE 2.** Ventral aspect of the arm and proximal forearm with respect to the arteries and veins. Legend: AB – arteria brachialis, ABr – arteria brachioradialis, mbb – musculus biceps brachii, mbr – musculus brachioradialis, ncam – nervus cutaneus antebrachii medialis, nm – nervus medianus, nu – nervus ulnaris, VB – vena brachialis, VBa – vena basilica.

## DISCUSSION

Our finding depicts a case of coincidental variation. But regarding the embryological background, both variants are a combined sequence of one development abnormality, as explained below.

First, we concentrate on the PHCA passing under the fused tendons of the teres major (*musculus teres major*, TM) and the latissimus dorsi (*musculus latissimus dorsi*, LD). This variant is rather neglected in the anatomical reference literature, in case the authors listed the PHCA running under the tendons, it is usually a brief note stating its possible existence. One of the few studies concerning this topic in particular and the most thorough one was performed by Adachi, is based on 398 AA and was published in 1928 as a part of his famous book “Das Arteriensystem der Japaner” [7]. The variant of the PHCA coursing below the tendons of the TM and LD was observed 63 times. The incidence was 15.8% of cases in this study.

Adachi described and classified four different groups of PHCA passing under the tendons and designated them as types D, E, F, and G in his larger concept of the branching pattern. The classification is based upon the origin of the PBA and the radial and medial collateral artery (*arteria collateralis radialis et media*) – see Table 1.

Several other authors reported on this variant in their larger studies, stating the incidence between 2.8% and 11.3% of cases [7-11,15]. Some of them mention just one of the muscles but exactly the PHCA turns around the fused tendons of both muscles – see Table 2.

Such variant can be denominated as the subtendinous posterior humeral circumflex artery (*arteria circumflexa humeri posterior subtendinea*), conjoint with the profundocircumflex trunk (*truncus profundocircumflexus*) to describe all the peculiarities and to avoid any possible misnomers.

Second, the latter variant, concerning the unusually proximally shifted origin of the RA, is not a rare arterial variation of the upper limb. Such a vessel should be denominated as the

**TABLE 1.** Overview of the branching types of the PBA according to Adachi [7], combined with the PHCA passing under the fused tendons of the TM and LD.

Type	Origin of PHCA and PBA	Number of cases	Frequency
D	PBA originates from AA	5 times in 398 cases	1.3%
E	PBA originates from PHCA (common trunk) and then PBA bifurcates into medial and radial collateral artery	26 times in 398 cases	6.5%
F	No regular PBA: Medial and radial collateral artery originates from PHCA	17 times in 398 cases	4.3%
G	No regular PBA: Radial collateral artery originates from PHCA and medial collateral artery originates directly from AA/BA	15 times in 398 cases	3.8%

**TABLE 2.** List of studies reporting on the PHCA passing under the tendons of the TM and LD

Author	Total limbs	Number of cases	Frequency
Adachi (1928) [7]	398	63	15.8%
Coulouma (1934) [8]	284	8	2.8%
Skopakoff (1959) [9]	610	69	11.3%
Keen (1961) [10]	104	3	2.9%
Olinger (2010) [11]	166	14	8.4
Kachlik (2009) [15]	130	11	8.8%
Konarik (2014)	214	23	10.7%

brachioradial artery (*arteria brachioradialis*), if we follow a classification proposed by *Rodríguez-Niedenführ et al.* [3], which we consider marvelous, simple and intelligible.

There are two different types of the BrA. If the artery courses superficially to the muscles of the forearm, it should bear the name of the superficial brachioradial artery (*arteria brachioradialis superficialis*, SBrA), but if the artery stays deep to the muscles (as usual RA), it should be denominated as the brachioradial artery only [2,3]. The precise definition of the BrA runs as follows: It is abnormal RA originating proximal to the interepicondylar line, either from the AA or the BA [12,13]. The “radial artery with high origin” is an often used synonym for this variant, but it is not an appropriate one and should be omitted and/or excluded [14]. Due to a long distance between the axillary and cubital fossae, the exact location of the origin

of the BrA (and the SBrA) can be classified into four groups – see Table 3. Our case of the BrA ranks into the Group 4 – the RA stemming from the proximal part of the BA.

Rodríguez-Niedenführ et al. performed in 2001 a deep and thorough survey of the upper limb arterial variants and summarized that the BrA was present in 13.8% of cases [3]. But the pattern, in which the RA originates directly from the AA, is present in 3.12% of cases only. That is why we have performed another literature survey and now we can conclude that this variant pattern is present in 1.25% of cases [15] and in 2.33% of cases in our dissection study. The general incidence of the BrA and the origin site are summarized in the Table 4.

Many authors in the 19th and even in the 20th century did not distinguish between the superficial brachial artery (which is an embryological precursor of the BrA) and the BrA itself. Thus, they erroneously mix both variants into one group and the data are not statistically reliable for both variants separately.

The clinical relevance of knowledge of such anatomical variant consists in more aspects.

The superficially located artery brings an elevated danger of heavy bleeding in all unexpected situations, due to its very close relationship to the skin and possible injury in any superficial cut in both the arm and forearm.

The anatomical knowledge of the BrA is worth during the transradial catheterization procedures, due to the possible narrower caliber of BrA. Such reduction of the caliber

of one the main arterial trunks of the upper limb (much more frequent than in usual radial and brachial arteries, being less than 2mm) can interrupt and disable the successful intervention during the transradial catheterization, used for example for diagnostic and therapeutic procedures on co-rorary arteries, such as the coronary angiography and percutaneous coronary intervention (now preferred as a method of choice)[21].

The superficial BrA (if not having the reduced caliber) can serve as a longer graft for aortocoronary bypasses than the usual radial artery.

The PHCA with different course can be harmed during injuries or/and surgical procedures concerning the surgical neck of humerus and the area around the proximal growth plate of humerus. It can also serve as a collateral in case of thrombotic closure of the axillary artery.

Both arterial variants have to be respected in radiodiagnostic, surgical and traumatologic procedures within the axilla and the arm.

Finally, the embryological background has to be discussed. The distal part of the right subclavian artery as well as the whole left subclavian artery comes from the seventh intersegmental artery (*arteria intersegmentalis septima sinistra*). The bud of the upper limb is supplied by the branches of this vessel, forming the axial artery (*arteria axialis*), which later gives rise to the AA, the BA, the ulnar artery, the RA, etc. The BrA (the variant concerning the RA with more proximal (“high”) origin) is based on the embryological abnormality, termed the superficial brachial artery (*arteria brachialis superficialis*). The superficial brachial artery arises from persistence of more than one cervical intersegmental artery, which can enlarge and does not perish [22-27].

**TABLE 3.** Classification of BrA (and SBrA) according to its origin [3]

Group	Location	Frequency
1	Distal third of brachial artery	3.9%
2	Middle third of brachial artery	7.7%
3	Proximal third of brachial artery	65.4%
4	Infrapectoral (distal) part of axillary artery	23%

**TABLE 4.** The origin site and incidence of the SBrA and BrA as a whole

Author	Number of cases	Total frequency	Origin from AA
Quain (1844) [16]	429	30%*	-
Müller (1903) [17]	300	25.8%*	-
Adachi (1928)[7]	1198	31%*	-
McCormack (1953) [18]	750	15%*	-
Wheatersby (1956) [19]	408	15.6%	-
Rodríguez-Baeza (1995)[20]	150	16.7%*	-
Skopakoff (1959)[9]	610	19.7%*	9%
Keen (1961)[10]	284	12.3%*	5.9%
Rodríguez-Niedeführ (2001)[3]	384	13.8%*	3.25%
Kachlik (2009) [15]	130	#	1.25%
Konarik (2014)	214	14.5%	2.33%

\*Most of the authors do not distinguish between the origin site of the SBrA or BrA, #The brachial artery was not a part of research; data were beyond our study outlines

## CONCLUSION

The knowledge of such arterial variant coincidence is crucial for the catheterization approach using the radial artery in coronary interventions, for the by-pass grafting in coronary vascular surgery and in surgery of humerus.

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## DECLARATION OF INTEREST

The authors declare that they have no conflict of interest and no financial interests.

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