

Bilateral accessory heads of biceps brachii muscle coexisting with brachioradial artery passing between two layers of atypical bicipital aponeurosis

Ming Zhou^{a,*}, Akimitsu Ishizawa^b, Hideo Akashi^a, Ryoji Suzuki^a, Yoshio Bando^a

^a Department of Anatomy, Akita University Graduate School of Medicine, 1-1-1 Hondo, Akita, 010-8543, Japan

^b Guidance Division, Kashiwa City Board of Education, 48-1 Oshimada, Kashiwa, 277-8503, Japan

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ABSTRACT

Purpose: Although variations of biceps brachii muscle (BBM) and arm arteries are common, however, combined bilateral variations involving muscles and arteries are rarely described. The report's aim was the detailed presentation of a case of bilateral multiple anatomical variations in the upper extremities encountered during the dissection of a 90-year-old Japanese female cadaver. **Results:** On the left side, a third (accessory) head of the (BBM) was observed. Interestingly, the bicipital aponeurosis was composed of two layers, a superficial layer and a deep one. Arterial variations involved the high division of the brachial artery into the brachioradial artery (BRA), running superficially to the median nerve and the ulno-interosseous trunk occupying a normal position of the typical brachial artery. On the right side, a four-headed BBM was observed. The bicipital aponeurosis was also composed of two layers (superficial and deep), similarly to the left side. On this side, the BRA took origin from the axillary artery and crossed over the median nerve's medial root. Then, the BRA descended along the median nerve. On both sides, the BRA passed between two layers of the bicipital aponeurosis and continued its course in the forearm as the radial artery. **Conclusions:** Knowledge about the co-existence of multiple variations on the arm is essential for clinicians performing surgical procedures, and for medical education.

1. Introduction

Knowledge of the muscular and arterial variations is essential for physicians conducting surgical procedures within the upper extremity [1–3]. Although variations of biceps brachii muscle (BBM) and arm arteries are common, combined bilateral variations involving muscles and arteries are rarely described [4]. The current case report emphasizes multiple anatomical variations, including the bilateral presence of accessory heads of the BBM and bilateral occurrence of the brachioradial artery (BRA), with the latter passing between two layers of the bicipital aponeurosis. The report's aim was the detailed presentation of changes in the topographical anatomy resulting from this atypical arrangement.

2. Case report

During routine dissection of a 90-year-old Japanese female cadaver, we detected the coexistence of multiple bilateral variations; those variations included the bilateral occurrence of accessory heads of the BBM

coexisting with the presence of the BRA. On both sides, the bicipital aponeurosis was divided into two layers, between which the BRA passed. The detailed observations are summarized below.

On the left side, an accessory third head of the BBM was observed. The accessory head (third head) was a muscular band (152 mm long x 11 mm wide) that originated from the anteromedial surface of the humerus, proximal to the origin of the brachialis muscle and lateral to the insertion of the coracobrachialis muscle (Figs. 1 and 2). The third head's muscle belly ran infero-medially to the main belly of the BBM and anterior to the brachialis muscle. This head was inserted into the distal part of the distal biceps tendon, at its posteromedial surface near the short head of the muscle. The branches of the musculocutaneous nerve innervated the third (accessory) head (Figs. 1 and 2).

Interestingly, the bicipital aponeurosis was clearly composed of two layers, a superficial layer and a deep one. The superficial layer was composed of the fascia covering the long and short heads of the BBM and the superficial layer of the fascia from the third head. In turn, the deep layer of the bicipital aponeurosis was composed of the deep fascia of the

* Corresponding author.

E-mail address: mzhou@med.akita-u.ac.jp (M. Zhou).

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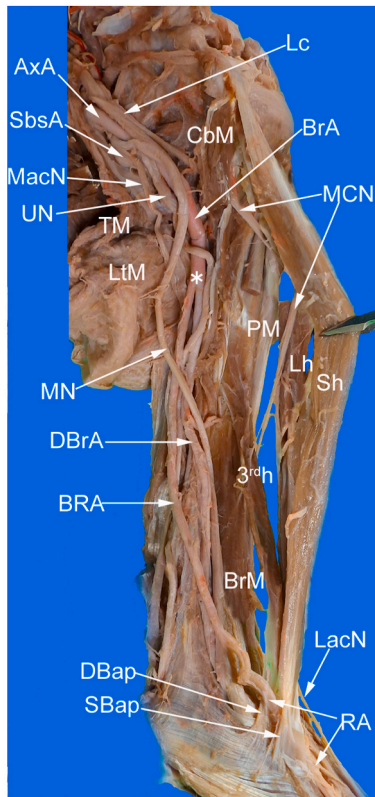


Fig. 1. Medial-anterior view of the left arm, showing an accessory head of the biceps brachii muscle, the bifurcation (asterisk) of the brachial artery into a brachioradial artery and a deep brachial artery, and two layers of atypical bicipital aponeurosis, through which the superficial brachial artery passed.

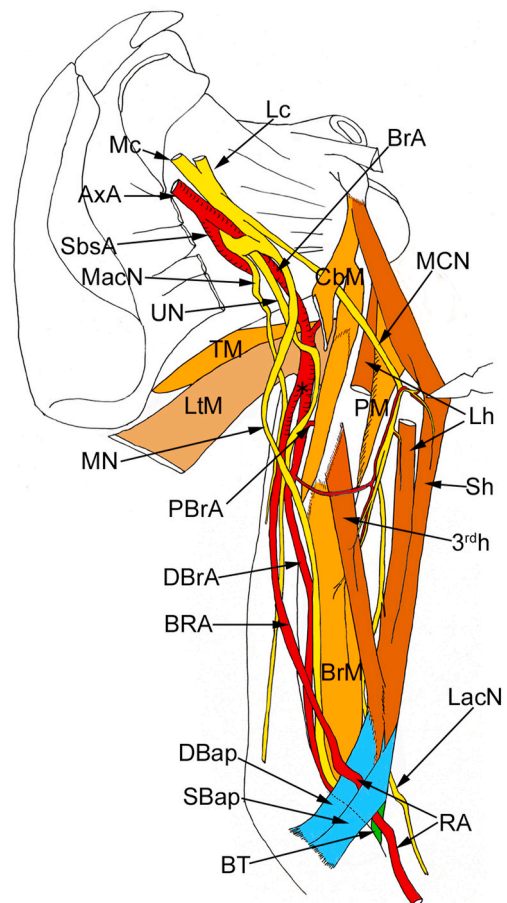


Fig. 2. Schematic drawing of Fig. 1.

third (accessory) head (Figs. 1 and 2).

Arterial variations involved the high division of the brachial artery into the BRA, running superficially to the median nerve and the ulno-interosseous trunk occupying a normal position of the typical brachial artery. The BRA took origin at the distal border of the latissimus dorsi muscle. The BRA coursed superficially to the anteromedial side of the median nerve then turned laterally and crossed over the nerve. In the cubital region, the BRA passed between the two layers of the bicipital aponeurosis, directly continuing as the radial artery in the forearm. The BRA gave off no muscular branches during its course. The ulno-interosseous trunk descended deep to the median nerve and gave off the profunda brachii artery and muscular branches to the brachial flexor muscles. Then, it passed under the deep layer of the bicipital aponeurosis (Figs. 1 and 2), gave off the common interosseous artery, and continued as the ulnar artery in the forearm.

On the right side, a four-headed BBM was observed. The third head of the BBM (150 mm long x 6 mm wide) originated from the body of the humerus more proximally to the origin of the brachialis muscle. The third head ran infero-medially to the main belly of the BBM and merged with it medially to the distal part of the short head. The muscular band (86 mm long x 5 mm wide) of the fourth head originated from the body of the humerus, below to the origin of the third head, and near the insertion of the coracobrachialis muscle. Its thin muscular belly joined the distal part of the third head and the distal biceps tendon. The branches of the musculocutaneous nerve innervated all heads of the BBM (Figs. 3 and 4). The structure of the bicipital aponeurosis was composed of two layers (superficial and deep), similarly to the left side. The superficial layer of the bicipital aponeurosis was composed of the fascia from the long, short, and third heads, and the superficial fascia from the fourth head, while the deep layer of the bicipital aponeurosis was composed of the deep fascia from the fourth head (Figs. 3 and 4).

On this side, the BRA took origin from the axillary artery and crossed over the median nerve's medial root (Figs. 3 and 4). Then the BRA descended along the median nerve. At the lower third part of the humerus, the BRA turned laterally, crossed over the median nerve, and passed between the two layers of the bicipital aponeurosis. It continued as the radial artery in the forearm. The second arterial trunk (ulno-interosseous trunk) descended deep to the median nerve, gave off muscular branches to the brachial flexor muscles at the level of the middle part of the humerus (Figs. 3 and 4), and finally passed under the deep layer of the bicipital aponeurosis. It gave off the common interosseous artery and then continued as the ulnar artery in the forearm.

3. Discussion

This case with multiple variations on both arms with accessory heads of the BBM, with both BRA passing between the two layers of the atypical bicipital aponeurosis, has hitherto not been reported before in the literature. The frequency of three-headed BBM is 14–20%, and four-headed BBM 1–4% in Japanese people [5]. The frequency of accessory heads on one side is 21.5%, while that on both sides is 12.2% [6]. Cases with three-headed BBM on the left and four-headed BBM on the right, as reported here, accounted for only 0.4% of 246 Japanese cadavers investigated [6].

The accessory heads of the BBM were classified as superior, infero-medial, and infero-lateral humeral heads according to the origin, location, and insertion, and insertion [7]. Higashi and Sone [6] classified these accessory heads into four types according to the origins between the long and short heads of the BBM and between the BBM and the adjacent muscles: biceps brachii group (type I), coracobrachialis group (type II), brachialis group (type III), and deltoid group (type IV). As

The arterial pattern of the upper extremity may be highly variable, and numerous terms were used to describe such variant, as described above. The radial artery typically arises in the cubital fossa. It may also take origin at a higher level. According to the most recent classification provided by Rodriguez-Niedenfuhr et al. [21], the high origin of the radial artery is referred to as the brachioradial artery (BRA). In most cases, the BRA takes origin from the upper half of the brachial artery [22], as in the present case on the left side. In rare cases, the BRA may originate from the axillary artery [17,22], as in the present case on the right side. Occasionally, a rare origin of the BRA may be observed from the distal part of the brachial artery [23]. Also, the low origin of the radial artery, deep to the pronator teres muscle, was described [24]. Contradictory to the BRA, the term superficial brachial artery should be applied to the artery located superficially to the median nerve and divided into radial and ulnar arteries or radial and superficial ulnar arteries [21,25].

The bicipital aponeurosis is a fascial expansion that arises from the tendon of the BBM descending medially across the brachial artery to fuse with deep fascia over the origins of the flexor muscles of the forearm. Its morphology and degree of contribution of fibers from the short and long heads differ from report to report, e.g., some authors reported that the bicipital aponeurosis was formed by the distal part of the short head [26], while others considered that the major one was formed from the long head [27]. Interestingly, Eames [27] pointed out that it was composed of three-layer fibrous fascia in which the long head formed two layers and the short head formed one layer. However, the other authors disagreed with this opinion that the bicipital aponeurosis was comprised of two layers with an equal amount of fibers from both long and short heads [28,29]. The thickness and width of the bicipital aponeurosis differ from person to person [29,30], and it was observed as bifurcating into medial and lateral variations [3,31,32]. In the present case, the bicipital aponeurosis was clearly comprised of two layers, the superficial and the deep ones. The deep layer of the bicipital aponeurosis was composed of the deeper fascia from the third head (left side) or the fourth head (right side), while the superficial layer was composed of the fascia from the rest of the heads of the BBM. As mentioned above, it could be confirmed that the bicipital aponeurosis is of a two-layer structure, and the superficial layer is thicker than the deep one. When the brachial artery or BRA passes under the deeper layer, it is hard to see the two-layer structure. Only when the BRA or brachial artery passes between the two layers of the bicipital aponeurosis, can one see clearly the two layers' structure. Interestingly, we saw some hand-drawn sketches where the superficial brachial artery passed between the two layers of the bicipital aponeurosis, or pierced it [16], and also some clear photographs showing the superficial brachial artery passing in front of or behind it [21], but none provided a detailed description of how the structures of the bicipital aponeurosis formed. Thus, this report is the first to describe in detail the structure formation of the two layers of the bicipital aponeurosis, through which the BRA passed between.

Accessory heads of the BBM and/or BRA are common variations observed in upper limbs during routine dissection, but both variations appearing concomitantly are uncommon. Coincidence with the BRA passing between the two layers of the bicipital aponeurosis is remarkably rare. When the BRA passes between the two layers of the bicipital aponeurosis, the radial artery pulse and/or the blood flow of the forearm may be affected by the aponeurosis contraction during elbow flexion. Thus, these findings are not only for anatomical education but can also serve as useful data for clinical diagnosis and treatment.

4. Conclusions

The appearance of the BRA and accessory heads of the BBM in the present case suggests the potential for encountering these in the arm during diagnosis and treatment. Clinicians should pay more attention to their existence in clinical practice. It is necessary and important to further investigate the formation and structure of the bicipital

aponeurosis in normal and accessory-headed BBM, and the relationship between the bicipital aponeurosis and the brachial artery and/or BRA, especially when both variations appear simultaneously.

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Ethical statement

The individuals as members of "Shiragiku-Kai" of Akita University Graduate School of Medicine had given their written informed consent for their donated bodies for medical education and scientific research prior to death. According to National Law, scientific institutions (i.e., Medical Universities) are entitled to receive the body after death. No bodies are accepted without the donor having registered their legacy and been given appropriate information upon which to make a decision based upon written informed consent (policy of ethics). All medical education and researches are under the guidance of ethics committee of Akita University.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

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Abbreviations

AxA =: axillary artery
 DBap =: deep layer of the bicipital aponeurosis
 SBap =: superficial layer of the bicipital aponeurosis
 BasV =: basilic vein
 BBM =: biceps brachii muscle
 Lh =: long head of the BBM
 Sh =: short head of the BBM
 3rdh =: third head of the BBM
 4thh =: fourth head of the BBM
 BrA =: brachial artery
 DBrA =: deep brachial artery
 PBrA =: profunda brachii artery
 BRA =: brachioradial artery
 BrM =: brachialis muscle
 BrV =: brachial vein
 BT =: biceps tendon
 CbM =: coracobrachialis muscle
 CeV =: cephalic vein
 Lc =: lateral cord
 LtM =: latissimus dorsi muscle
 LacN =: lateral antebrachial cutaneous nerve
 MacN =: medial antebrachial cutaneous nerve
 Mc =: medial cord, MCN = musculocutaneous nerve
 MN =: median nerve
 PM =: pectoralis major muscle
 RA =: radial artery
 SbsA =: subscapularis artery
 TbM =: triceps brachii muscle
 TM =: teres major muscle
 UN =: ulnar nerve