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A superficial brachioradial artery coexisting with an atypically formed median nerve and a distal anastomosis between musculocutaneous and median nerve

Konstantinos Natsis[1], Maria Piagkou[2], Maksim Tishukov[1], Evangelia-Theophano Piperaki[3], Nikolaos Lazaridis[1]

[1]Department of Anatomy and Surgical Anatomy, School of Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece, [2]Department of Anatomy, School of Medicine, Faculty of Health Sciences, National and Kapodistrian University of Athens, Greece, [3]Department of Microbiology, School of Medicine, Faculty of Health and Sciences, National and Kapodistrian University of Athens, Greece

SUMMARY

A radial artery (RA) of axillary or brachial origin is the most commonly reported variation of the upper limb arterial pattern. A variant RA with a high origin from the proximal segment of the axillary artery (AA) coursing anterior to the median nerve (MN), the so-called superficial brachioradial artery (SBRA), is a rare case. The current report describes an unusual high origin of the right RA from the 2nd part of the AA, 2.9cm proximal to the subscapular artery emersion. The RA advanced anterior to the MN and becomes a SBRA. The AA advanced as brachial artery (BA) with the typical branching pattern giving off the radial recurrent artery. The SBRA had no anastomosis with the BA in the cubital fossa. The latter, under bicipital aponeurosis, was divided into the ulnar and the common interosseous arteries. Besides the SBRA, a MN with three (two lateral and one medial) roots and three anastomoses coexisted; one between the lateral cord (LC) of the brachial plexus and the medial root (MR) of the MN, the other between the LC and the ulnar nerve (UN) and the last one between musculocutaneous (MCN) and MN, found at the lower third of the arm. A connection of the left-sided LC with the MR was also observed. The present paper focuses on an aberration of the typical arterial pattern at the right axilla and arm highlighting the concomitant neural aberrations and their embryological background. This could be valuable to any physician involved in the treatment of vascular emergencies, requiring prompt diagnosis and surgical repair.

Key words: Upper limb – Anastomosis – Median nerve – Musculocutaneous nerve – Radial artery – Arterial variations – Superficial brachioradial artery

INTRODUCTION

A plethora of various origins branching patterns and course abnormalities of axillary artery (AA) has been extensively reported among genders and ethnic groups (Daimi et al., 2010). The most frequent AA variants include the persistent superficial brachial artery (SBA) and the high division of the brachial artery, the radial or the ulnar artery (BA, RA or UA) (McCormack et al., 1953; Jurjus et al., 1986; Rodríguez-Niedenführ et al., 2001). Terminology employed to describe these high origins, varies widely: a RA originating from the BA or the AA, a high bifurcation of the BA, the SBA continuance as the RA, or a double BA. Rodríguez-Niedenführ et al. (2001) propose the term "brachioradial artery" (BRA) and "brachioulnar artery" for the high origins of the RA and UA. A BRA of AA or BA origin with a superficial course is de-

Corresponding author: Konstantinos Natsis MD, PhD. Department of Anatomy & Surgical Anatomy, School of Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, P.O. Box 300, Thessaloniki, 54124, Greece. Phone: +30 2310 999681; Fax : +30 2310 999334; Mob:+306932600066. E-mail: natsis@auth.gr

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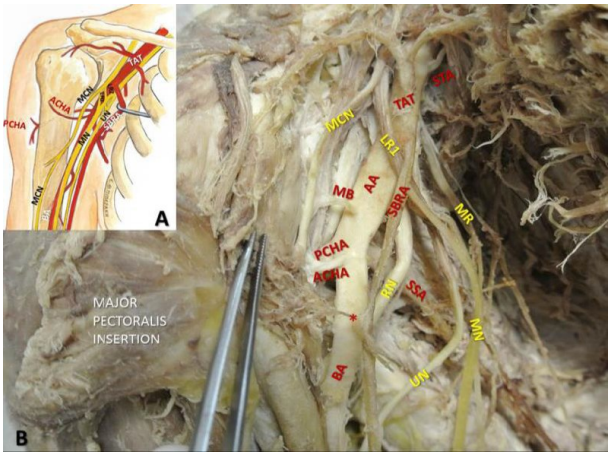

Fig 1. A, B. Dissection of the right axillary artery (AA) and its branches, thoracoacromial trunk (TAT), STA: superior thoracic artery; SBRA: superficial brachioradial artery originating from the 2nd part of the AA and courses anterior to the median nerve (MN); SSA: subscapular artery; MB: muscular branch to coracobrachialis muscle; PCHA: posterior circumflex humeral artery; ACHA: anterior circumflex humeral artery; * branch to the short head of biceps brachii muscle; BA: brachial artery; MCN: musculocutaneous nerve; LR1: lateral root; MR: medial root: RN: radial nerve; UN: ulnar nerve.

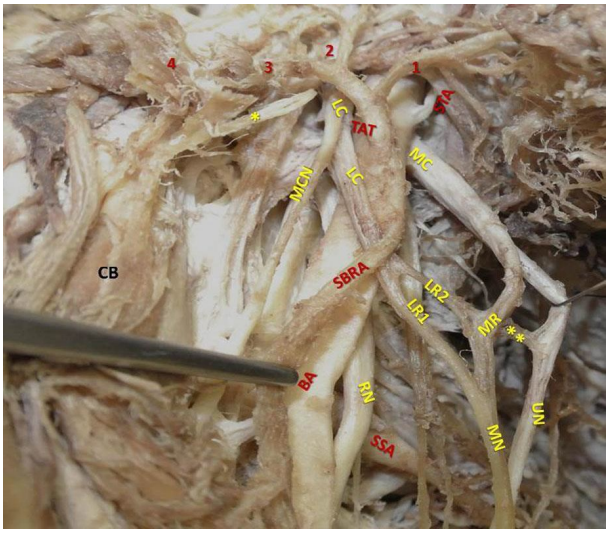

Fig 2. Detailed view of the median nerve (MN) formation by three roots (two lateral, LR1 and LR2 and one medial, MR); thoracoacromial trunk (TAT) branching pattern (1,2,3,4); STA: superior thoracic artery; SBRA: superficial brachioradial artery; SSA: subscapular artery; * branch to coracobrachialis muscle (CB) from the lateral cord (LC); BA: brachial artery; MCN: musculocutaneous nerve; RN: radial nerve; UN: ulnar nerve; **connecting branch between MR and UN.

scribed as superficial brachioradial artery (SBRA) according to Rodríguez-Niedenführ et al. (2001). The AA and BA variability is often paired with neural alterations of the brachial plexus arrangement (Piagkou et al., 2016).

The current case report describes an unusual SBRA originated from the 2nd part of the AA, 2.9cm proximal to the subscapular artery (SSA) emersion. Besides the SBRA, a median nerve (MN) with three (two lateral and one medial) roots and two connections coexisted; the one between the lateral cord (LC) of the brachial plexus and the ulnar nerve (UN) and the other one between the musculocutaneous (MCN) and the MN, at the lower third of the arm. A contralateral connection of the LC of the brachial plexus and the MR was also observed. The authors of the present paper report on an aberration of the typical arterial pattern at the right axilla and arm highlighting the concomitant neural aberrations and their embryological background. This could be valuable to any physician involved in the treatment of vascular emergencies, requiring prompt diagnosis and surgical repair. Morphometric details recorded throughout the dissection are also provided.

CASE REPORT

During a routine dissection of the right axilla of a 75-year-old Greek Caucasian male cadaver, an atypical thin arterial branch was observed to originate from the 2nd part of the anterior aspect of the AA, 1.68cm distal to the thoracoacromial trunk (TAA) (Fig.1). Further dissection of the arm revealed the course of the aberrant vessel, which advanced superficially to the MN, and ultimately in the forearm it proved to follow the typical route of the RA. The atypical vessel due to its course constitutes a SBRA of AA origin (Figs. 1, 2). Detailed dissection in the arm unveiled three muscular branches originating from the aberrant vessel towards the short head of biceps brachii muscle. The SSA emanated 2.96 cm below the SBRA origin, providing the circumflex scapular artery, a single branch for the subscapularis muscle and the thoracodorsal artery. Regarding the other branches of AA, no atypical formation was observed. The AA advanced as the BA, with the typical branching pattern, giving off an additional branch from its posteromedial aspect, which was the radial recurrent artery (RRA), 1.5 mm in diameter (Fig. 3). The SBRA did not form an anastomosis with the BA in the cubital fossa, i.e. no cubital crossover or connection existed. The BA, under bicipital aponeurosis, divided into the UA and a common interosseous artery which further divided into the anterior and posterior interosseous branches. The SBRA after a tortuous course in the forearm, near the lower border of the pronator quadratus, divided into a small superficial carpal branch in the wrist, and the superficial palmar branch of the RA coursing through the anatomical snuff box and between the heads of the 1st dorsal interosseous muscle. At the dorsal surface of the 1st dorsal interosseous muscle, the RA merged with its small superficial carpal branch. The superficial palmar arch is formed predominantly by the UA, with a contribution from the superficial palmar branch of the RA. Dissection of the left axilla and arm showed no vascular variations.

Coexisted neural variations: On the right side, the MN is atypically formed by two lateral and one medial root (LR_1, LR_2 and MR). Specifically, two connections appear, one between the LC and

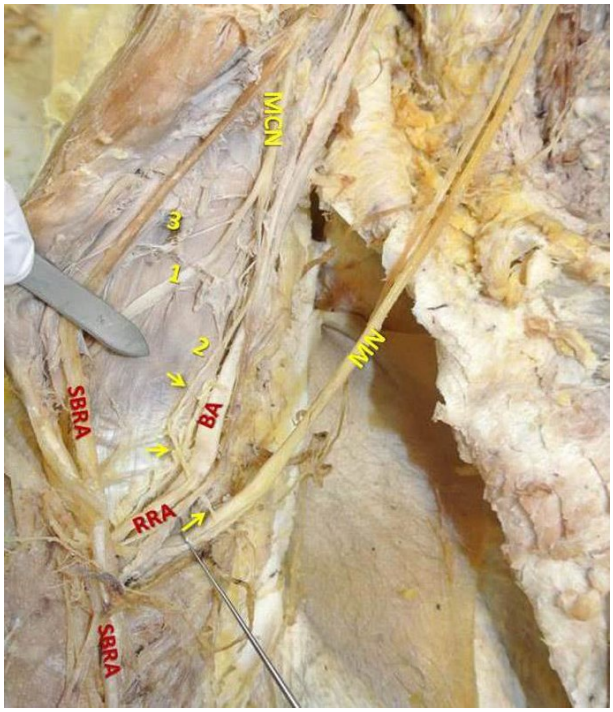

Fig 3. Course of the superficial brachioradial artery (SBRA). Branches of the musculocutaneous nerve (MCN) (1) continuance as the lateral cutaneous nerve of the forearm, (2) anastomotic branch connecting MCN and median nerve (MN), (3) small muscular branch to the long head of biceps brachii. RRA: radial recurrent artery from the posteromedial aspect of the brachial artery, yellow arrows indicate the course of anastomotic branch until its connection to the MN, posteriorly to the RRA.

the MR– the so-called LR_2 (3.5 cm in length) and the other between the LC and the UN (4.8 cm in length). At a distance of 22.3 cm distal to the coracoid process, at the lower third of the humerus, a connection (13.2 cm in length) between MCN and MN was detected, the pattern 2a according to Choi et al. (2002) classification (Fig. 3). The connection coursed in between the BA trunk and the RRA point of origin. At the left axilla, the MR of the MN is connected with the LC of the brachial plexus via a short branch (2.71 cm in length). Measurements of the arterial morphometric characteristics were carried out with an electronic caliper (*Mitutoyo Company, Japan, accuracy 0.01 mm*). Each measurement was taken twice, and the mean of both measurements was recorded as the final figure. The body donor gave a written informed consent before his death and his anonymity has been preserved.

DISCUSSION

A BRA is the most commonly reported variation in the upper limb arterial pattern. It could arise from the BA proximal segment, the AA distal segment and less frequently from the BA middle or distal segment. Its incidence varies between 12.3-16.7% (Keen, 1961; Rodríguez-Baeza et al., 1995; Rodríguez-Niedenführ et al., 2001). A variable incidence has been reported among dissection (14.27%) (McCormack et al., 1953) and angiographic studies (9.75%) (Karlsson and Niechajev, 1982). Gender dimorphism (13.9% in males versus 9.9% in females) (Rodríguez-Niedenführ et al., 2001) was also observed. A BRA of axillary origin is less frequently reported and varies from 1.25% (Konarik et al., 2014) up to 15.6% (Weathersby, 1956), 5.9-12.1% among Caucasians, 5% in Africans and only 2.3% in Koreans (De Garis and Wartley, 1928; McCormack et al., 1953; Keen, 1961; Fuss et al., 1985; Yang et al., 2008). Catli and co-authors (2012) described a BRA coexisting with supernumerary heads of the coracobrachialis and biceps brachii muscle along with a connection between MCN and MN. A SBRA is a very rare variation with an incidence of up to 0.26% -Niedenführ et al., 2001). In our case, the SBRA from the 2nd part of the AA, coursed superficially to the MN and had similarities with the case reported by Calisir et al. (2015). In some cases, according to published data, the SBRA crosses the cubital fossa and anastomoses with the BA, forming a cubital crossover (McCormack et al., 1953). In McCormack et al. (1953) study, the cubital crossover was found in 17.8% of the limbs with a high origin of the RA. Rodríguez-Niedenführ et al. (2001), in their 384 upper limb dissection study, observed the cubital anastomosis in 26.4% of the BRA cases. In the current case, cubital crossover was not formed.

Variations in the origin, course and distribution of the RA often coexist with variations of the RRA. The RRA may originate from the RA (64.8%), posterior radio-ulnar division (9%), anterior radio-ulnar division (5.4%), BRA (7.8%), BA (7.2%), ulno-interosseous trunk (2.7%) or even from the interosseous trunk (0.3%) (Vazquez et al. 2003). Rodríguez-Niedenführ et al. (2001) reported that in cases of BRA, the RRA originated from it in 46%, from the typical BA in 34% and from the cubital crossover in 20%. In the currently reported case, the RRA branched off the typical BA, while McCormack et al. (1953) found it to arise from the cubital crossover in 71.4% of the cases studied.

Embryologic background

Based on recent theories, the definitive arterial pattern of the upper limb is formed from the primitive capillary plexus, in which the dominant vascular channels gradually differentiate, following capillary remodeling (Rodríguez-Niedenführ et al., 2001a, b, 2003). Consequently, some typically retained vessels may disappear or may be incompletely developed; while some collateral pathways may persist (Jurjus et al., 1999). The SBA is a consistent embryonic vessel that plays a fundamental role in the typical morphogenesis of the upper limb arterial supply. During early stages of upper limb formation, at the elbow level, the anastomotic branch between BA and SBA becomes enlarged and forms the RA, which will eventually become a major artery of the forearm, while the SBA proximal portion atrophies correspondingly (Rodríguez-Baeza et al., 1995). In the currently reported case,

the SBA persistence gave off a SBRA due to an undeveloped anastomotic channel between the SBA and the main BA, while the BA gave off the UA and the common interosseous arteries. Brachial plexus formation is interconnected with the AA formation and their variations are usually paired (Troupis et al., 2014). The AA formation from the 6^{th} or 8^{th} intersegmental artery or any variability in its branching pattern has a profound impact on the brachial plexus formation, although the exact developmental mechanism remains unknown (Miller, 1934).

Associated neural variations

Although SBA origin is related to brachial plexus variations, paired neural and arterial variations are extremely difficult to classify (Miller, 1939). A plethora of MN and MCN interconnections has been described and classified on the basis of their point of origin taking into consideration gender dimorphism and racial differences (Choi et al., 2002; Kosugi et al., 1986; Venieratos and Anagnostopoulou, 1998). Choi et al. (2002) after a detailed review on MN and MCN interconnections found an incidence ranging from 6.6-69.9% among different cadaveric studies and mentioned a unilateral dominance. Catli et al. (2012) reported on connecting branches originated from the MN at the upper third of the humerus, coursed downwards through two supernumerary heads of biceps brachii muscle and finally joined the MCN, at the lower third of the humerus. Few reports described the coexistence of a SBA with additional LRs or connections between the MN roots (Ghorai, 2013; Natsis et al., 2014). Natsis et al. (2016) documented an unusual MN formation by five roots.

Clinical significance

Apart from its anatomical rarity, the described SBRA case is clinically important to angiologists, radiologists, vascular, orthopedic, and plastic surgeons, since it is often used in vascular, plastic and reconstructive surgery and in puncture and cannulation procedures (Atlasi, 2014). Transradial approach, during coronary angiography, should be avoided in cases of an atypical origin of the BRA, due to the fact that the vessel's tortuosity can increase the risk of failure of transradial catheterization. In reconstructive upper limb surgery, the superficial vessel can be erroneously ligated or cut considered as a vein, directly compromising hand arterial supply (Gourassas et al., 2003). Inadequate knowledge of the atypical anatomy of the RA may increase intraoperative risk and complications. Patients with RA of high origin, radial loop, severe radial tortuosity and other vascular anomalies may end up to an eventful procedure in 4.6%, 37.1%, 23.3% and 12.9%, respectively (Lo et al., 2009). Thus, imaging of the RA preoperatively, is strongly suggested by using Color Doppler ultrasonography (Natsis et al., 2006), which facilitates the assessment of the origin, course, variations and locations of any atypical arteries and their accompanying veins. Computed tomography angiography (CTA) may also be used for the evaluation of the variable arterial branching pattern (Bozlar et al., 2013). Multi-detector CTA yields detailed evaluation of the abnormal arterial origin and course (Hamidi et al., 2013), thus contributing to a better surgical planning and an uneventful procedure (Pieroni et al., 2009). Anatomical variations of both RA and RRA may influence safety and success rate of plastic and reconstructive surgery. The presence of a RRA may be useful in the radial forearm free flap procedures. The superficial palmar branch of the RA can be also used in similar procedures, as the RA superficial palmar branch perforator flap (Hamahata et al., 2012).

The detailed knowledge and understanding of MCN-MN connection is of great importance to physicians involved in diagnosis and treatment of the MN and MCN dysfunction, especially in post-traumatic surgical repair (Sonck et al., 1991).

An atypical MN with extra roots may pose a certain risk during surgery, due to possible existing sensory-motor alterations. Entrapment neuropathy may also ensue. Occasionally, the additional LR may exert compression on the axillary vessels leading to ischemia. This is why it is of immense significance to elucidate anatomical aberrancies of the axillary vessels, prior to applying regional anesthesia to this area.

Conclusion

An unusual case of a SBRA of axillary origin, proximal to the SSA emersion is described, dissected on the right side of a 78 year-old Caucasian male cadaver. The atypical vessel had no anastomosis with the typical BA and also coexisted with an abnormally formed MN by three roots (two lateral and one medial). Two connections namely between MR and UN and the other one between MCN and MN were also observed. On the left side, a connection was found between the LC of the brachial plexus and the MR. Commonly reported abnormal anatomy of the RA is of great clinical importance in the management of vascular emergencies, requiring prompt diagnosis and successful surgical repair.

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DISCLOSURE

All authors have participated in the research and the article preparation. KN and MP made the project, MT and NL searched the literature, MP, NL and MT prepared the manuscript. KN edited the paper. All the authors approved the final form of the paper.

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