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Anatomical study of the third head of biceps brachii muscle and its innervation by median nerve in human dissection

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Several studies have described the biceps brachii muscle as one of the muscles in the upper limb with most frequent anatomical variations. They also reported the presence of this anomaly in varying frequency in different populations. The aim of this study was to assess the anatomical description of the third head of biceps brachii muscle and its abnormal innervation in human autopsies which would be of value for the surgical approach in the arm. Forty arms (20 cadavers) were dissected. The upper arm and axilla region of all cadavers were dissected carefully, then the biceps brachii muscle and surrounding structures were clearly demonstrated to show any muscle variations and abnormalities of its nerve supply, then different photographs were collected. The present study demonstrated the third head of the biceps brachii muscle in 6 out of 40 specimens (15%). The third head of biceps brachii was dominant in the right arm (4 specimens) in contrast to two specimens in the left arms and the muscle was innervated by the median nerve instead of normal innervations by the musculocutaneous nerve. In conclusion, the present study of anatomical variations of the biceps brachii muscle in the arm may contribute to a better developmental understanding and surgical approach.

Key words: Biceps brachii, anatomical variation, median and musculocutaneous nerves, human autopsy.

INTRODUCTION

Biceps brachii muscle is described as a two headed muscle that originates with a short head in combination with coracobrachial muscle from the coracoid process and with a long head from the supraglenoid tubercle of the scapula. The two heads unite distally to form a common tendon that inserts into the posterior aspect of the radial tuberosity, mainly contributing to the flexion and supination of forearm (Williams et al., 1995).

Several authors (Ronald et al., 1995; Williams et al., 1995; Asvat et al., 1993; Kopuz et al., 1999; Rodríguez-Vázquez et al., 1999; Kumar et al., 2008; Poudel and Bhattarai, 2009; Kervancioglu and Orthan, 2011) have described the biceps brachii muscle as one of the muscles in the upper limb with the most frequent anatomic variations; variations are in the form of a supernumerary head, third, fourth or fifth heads. The presence of this anomaly varied frequency in different populations (Kopuz et al., 1999; Alberto et al., 2002; Kosugi et al., 1992; Rai et al., 2007; Poudel and Bhattarai, 2009).

The third head of biceps brachii muscle is a thin fascicle that originated at the humeral shaft between the

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coracobrachial and brachial muscles. Alternatively between the groove of the radial nerve and the brachial muscle, it descends to join the common distal tendon of the biceps brachii muscle and very rarely joining its muscle body (Rincón et al., 2002).

The biceps brachii muscle is normally innervated by musculocutaneous nerve of the lateral cord of the brachial plexus (Williams et al., 1995). Many investigators (Eglseder and Goldman, 1997; Hooghergen and Kauer, 1992; Kosugi et al., 1992; Uzun and Seelig, 2001) have recorded variations of nerve supply from median nerve in the absence of musculocutaneous nerve. They also observed a communication between median and musculocutaneous nerves. In addition, they described that the lateral cord of the brachial plexus supplies the complete anterior compartment of the arm after piercing the coracobrachial muscle.

The aim of this study was to assess the anatomical description of the third head of biceps brachii muscle and its abnormal innervations in human which would be of value for the surgical approach in the upper limbs.

MATERIALS AND METHODS

Twenty cadavers, 11 males and 9 females at ages 40 to 65 years old were used for this study. Forty Arms (20 right arms and 20 left arms) were dissected in the Department of Anatomy, Faculty of Medicine, at Umm Alqura University. The cadavers were provided from Institute for Plastination, Dr. Angelina Whalley, Im Bosseldorn 17, 69126 Heidelberg, Germany for academic purpose. They were placed in 10% formalin for adequate preservation.

The specimens were dissected through a longitudinal incision at the anterior aspect of the arm extending from the level of the acromion process to the elbow joint. Careful dissection and separation of skin, brachial fascia was carried out. The muscular system was exposed and studied for any variations. The nerves and major vessels were gently and carefully traced. Appropriate photographs were taken.

RESULTS

Six out of forty arms (15%) were observed to have a three headed biceps brachii muscle. All of them were innervated with median instead of the musculocutaneous nerve.

The third head of biceps brachii was found in four right arms (10%) and two left arms (5%). Three male cadavers (7.5%) and one female cadaver (2.5%) have had the third head of biceps brachii. Among these cadavers, one male (two arms) and one female (two arms) had a third headed muscle bilaterally, while the other two males (two arms) were found to have a unilateral third head muscle in their right arms.

The third head of the six cases was observed to arise commonly from the middle third of the humerus shaft near the insertion of the coracobrachial muscle (Figures 1 to 4). This additional head was seen to join the other two heads in the lower third of the arm resulting in a combined tendon inserted into the radial tuberosity (Figure 1). In one specimen, the short head formed a muscle slip adjacent to the brachial muscle forming a tunnel, in which the median nerve and brachial artery passed through (Figures 3 and 4).

The median nerve in the six cases was shown to be formed out of two roots in the upper part (Figure 1) or between the upper and middle third of the arm as shown in Figure 3. The median nerve appeared to provide two muscular branches at upper arm level as shown in Figures 1 to 4. The proximal branch crossed right above the third head of biceps brachii muscle supplying it by a slender branch to its anterior surface, continuing more deeply towards the other two heads, and supplying them also (Figure 2 and Table 1). The proximal branch in the other specimens was seen to arise from the lateral root of the median nerve. It passed underneath the muscle slip, proceeded over the third head without supplying it and ran into more depth towards the other two heads supplying them (Figures 3 and 4 and Table 1).

The distal branch appeared to be smaller and was divided into upper and lower divisions. The upper division supplied exclusively the third head from its deep surface as shown in Figure 2, while the lower ones innervated the brachial muscle (Figures 1 and 2). Another lower muscular division was shown to be rather long, located in the middle third of the arm and split off in the lower third of the arm into two branches supplying the third head and the two main heads of the muscle (Figure 4 and Table 1). The coracobrachial muscle and anterior group muscles are supplied by the median nerve.

DISCUSSION

Knowledge of variations in anatomy is important to anatomists, radiologists and surgeons and has gained more importance due to the wide use and reliance on computer imaging in diagnostic medicine. Also, the presence of anatomic variations of the peripheral nervous system is often used to explain unexpected clinical signs and symptoms (Sud and Shama, 2000). Description of nerve variations are useful in clinical surgical practice since an anatomical variation can be the cause of a nerve palsy syndrome due to uncommon connection between nerve and related muscle (Hoogbergen and Kauer, 1992).

The absence of the musculocutaneous nerve and replacement by the median nerve are in line with Sud and Shama (2000), and is associated with third head of biceps brachii (Abuel-Makarem et al., 2007; Eid et al., 2012; Ongeti et al., 2012). On the other hand, Nakatani and Tanaka (1997a) described the absence of musculocutaneous nerve and that the anterior muscles of

Table 1. Median nerve and its branches supply the third head and other two head of biceps brachii and brachial muscles.

Nerve branch	Number of right and left arm	Muscular supply
Proximal branch		
Proximal branch (median nerve)	2 R arms and 2 L arms (one male and female)	Anterior surface of third head and other two head of biceps brachii
Proximal branch (lateral root of median nerve)	2 R arms (two male)	Supply the two head of biceps brachii only (not third head)
Distal branch (median nerve)		
Upper division	4 R arm and 2 L arm (three males and one female)	Supply the third head of biceps brachii deep surface
(a) Lower division	3 R arm and 2 L arm (two males and one female)	Supply brachial muscle
(b) Lower division	1 R arm (one male)	Supply third head and other two head of biceps brachii

the arm were supplied by the lateral cord of the plexus which pierced the coracobrachial muscle. The formation of the median nerve out of three roots was described by Uzun and Seelig (2001). Two of the roots split off from the lateral cord and the other one splits from the medial cord. The lateral roots were found in close contact cranial to the axillary artery. In our studies, the median nerve was exclusively formed by two roots that united at the level of upper or middle arm thirds. A surgeon must be aware that this kind of variation is more prone to injury during surgical procedures in this region.

Additionally, our studies are in agreement with the results of Sud and Shama (2000), such that the coracobrachial muscle and the other anterior group muscles of the arm were found to be innervated by the median nerve, but not by the musculocutaneous nerve or the lateral cord of the brachial plexus.

Anomalies of the nerves of the upper limb are often accompanied by abnormalities of vessels (Hennesberg and Ceorge, 1992). Variations of cord formation in the cranial axilla have been described by many authors (Eglseder and Goldman, 1997; Santo-Neto et al., 1999), and were topographically related to the course of the subclavian and axillary vessels. In our study, the axillary and brachial vessels were normal.

The other anomaly in this study was the presence of third head of the biceps brachii muscle. It is found three times as often on right than on left arms. This is in agreement with Kosugi et al. (1992), Santo-Neto et al. (1999) and Poudel and Bhattarai (2009).

Male cadavers were found to present a high variance in this study (Asvat et al., 1993). The rate of the third head in this study was different to those from most other published data. While our study elicited a prevalence of 15% white European. Other research groups described a prevalence rate of 8% in Chinese, 10% in white European, 12% in Black Africans, 18% in Japanese, 7.1% in Indian and 12.5% Nepalese population (Kopuz et al., 1999; Alberto et al., 2002; Kosugi et al., 1992; Rai et al., 2007; Poudel and Bhattarai, 2009). The presence of the third head may be a specific functional adaptation of the population characterized by continuous moderate physical activity (Kopus et al., 1999). The compression of median nerve and vessels by third head has clinical implication that should be considered in patients (Paraskevas et al., 2008). In this study, the median nerve and brachial artery appeared to pass through a tunnel formed by a slip of muscle fiber of the short head of biceps to the brachial muscle. Kosugi et al. (1992) described a case of a Japanese male with bilateral four headed biceps brachii muscle, in which the left third head spread completely into the posterior fascia of the pronator teres muscle, forming a tunnel. The median nerve and brachial artery passed through this tunnel where they appeared compressible against the developing limbs, which lie lateral to the neural tube and cause a bulge in the overlying ectoderm. Spinal nerves are derived from two sources: motor nerves from the neural tube and sensory nerves from neural crest (Williams et al., 1995). Scannes et al. (2000) suggested that the guidance of the developing axons is regulated by expression of chemo-attractants and repulsants in a highly coordinated specified fashion. Any alterations in signaling between mesenchymal cells and neural growth cones can lead to significant variations and cause the median nerve to replace the musculocutaneous nerve in order to supply the anterior group muscles of the arm. Once formed,

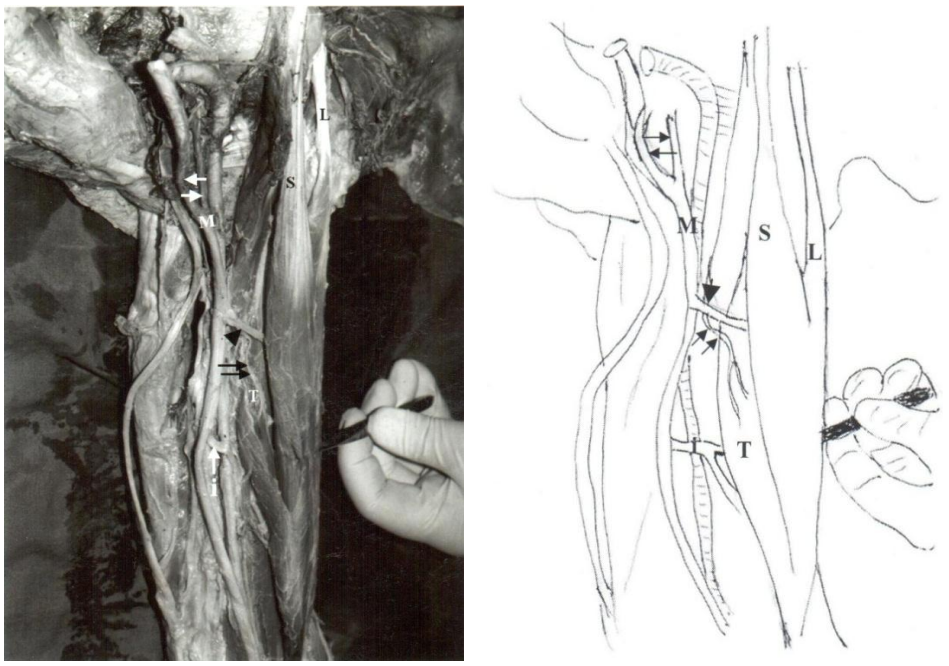

Figure 1. A photograph (A) and corresponding scheme drawing (B) of anterior view of the left arm showing the biceps brachii muscle with its long (L), short (S) and third (T) heads. The median (M) nerve gives upper (arrow head) and lower (l) muscular branches. The upper branch gives a long thin branch (double arrows) to the third head. Note the two roots of median nerve (white arrows) united at the upper part of arm.

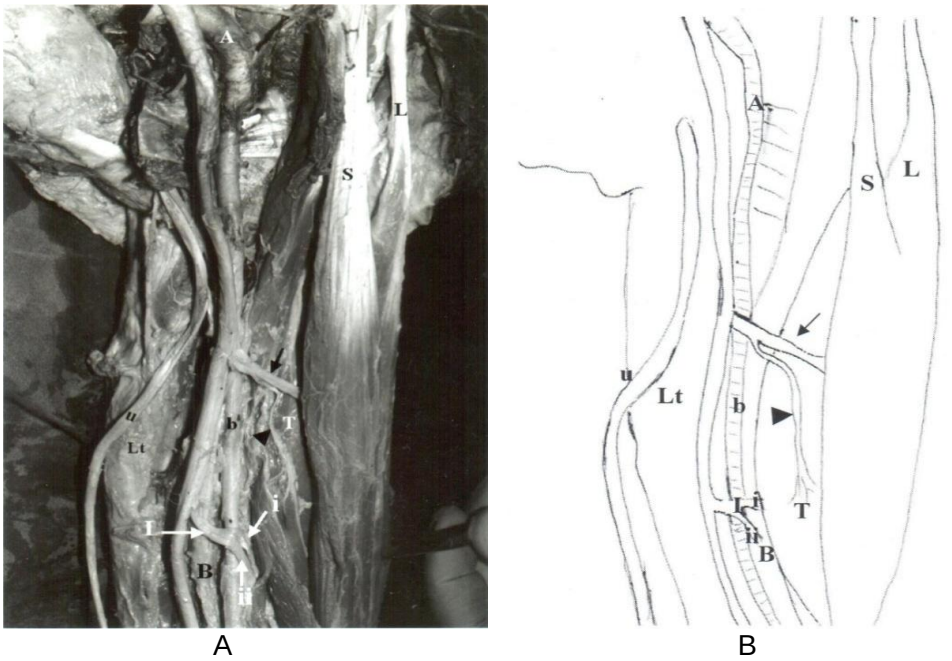

Figure 2. Higher magnification of the pervious Figure 1 (A) and corresponding schematic drawing (B) showing a large upper muscular branch (arrow) supplying the deep surface of both long (L) and short (S) heads. Also, this branch gives a long small branch (arrow head) to the anterior surface of the third head (T). The lower branch (l) splits into two muscular branches: one (i) passes deep into the third head and the other (ii) to the brachial muscle (B). Note ulnar nerve (u), axillary artery (A), brachial artery (b) and long head of triceps brachii muscle (Lt).

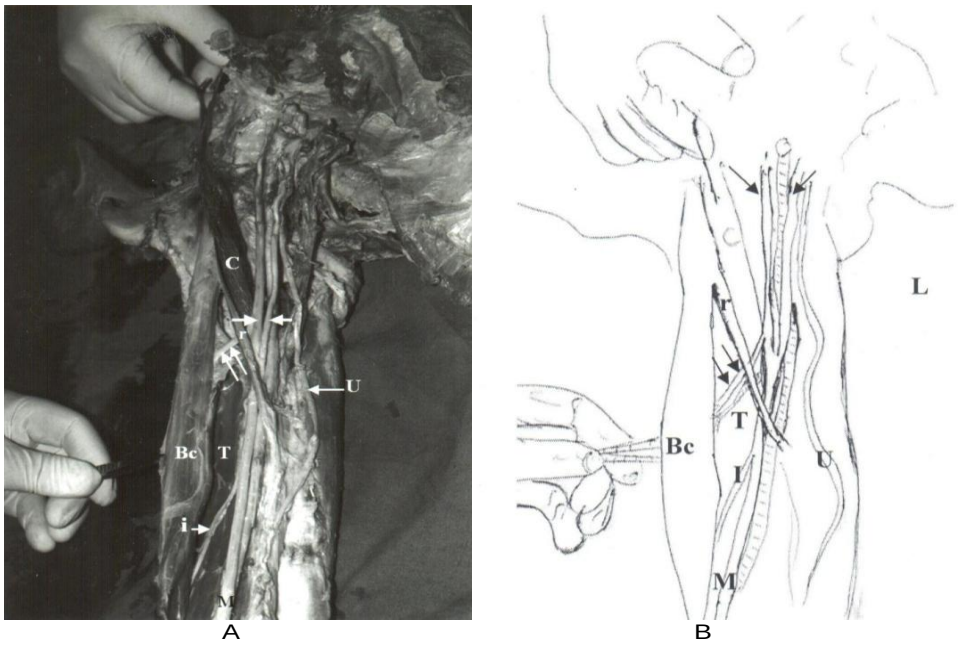

Figure 3. A photograph (A) and corresponding schematic drawing (b) of the right arm (anterior view) showing coracobrachial muscle (C) and the two roots of median nerve (upper arrows) united at the junction level between upper and middle third of arm. The upper branch (double arrows) of median nerve arises from the lateral root of the nerve. Note median nerve (M), lower branch (I), third head (T), biceps brachii (Bc), ulnar nerve (U) and muscle slip (r).

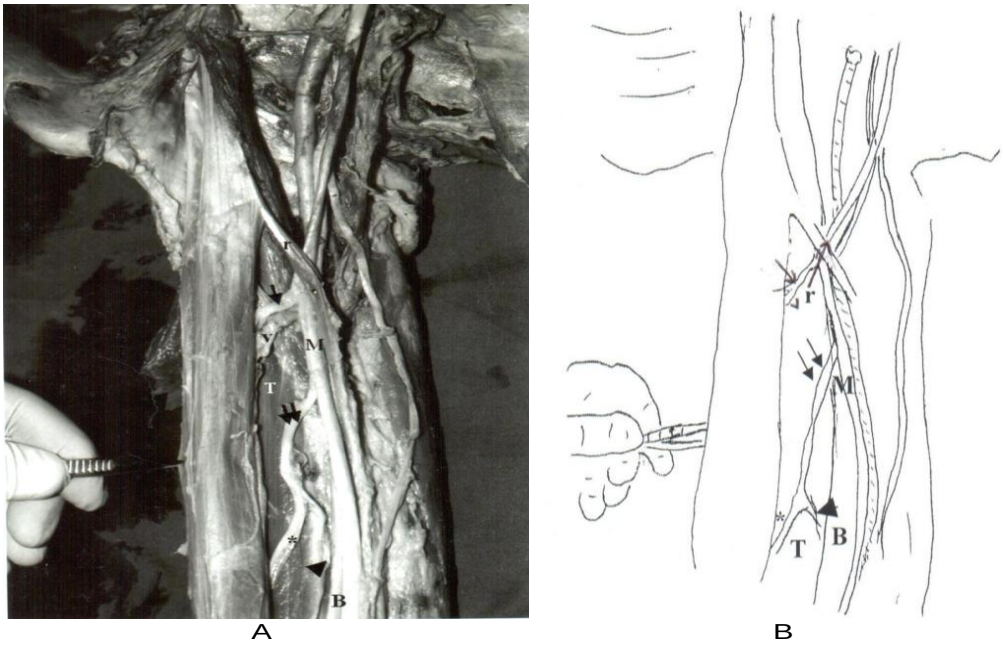

Figure 4. Higher magnification of the pervious Figure 3 (A) and corresponding schematic drawing (B) showing the median nerve (M) passing through a tunnel formed by a slip of fiber (r) attached to the brachial muscle (B). In the cranial part of arm the lateral root of the median nerve gives a muscular branch (arrow) accompanied with the vascular supply (v), this branch passes over the third head, then runs deep into the long and short heads supplying them from the depth. At the middle of the arm the median nerve gives a large muscular branch (double arrows) which divides into two branches, one (arrow head) to the third head (T) and the other branch (*) to the distal part of the deep surface of the other two heads.

any developmental difference would persist postnatally (Rodrguez-Niedenfohr et al., 1999; Scannes et al., 2000).

Therefore, general surgeons, orthopedic surgeons and medical professionals should have more knowledge about these anatomical variations when dealing with some known clinical syndromes like humeral fracture with unusual bone displacement or shoulder pain syndromes (Brown et al., 1991; Nakatani and Tanaka, 1997b).

Conclusively, this work showed some of the anatomical variations of the biceps brachii muscle and its innervations which is highly important for some developmental understanding and surgical approach.

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