Variations in the Biceps Brachii in North Bengal - An Observational Study

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ABSTRACT

BACKGROUND

Supernumerary heads of the biceps brachii are a common anatomical variation, with an incidence of 3.7 % to 20.5 % in various studies carried out around the world. They can occur in various forms, and produce a range of clinical symptoms, such as impingement syndromes at the shoulder joint, and nerve-compression syndromes in the arm. An awareness of these variations is helpful when assessing patients with pain symptoms in the region of the shoulder and arm. The purpose of this study was to examine the morphology, nerve supply, and variations in morphology, of the biceps brachii in a population in Eastern India.

METHODS

This observational study was carried out on 20 (17 males, 3 females) formalin-embalmed cadavers during routine gross anatomy dissection of the upper limb, using standard dissection methods. We examined the morphology, nerve supply, and variations in morphology, of the biceps brachii in a population in Eastern India.

RESULTS

Three upper limbs (7.5 % out of 40 limbs) showed supernumerary heads. In one male, a third humeral head of origin, from the anteromedial surface of the shaft of the humerus was observed in the left upper limb. In another male cadaver, we found a unique case with bilateral third heads with an aponeurotic origin from the capsule of the shoulder joint, with the third head comparable in size and bulk to the long and short heads. The remaining upper limbs showed the usual morphology, with the long head originating intracapsularly from the supraglenoid tubercle of the humerus and the glenoid labrum, and the short head from the tip of the coracoid process of the scapula. Insertions were usual.

CONCLUSIONS

Our study found an incidence of 7.5 % in a population sample from Eastern India, North Bengal. Supernumerary heads can occur in various forms, and can result in varied clinical symptoms.

KEYWORDS

Biceps Brachii, Biceps Brachii Variations, Supernumerary Head, Third Head, Humeral Head, Long Head of Biceps

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BACKGROUND

The biceps brachii muscle in the anterior compartment of the arm, is a powerful flexor at the elbow joint and supinator at the radioulnar joints, and a stabilizer of the shoulder joint.[1] Its usual morphology[1,4] is described as having two heads, long and short, with the long head originating intracapsularly from the supraglenoid tubercle of the humerus and the glenoid labrum, and the short head from the tip of the coracoid process of the scapula conjoined with the coracobrachialis.

The two heads form a muscle belly which inserts by a tendon into the radial tuberosity, and by an aponeurosis that blends with the antebrachial fascia. Nerve supply to both heads is from the musculocutaneous nerve carrying fibers from C5 - C7 spinal nerves. Variations in morphology of the biceps brachii can occur in various forms, as reported by Tubbs et al.[4] including various types of supernumerary heads, as well as variations in origin of the tendon of the long head.

A review of the literature revealed the presence of supernumerary heads in from 3.7 % to 20.5 % of cases, in studies carried out in various population samples from around the world. Morphological variations in the biceps brachii may produce a range of clinical symptoms, including shoulder impingement syndromes and nerve compression syndromes of the musculocutaneous and median nerves in the arm. An awareness of these variations is helpful when assessing patients with pain symptoms in the region of the shoulder and arm. The present study examines morphology of the biceps brachii in a population in Eastern India.

Objectives

- The primary objective of this study was to study the morphology,nerve supply, and variations in morphology, of the biceps brachii muscle in a sample of adult male cadavers in Eastern India.
- The secondary objective was to estimate the incidence and types of variations in morphology of the biceps brachii in the sample.
- The aim was to integrate data from our study with data from other studies carried out in diverse populations from across the world, to form a picture of variations of the morphology of biceps among different geographical populations and races.

METHODS

This observational study was carried out at the Department of Anatomy, Malda Medical College, West Bengal from 2016 to 2020. A sample of 20 (17 males, 3 females) formalin-embalmed cadavers were studied during routine gross anatomy dissection classes for MBBS students. Selected upper limbs had normal external appearance. Dissection of the flexor compartment of the arm was carried out, following standard methods.[2,3]

With the cadaver in supine position, a skin incision was made transversely from the jugular notch to the acromion, then extended vertically downwards along the lateral (preaxial) border of the arm to mid-arm level. At this level, a circumferential incision was made. A vertical incision along the medial border of the arm was carried upwards from this level to the axilla, then down the lateral thoracic wall along the midaxillary line to the inferior costal margin. A circumferential incision was made at the wrist, and a vertical incision extended from here to the mid-arm circumferential incision along the anterior surface of the forearm & arm. Skin was removed, and the deep fascia of the arm exposed. The brachial fascia was incised with scissors longitudinally from deltoid to cubital fossa, and reflected, along with superficial veins and cutaneous nerves lying on it. Superficial veins were transected where necessary. The bellies of the biceps brachii, coracobrachialis, and brachialis were separated with fingers, cleared, and defined from origin to insertion, while carefully observing for supernumerary heads of the biceps. When present, these were dissected and defined. Fascia covering the muscles was removed, to expose their tendons of origin and insertion.

The musculocutaneous and median nerves were traced from their origins from cords of the brachial plexus to the cubital fossa. Muscular branches of the musculocutaneous nerve were traced to their destination muscles. Any anomalous branches of the median nerve supplying the anterior compartment arm muscles were noted, as were any communications of the musculocutaneous nerve with the median nerve in the arm.

Tendons of insertion of biceps brachii and brachialis were dissected to their distal attachments on the tuberosities of the radius and ulna respectively, in the cubital fossa. The coracoid attachment of the short head of the biceps brachii and coracobrachialis was exposed, and the coracobrachialis traced to its attachment on the humerus. The deltoid muscle was detached from its attachments to the clavicle, acromion and spine of the scapula, and reflected distally, while preserving the branch of the axillary nerve that supplied it. This exposed the anterior surface of the shoulder joint capsule. The tendon of the long head of biceps was traced proximally in the intertubercular sulcus upto its emergence from the capsule of the shoulder joint. After placing the cadaver in the prone position, the tendon of the long head of the triceps brachii was detached from the infraglenoid tubercle, exposing the posterior surface of the capsule of the shoulder joint, which was incised. The interior of the joint was explored with a probe, and the glenohumeral ligaments and glenoid labrum were observed. The intracapsular portion of the tendon of the long head of biceps (LHBT) was traced to its attachment to the supraglenoid tubercle and glenoid labrum. Any splitting or additional attachments of the tendon were explored and noted.

RESULTS

Out of the 20 cadavers dissected, 18 showed the usual morphology[1,4] of the biceps brachii muscle in both upper limbs, with the two heads, long and short, originating intracapsularly from the supraglenoid tubercle of the humerus and the glenoid labrum, and from the tip of the

coracoid process of the scapula, respectively. Insertions were usual, with the bicep's tendon inserting into the radial tuberosity, and the bicipital aponeurosis blending with the antebrachial fascia. Nerve supply was from the musculocutaneous nerve, to both heads. Three upper limbs (7.5 % out of 40 limbs) showed supernumerary heads.

In one male cadaver, a third humeral head of origin (Fig. 2), from the anteromedial surface of the shaft of the humerus was seen unilaterally in the left upper limb. The head was in the form of a slip, smaller in size than the long and short heads. Approaching the cubital fossa, the head split into 2 slips, which attached to the biceps tendon, and to the bicipital aponeurosis, respectively. The long and short heads showed the usual morphology and attachments. All 3 heads were supplied by the musculocutaneous nerve, which had a communication with the median nerve (Fig. 2).

In another male cadaver, an aponeurotic third head of origin was seen in both upper limbs (Fig. 1), arising from the capsule of the shoulder joint. The third head was comparable in size to the long and short heads, and merged with these heads at mid-arm level. The long and short heads showed the usual morphology and attachments. Insertion of the muscle was into the radial tuberosity by a tendon, and into the bicipital aponeurosis. All 3 heads were supplied by the musculocutaneous nerve on both sides.

Statistical Analysis

As this was a morphological study, and no numerical data was not collected, only basic distribution of different morphologies of the biceps brachii are shown below.

Number of Limbs	Usual Morphology			Variant Morphology		
	Right	Left	Total	Right	Left	Total
Male	16 (80 %)	15 (75 %)	31	1 (5 %)	2 (10 %)	3
Female	3 (15 %)	3 (15 %)	6	0 (0 %)	0 (0 %)	0
Total	**19 (95 %)**	**18 (90 %)**	**37**	**1 (5 %)**	**2 (10 %)**	**3**

Table 1.

Figure 1. Anterior Views of Dissected Left and Right Shoulder Regions. 1. Tendon of Long Head of Biceps Brachii (Intracapsular); 2. Tendon of Short Head of Biceps Brachii Arising from Coracoid Process of Scapula; 3. Aponeurotic Origin of Supernumerary Head from Capsule of Shoulder Joint; 4. Pectoralis Major (Reflected); 5. Pectoralis Minor, Coracoid Attachment; 6. Deltoid

The most frequently occurring morphology, the mode, was the usual one, with the long head originating intracapsularly from the supraglenoid tubercle of the humerus and the glenoid labrum, and the short head from the tip of the coracoid process of the scapula, and insertion of the biceps tendon into the radial tuberosity and the bicipital aponeurosis. Among the variant morphologies, the most frequently occurring was the aponeurotic origin of a third head from the capsule of the shoulder joint, in two upper limbs (bilaterally in the same individual).

Figure 2. Anteromedial View of Dissected Left Arm & Cubital Region. 1. Supernumerary Humeral Head of Biceps Brachii; 2. Long Head of Biceps Brachii; 3. Short Head of Biceps Brachii; 4. Tendon of Biceps; 5. Bicipital Aponeurosis; 6. Musculocutaneous Nerve; 7. Median Nerve; 8. Ulnar Nerve; 9. Medial Epicondyle of Humerus; 10. Brachial Artery

DISCUSSION

In Bergman's compendium, Tubbs et al.[4] cite the most common form of a third head as a slip that arises from the ventral surface of the humerus near the insertion of the coracobrachialis, and we observed this type of supernumerary head in one upper limb in our study. Additional heads can occur from the distal portion of the deltoid tuberosity, tendon of the pectoralis major and the capsule of the shoulder joint.[4] Tubbs et al.[4] report incidence of supernumerary heads in about 8 % of Chinese, 10 % of white Europeans, 12 % of black Africans, and 18 % of Japanese in one cited study (Kudo and Bando 1956), or in 14 % of Chinese 18 % of white Europeans, 13 % of black Africans, and 18 % of Japanese in another study (Nishi 1952).

Among contemporary studies with significant sample sizes, Asvat et al. (1993)[5] found supernumerary heads among 20.5 % blacks and 8.3 % whites in a sample of 170 limbs in South Africans. They found three different origins: (1) from the surface of the humeral shaft inferior to coracobrachialis; (2) from the medial surface of the humeral shaft, adjacent to brachialis; and (3) a dual origin, with medial fibers arising from the short head of biceps and lateral fibers from the deltoid fascia and insertion area of this muscle. In all cases, the third head inserted together with the other 2 heads into bicipital aponeurosis and radial tuberosity, and received innervation from the musculocutaneous nerve. Neto et al. (1998)[6] observed a third head in 9 % of 100 limbs in black subjects and in 20 % of 100 limbs from whites in a Brazilian population. Ilayperuma et al. (2011)[7] described a third humeral head in 3.7 % of 270 upper limbs in Sri Lankans, all male, all unilateral, and in all cases arising from the anteromedial surface of the shaft of the humerus. Kopuz et al. (1999)[8]

studied 160 limbs of 60 neonatal and 20 adult cadavers, observing a third head in 24 (15 %) specimens, frequently arising from the anterior surface of the humerus distal to insertion of coracobrachialis. In all cases, the third head inserted into the conjoined tendon of biceps brachii and received its nerve supply from the musculocutaneous nerve. Jayanthi et al. (2012)[9] in a sample of 120 cadavers (70 adult, 50 fetuses; 80 male, 40 female) found supernumerary heads in 10.8 % of cases; 15.2 % were males and 2.5 % females. Supernumerary heads were on the left side in 6.7 % and on the right side in 5 %. Bilateral triple heads were observed in one case.

Among the studies carried out in the Indian subcontinent, the incidence of a third head was reported to be 3.7 % in Sri Lanka by Ilayperuma et al. (2011),[7] 6.2 % in Nepal by Poudel and Bhattarai (2009),[10] 10.8 % in Kerala by Jayanthi & Elezy (2012),[9] and 18.7 % in Chattisgarh by Morampur et al. (2105)[11] Poudel and Bhattarai[10] found four heads in 6.2 % of their sample.

Rodriguez-Niedenfuhr (2003)[12] found the presence of a third head in 23 of 175 (13.1 %) cadavers or in 27 of 350 (7.7 %) arms. They classified supernumerary bicipital heads into three types, superior, inferomedial and inferolateral humeral heads, with the inferomedial type being most common, with an incidence of 9 % out of 350 limbs. They observed a superior humeral head in 5 (1.5 %), and an inferolateral humeral head in 1 (0.3 %) of 350 arms.

Testut & Latarjet[13] propose an explanation for the most common type of supernumerary head of the biceps, that arising from the anteromedial surface of the humeral shaft adjacent to the coracobrachialis insertion. They state that embryologically, this third head arises from the brachialis muscle, and its distal insertion translocates from the ulna to the radius.

Variations in the long head as cited by Tubbs et al.[4] include underdeveloped or absent long head, and accessory slip from the deltoid. They cite variations in the long head biceps tendon (LHBT), such as its origin from the bicipital groove, greater tubercle, lesser tubercle or capsule of the shoulder joint. They also cite dual intracapsular attachment of the tendon to the supraglenoid tubercle and posterior capsule of the shoulder joint.

In an arthroscopic study of 2 samples, each of 1500 Italian patients, Dierickx et al.[14] classified variations of the intra-articular portion of the tendon of the long head into four major families, each divided into subgroups. These were a mesotenon (MESO) family, an adherent (ADH) family, a split (SPL) family, and an absent (ABS) family, in which the intraarticular LHBT had a mesotenon, was adherent to the capsule/rotator cuff tendons, was split, or was absent, respectively. Several functional consequences can result from presence of supernumerary heads of biceps. Anomalous attachments of the intraarticular portion of LHBT may cause shoulder pain, impingement syndromes, painful arc, subacromial bursitis etc.[15,14,16]

In our study, we found a case with bilateral third heads with an aponeurotic origin from the capsule of the shoulder joint, with the third head comparable in size and bulk to the long and short heads. We found no comparable case in our literature review, although we found one instance of a tendinous origin of a third head from the shoulder joint capsule,[17] but this head was much smaller than the other two heads.

Another case report mentions origin of the tendon of the long head from the shoulder joint capsule,[18] but its usual attachment to the supraglenoid tubercle was not present, as it was in our study. The third heads of origin from the shoulder joint capsule observed by us formed muscle bellies of comparable size to the bellies of the long and short heads, and hence would result in a significant increase in cross-sectional area of the muscle, and therefore in muscle power. Humeral heads, as found in one limb in our study, would also contribute to muscle power, and additionally may cause entrapment and compression syndromes of the musculocutaneous nerve.[4]

Molecular mechanisms leading to muscle and tendon formation have been elaborated,[19,20] and it may be hypothesized that dysregulation of these pathways leads to variations in muscle and tendon morphology. Limb muscles develop from the myotome of somites. Tendons of muscles develop from the syndetome,[19] which is the fourth compartment of a somite, lying between the myotome and the sclerotome, and discovered only subsequent to the discovery of molecular markers that defined the sclerotome (Pax1) and syndetome (scleraxis). Myotome cells secreting Fgf8 induce syndetome formation. Syndetome cells express scleraxis protein.

Cartilage cells in the sclerotome (which will later form bones) express Sox5 & Sox6, which inhibit scleraxis expression along the length of the syndetome adjacent to the future bone. Scleraxis is expressed only at the anterior and posterior ends of the syndetome, so that tendon formation occurs only at the ends of bones, where muscles attach. Dysregulation of this syndetome differentiation pathway may be responsible for variations in the origin of the long head of biceps, or of various origins of supernumerary heads.

Flexor muscles of the upper limb, including biceps brachii, develop from the ventral muscle mass of the myotome. Cells of this region undergo a stepwise sequence of commitment, migration, proliferation, determination, differentiation, and finally formation of specific muscles, each step regulated by multiple genes and transcription factors. Meox2, a homeobox geene and Lbx1, a homeobox transcription factor, are responsible for patterning of the morphology of specific muscles.[20] Abnormal temporal and spatial expression patterns of these genes may contribute to variations in morphology of the biceps brachii.

CONCLUSIONS

Incidence of supernumerary heads of biceps brachii vary from around 5 % to 15 - 20 % in various studies in varied populations around the world. Our study found an incidence of 7.5 % in a small sample from Eastern India. Supernumerary heads can occur in various forms. We found two types of third heads, supernumerary head, a common humeral type, and an unusual aponeurotic origin from the shoulder joint capsule, which, as far as our review of the

literature could tell us, is previously unreported. Supernumerary heads of biceps can result in varied clinical symptoms, such as painful arc and impingement syndromes of the shoulder, and nerve entrapment syndromes in the arm. These should be kept in mind as differential diagnoses in patients presenting with such symptoms.

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