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The axillary artery high bifurcation: coexisting variants and clinical significance

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Several branching patterns of the axillary artery (AA) have been described. Unusually, the brachial artery (BA) follows a course in front of the median nerve (MN), the so-called superficial brachial artery (SBA). The SBA may result in MN entrapment. The current cadaveric report highlights a high AA bifurcation, its continuation as SBA and the coexistence of muscular, neural, and vascular asymmetric aberrations. At the right side, the coracobrachialis muscle (CB) had a single head, and the ipsilateral musculocutaneous nerve (MCN) followed a medial course. The AA was highly divided into superficial and deep stems (SAS and DAS), at the 2nd rib lower border. Between two stems, the brachial plexus (BP) lateral and medial cords were identified. The MN originated from the BP lateral cord. The SAS, continued as SBA with a tortuous course. The DAS coursed posterior to the BP medial and lateral cords and gave off the subscapular artery. A bilateral 3rd head of the biceps brachii was identified. The MN atypically originated from the BP lateral cord. At the left side, the two-headed CB was typically penetrated by the MCN. A common trunk of the circumflex humeral arteries was identified in coexistence with an interconnection of the BP lateral cord with the MN medial root. The rare coexistence of muscular, neural, and arterial variants in axillary and brachial region is emphasized, taking into consideration the AA high division and related branching pattern. Documentation of such rare vascular variants is important in aneurysm and trauma surgery, and angiography, where all therapeutic manipulations must be accurately performed due to the possibility of complications. (Folia Morphol 2024; 83, 1: 200–206)

Keywords: superficial brachial artery, high origin, variation, accessory head, axilla, brachial plexus, entrapment

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INTRODUCTION

The axillary artery (AA), the subclavian artery's continuation at the 1st rib lower border, gives rise to the brachial artery (BA) at the teres major muscle lower border. The AA typically is divided by the pectoralis minor into three parts, giving off the superior thoracic artery (STA) (1st part), the thoracoacromial and lateral thoracic artery (TAA and LTA, 2nd part) and the subscapular artery (SBSA, 3rd part) [1]. Several AA branching variants have been described, some of them rarely be identified (concerning the branches' origin and course) [13]. Unusually (3.6–9.6%) [31], the BA could follow a course in front of the median nerve (MN) [31]. Adachi [1] defined this type of artery as superficial brachial artery (SBA). When present, the SBA may completely replace the BA or may be accompanied by a BA trunk running posterior to the MN. This altered course may result in MN entrapment [25]. AA and BA variability is of paramount importance for surgeons and interventionists [23]. The current cadaveric report highlights a high AA bifurcation and its continuation as SBA and coexistence of asymmetric muscular, neural, and vascular aberrations.

MATERIALS AND METHODS

An 81-year-old donated male cadaver was bilaterally dissected at the axillary and brachial area. The body was donated before death, after a written informed consent.

RESULTS

At the right side, the coracobrachialis muscle (CB) had a single head, and the ipsilateral musculocutaneous nerve (MCN) didn't penetrate it but followed a medial course. An AA of anterior course in relation to the ansa pectoralis was identified. The vessel was highly divided into superficial and deep stems (SAS and DAS), at the 2nd rib lower border. Between two stems, the brachial plexus (BP) lateral and medial cords were identified (Fig. 1). The AA before bifurcation, gave off an aberrant suprascapular artery (coursing between the anterior and posterior branch of the C7 root, posterior to the BP upper trunk) (Fig. 2), the STA, the 1st LTA, and the TAA, 1.1 cm distally. The MN originated from the BP lateral cord (Fig. 3). The SAS, anterior to the BP lateral and medial cords gave off the 2nd LTA (Fig. 1) and continued as SBA with a tortuous course, anterior to the MN. The

Figure 1. High bifurcation of the right-sided (R) axillary artery (AA) into superficial and deep axillary stems (SAS and DAS); STA — superior thoracic artery; LTA1 — 1st lateral thoracic artery; TAA — thoracoacromial artery; LTA2 — 2nd lateral thoracic artery bifurcation (1, 2); UN — ulnar nerve; Pm — pectoralis minor retracted tendon; ICBN — intercostobrachial nerve; LC — lateral cord of the brachial plexus; MC — medial cord of the brachial plexus.

SBA was accompanied by two brachial veins that anastomosed with the basilic vein and drained into the axillary vein. At the bicipital tendon insertion, the SBA divided into radial and ulnar arteries, that were slightly tortuous in the distal forearm. The DAS coursed posterior to the BP medial and lateral cords and 5 cm distally gave off the upper subscapular artery and the SBSA that divided into a lateral and a medial trunk. The lateral trunk gave off the anterior and posterior circumflex humeral arteries (ACHA and PCHA), the profunda brachii artery (PBA) and a muscular branch for the teres minor upper part and the latissimus dorsi muscles. The medial trunk divided into the circumflex scapular artery, a muscular branch for the latissimus dorsi muscle and the thoracodorsal artery (Fig. 4). A 3rd head of the biceps brachii (BB) was bilaterally identified, originating from the CB insertion, and inserting at the radial tuberosity, after joining the bicipital tendon (Figs. 3B, 5). The MN atypically originated from the BP lateral cord and the MCN had a medial course related to the CB and innervated the BB and brachialis muscle. CB innervated by the MCN neural filaments. The BP posterior cord was located posterior to the DAS. At the level of the posterior cord formation, the upper

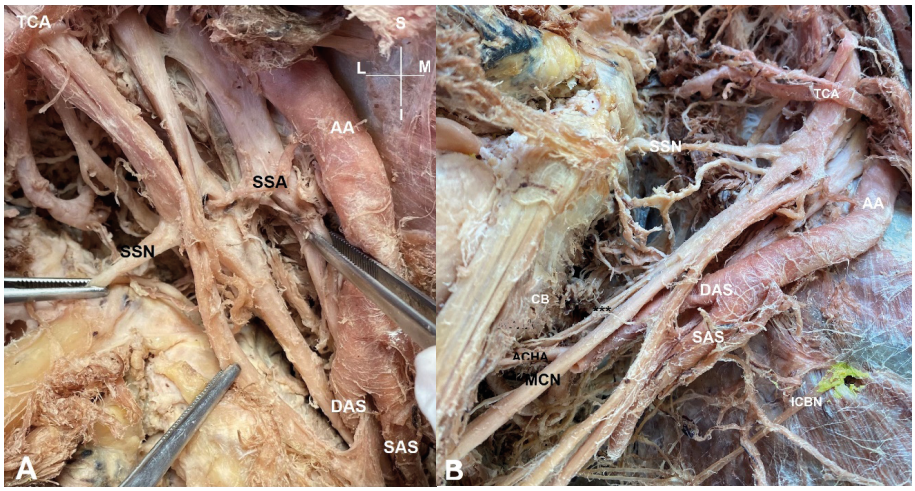

Figure 2. A. B. Ectopic origin of the right-sided suprascapular artery (SSA) from the 1st part of the axillary artery (AA); SSN —suprascapular nerve; TCA — transverse cervical artery; SAS — superficial axillary stem; DAS — deep axillary stem; MCN — musculocutaneous nerve; *** accessory MCN; ACHA — anterior circumflex humeral artery; ICBN — intercostobrachial nerve.

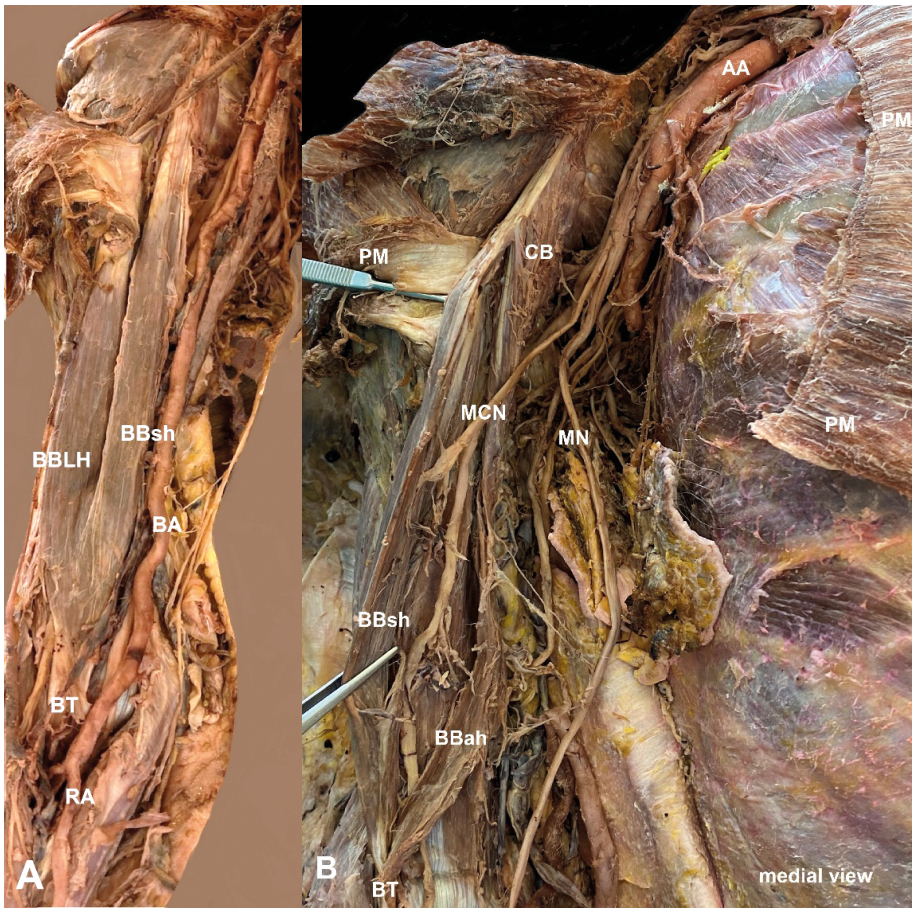

Figure 3. A, B. Right side views — variant biceps brachii with a 3rd (accessory) head, short head (BBsh), long head (BBLH) and accessory head (BBah) joining the bicipital tendon (BT) and inserting into the radial tuberosity. **A.** Brachial artery (BA) of tortuous course; **B.** Musculocutaneous nerve (MCN) of medial course and its division, median nerve (MN) of atypical origin exclusively from the lateral cord; CB — coracobrachialis muscle; AA — axillary artery; RA — radial artery; PM — pectoralis minor.

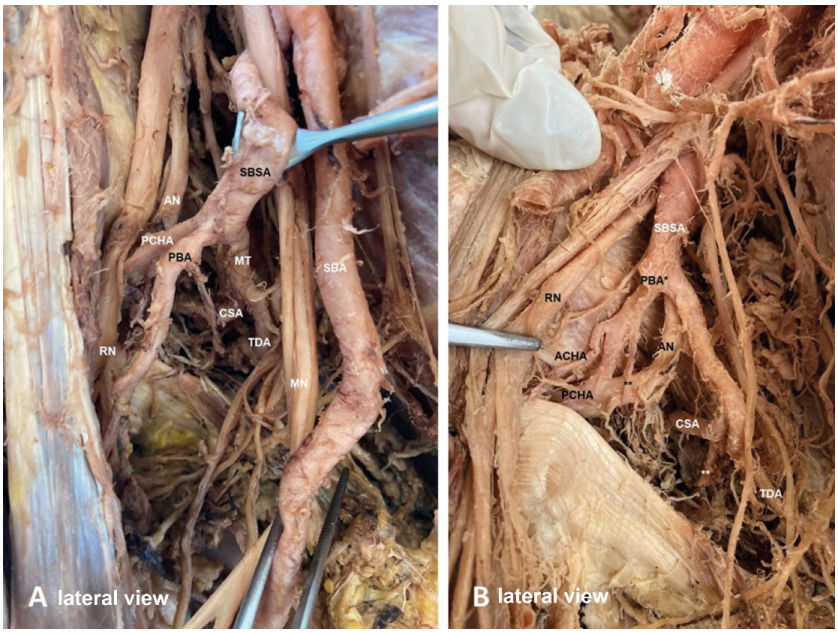

Figure 4. A. Right side — the branching pattern of the deep axillary stem into the subscapular artery (SBSA); SBA — superficial brachial artery; MT — medial trunk divided into the circumflex scapular artery (CSA) and the thoracodorsal artery (TDA); RN — radial nerve; AN — axillary nerve; MN — median nerve; **B.** Right side — PBA* [posterior brachii artery (the missing vessel)]. The lateral trunk giving off the PBA, the anterior circumflex humeral artery (ACHA) and the posterior circumflex humeral artery (PCHA); **muscular branches for the latissimus dorsi and teres major muscles.

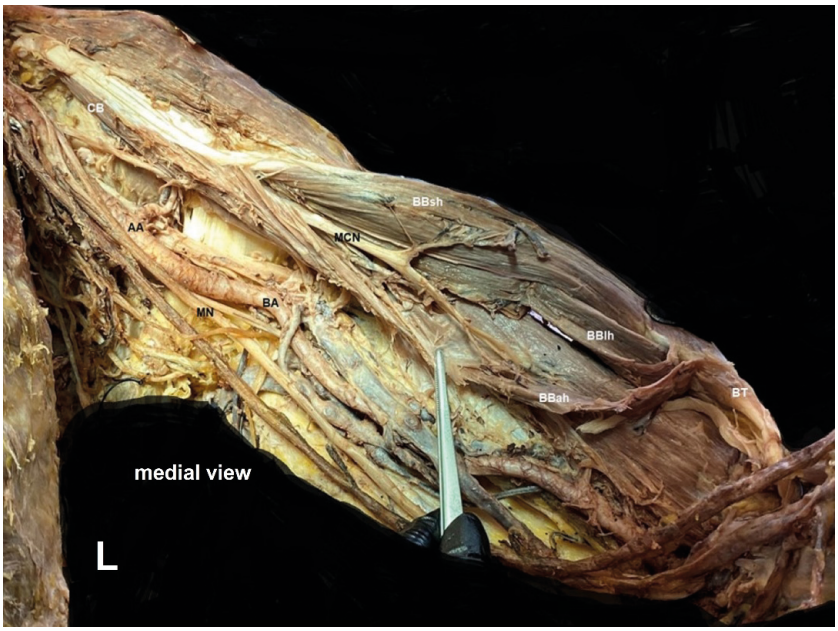

Figure 5. The left-sided variant biceps brachii muscle with a short (BBsh), a long head (BBlh) and a 3rd head (BBah) joining the bicipital tendon (BT), the typical coracobrachialis muscle (CB), the musculocutaneous nerve (MCN), the axillary artery (AA), the brachial artery (BA), and the median nerve (MN).

subscapular nerve originated, followed by the lower subscapular nerve, 5.4 cm distally to the lower border of the 1st rib, the thoracodorsal nerve, and muscular branches for the teres major and minor muscles, and the axillary, and the radial nerve. At the left side, the two-headed CB was typically penetrated by the MCN. The AA gave off the superior thoracic artery and the 1st LTA. The TAA originated 0.5cm distally to the 1st

Figure 6. Left-side — the double lateral root (LR1, LR2) of the median nerve (MN); MR — medial root; MCN — musculocutaneous nerve penetration to coracobrachialis muscle (CB); UN — ulnar nerve.

LTA origin, at the same level with a muscular branch for the subscapularis muscle upper part. The 2nd LTA originated 1.8 cm distally to the TAA origin, and 5 cm distally, originated the SBSA originated that further divided into a branch for the upper part of the latissimus dorsi, the circumflex scapular artery, muscular branches for the teres minor and major, branch for the subscapularis lower part and the thoracodorsal artery. A common trunk of ACHA-PCHA was identified, 1.3 cm distally and laterally to the SBSA origin. The AA continued its course as BA, with an evident tortuosity, and 3.4 cm distally to the lateral humeral epicondyle, bifurcated into radial and ulnar artery. An interconnection of the BP lateral cord with the MN medial root was identified (Fig. 6).

DISCUSSION

The current report highlights an AA high bifurcation similarly to other reports [4, 19, 23, 40]. The AA high bifurcation is more commonly identified in African Americans (13.4%) than in Caucasians (4.6%) [6]. In the current case, the AA highly bifurcated into a SAS and a DAS, at the AA 2nd part. Many authors described a lower bifurcation (AA 3rd part) [4, 7, 14, 28, 37], while the extreme high origin (AA 1st part) is quite rare [13]. The current report highlights the rarity of the AA variants' coexistence compared to the wide variability of the isolated AA branching pattern variants [39]. In the current case, the bilateral coexistence of a 3rd head of the BB was identified. The presence of such an accessory head has a wide variability (0.18–21.5%) among populations [9, 16], with the Africans having the higher prevalence (9–21.5%) [9, 24]. Other reports [35] described the coexistence of an SBA of axillary origin with the absence of the BP lateral cord and the cephalic vein. The coexistence of anomalies in BP arrangement with the axillary and brachial arteries' variability was emphasized [30] and additionally the coexistence of SBA of axillary origin with an atypical MN formed by three roots was underlined. Caroll et al. [3] described the coexistence of a unilateral SBA with a contralateral single-corded BP posterolateral to the AA. No MN roots were identified, similarly to the current case. In the current report, the high bifurcated AA, continued partially as SBA. The SBA was identified from 0.12% to 19.7% among several studies [17]. The current case highlighted the SBA unilateral presence, that was identified in 5–12.2% [14, 29, 39], while Jurjus et al. [13] and Yang et al. [39] referred to the SBA occasional bilateral existence. The SBA presence is more commonly in males at the right side [31], as in our case. In cases in which the SBA did not gave branches, the PBA supplied the upper limb [4, 37]. In the current case, similarly to Natsis et al. [23], the SBA divided into radial and ulnar artery, while in other studies it terminated as superficial radial [4, 15, 21, 31] or superficial ulnar artery [15, 22, 31]. Jayakumari et al. [12] described the SBA bifurcation into radial and common interosseous artery. In the current study, similarly to Natsis et al. [23], the DAS terminated as PBA, while previously divided into the SBSA branching pattern. The SBA and the level of its axillary origin has clinical significance [23]. BA variations in the branching pattern may cause difficulties in conducting flap harvesting during reconstructive surgeries and in arteriography [10]. The BA tortuosity (presence of curves, angulations, or loops) may affect the trans-radial coronary angiography time, leading to perforation [34]. Degradation of elastin in the vessel wall results in aneurysm and vessel's elongation leading to tortuosity [8]. Entrapment of the MN

between SBA and AA could explain the idiopathic MN neuropathy. Nicomozepis et al. [25] presented three cases of unilateral presence of the SBA.

Many theories have been developed concerning the complexity of the embryological development of the upper limb arteries. Rodríguez-Niedenführ et al. [31] after a systematic study on fetuses' upper limbs, they concluded that the upper limb arterial system is developed after the selective enlargement or regression of a capillary plexus and not after the vessels' multiplication around a main arterial trunk that is closely connected with the bones' development. The arterial variants are an aberration from the typical vascularization's pattern [18, 33]. Specifically, the SBA presence is derived after the persistence of one or more intersegmental cervical arteries, that they enlarged [13]. Miller [20] explained the BP arrangement and relationship with the AA as a combination of embryological and evolutionary processes.

As various interventional procedures are performed in the upper limb, knowledge of the regional arterial variants is of paramount importance to avoid injury. Although the AA superficial course and its continuation as SBA facilitates the vascular graft reception and the vessels' catheterization, the AA high bifurcation may confuse interventionist during angiography, leading to misinterpretation. The SBA and its atypical origin increase the risk of iatrogenic injury due to its incorrect consideration as a vein, resulting in severe bleeding [13] or in a pseudoaneurysm formation [38]. Intraarterial injection can cause severe thrombosis, ischaemia, and upper extremity necrosis [5, 27]. Inappropriate cannulation due to the aberrant location and course of the arteries' branches may result in gangrene, and in limb loss [36]. Especially in axillary approaches, for the shoulder instability treatment, the performance of transverse incision can lead to injury the AA atypical branches. Thus, it is of the utmost necessity, the preoperative imaging of the area with ultrasound or computed tomography angiography, especially in urgent cases where thoracic wall reconstruction is required, such as in Poland syndrome [32] or in breast surgery and in axillary lymph node dissection, where surgeons should identify and protect the axillary vessels [13]. Vessels' branching pattern variants of the upper arm usually coexist with BP variations, resulting in an incomplete block [14]. Furthermore, BA pattern variants may implicate planning and conducting flap harvesting during reconstructive surgeries and arteriography [15].

CONCLUSIONS

The current interesting, rare report emphasizes on the coexistence of muscular, neural, and arterial variants of the axillary and brachial region providing detailed information of the AA branching pattern and distribution in the case of its high division. Documentation of such rare vascular variants in the axilla is important in aneurysm and trauma surgery, and angiography, where all therapeutic manipulations must be accurately performed due to the possibility of complications.

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Conflict of interest: None declared

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