Original Article

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Revisited Anatomy of Additional Heads of Biceps Brachii Muscle and Coexisting Musculocutaneous Nerve Variants

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Abstract

Introduction: To determine the incidence and gross morphology of additional head of biceps brachii in the Indian population, and to note concurrent musculocutaneous nerve variations. **Subjects and Methods**: One hundred and twenty upper limbs (males- 100, females- 20) from 60 formalin-embalmed cadavers were utilized for the study. **Results:** The additional heads were found in 11 cadavers. Third head was present in 16.6% and fourth head in 1.7%. The variation was unilateral in 72.7% and bilateral in 27.3% cadavers. Out of 120 limbs, 14 had additional head, and 71.4% of these were left-sided. In 73.3%, additional head joined with tendon and with the belly of BB in 26.7%. Three types of origin: anterolateral, posteromedial and high humeral were observed in 60%, 26.7% and 13.3%, respectively. The additional muscle was 11.7 ± 3.9 cm in length. The mean length on the right and left sides was 9.8 ± 3.3 cm and 12.4 ± 3.9 cm, respectively. Incidence of concurrent additional head and musculocutaneous variations was 42.8%. The nerve variations were unilateral with 80% on the left, and ipsilateral to additional muscle. **Conclusion:** The incidence of additional head in biceps brachii is 18.3% in the Indian population. Most common presentation is of a left-sided third head, and musculocutaneous variants occur on the same side as additional muscle. Presence of extra head should be considered during the analysis of the diagnostic scans, and awareness of the associated musculocutaneous nerve variations would be helpful in avoiding complications during surgical interventions.

Keywords: Morphology, Musculocutaneous nerve, Upper extremity, Biceps brachii, Musculoskeletal Abnormalities.

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Introduction

Biceps brachii (BB) is a muscle of the front of arm. The long and short heads of BB arise from the supraglenoid tubercle and the coracoid process, respectively. Two heads form a tendon near the elbow for insertion into the radial tuberosity.[1] When another muscle mass joins it before insertion, it is termed as an extra, supernumerary, additional or accessory head of BB.[1-6] The third head in BB is encountered more often than the fourth or higher number of heads, however its incidence is variable. The accessory muscle usually attaches to the medial side of humerus near coracobrachialis (CB) or brachialis, and distally fuses with the inner aspect of biceps brachii tendon.[1-3] It is seen as a thick muscle in most of the cases and may present as a soft tissue mass in the arm especially if bulky.[7] Moreover, an extra head is likely to simulate a muscle tear in the diagnostic image of the upper limb.[5]

Variable incidence of the additional head of biceps muscle (AHB) is described in the literature from the multiple ethnic populations such as, 8% in Chinese, 10% in white Europeans, 12% in black Africans, and 18% in Japanese.[3] In comparison, the prevalence is reported to be low in the Indian population.[4,8-10]

BB acts as a flexor at the elbow, and its principal action is supination.[1] The presence of an additional head adds to the muscle mass. This is likely to affect the biomechanics of BB,[11] and has the potential to create imbalance at the elbow due to extra muscle bulk in the flexor aspect of the brachium.

Musculocutaneous nerve (MCN) is one of the branches of the lateral cord of brachial plexus. It supplies BB and the other muscles of the anterior compartment of arm, before giving the lateral cutaneous nerve of forearm. After passing through CB, MCN runs beneath BB in the arm. A communicating branch (COB) is seen if few median nerve (MN) fibers enter MCN and later leave it to join MN, though rarely fibers travel in the reverse direction.[1] The incidence of absent MCN is 3.6%, and that of the nerve connections between MCN and MN is 53.6%.[12] Venieratos and Anagnostopoulou observed such COB in 13.9%.[13]

It has been suggested that AHB influences the course of MCN leading to the nerve variants, and can impinge on it especially if the nerve is running in close relation to it.[8,14] In studies on the AHB, variations in MCN, like the absence of MCN, duplication of MCN, altered course of MCN, or communicating branches between MN and MCN have been reported.[4,7,15,16] Communicating branches concurrent with AHB are seen in 9.3%, 23.8% and 54.7% according to Techataweewan et al., Ballesteros et al. and Kosugi et al., respectively.[4,7,16] However, there is scarcity of literature on the incidence of MCN variations associated with AHB in the Indian population. Also, the existing knowledge on the morphology of AHB in Indians is limited. This study proposed to find out the incidence of AHB in the Indian population, and describe its morphology, and the simultaneous presence of MCN variants.

Subjects and Methods

Sixty adult formalin-embalmed cadavers (50 male, 10 female), with an average age of 61 years (range 52-70), available in the department of Anatomy from 2014-2019 were selected for this study. The upper limbs with any apparent deformity, damage, or signs of surgery were excluded. The cadavers were obtained through institutional body donation program following ethical guidelines and all the specimens were stored in 10% formalin solution after embalming.

For dissection, a vertical incision was placed in the skin of the front of the arm and the elbow. The line of incision extended from the acromion process to the radial tuberosity, and was joined by horizontal incisions at the two ends. After reflecting the skin flaps, the muscles of the anterior compartment of arm were exposed by the blunt dissection and subsequently examined for the presence of AHB. The number, laterality, attachments, shape, length, and nerve supply of the extra heads were recorded. The length of AHB from origin to its fusion with BB was measured using a Vernier Caliper with a sensitivity of 0.01mm, and the mean of three readings was taken as final. In the limbs with an additional head, any MCN variation if present, was noted. Two independent observers, both anatomists, recorded the findings.

Results

Out of 60 cadavers examined, AHB was seen in 11 (18.3%), 10 male and one female. The accessory muscle was bilateral in three (27.3%) and unilateral in eight (72.7%). The four-headed muscle was present on the left arm in one male cadaver (1.7%) and rest of the cases had an extra third head (16.6%). The female cadaver had a unilateral left-sided third head.

In 120 upper limbs (males- 100, females- 20), BB with two heads was observed in 106 limbs (88.3%), three heads in 13 (10.8%) and four heads in one (0.8%). The distribution of number of heads in BB is shown in Table 1. The incidence of AHB was 13% in the males and 5% in the females. Among the 14 limbs, AHB was left-sided in 10 (71.4%) and right-sided in four (28.6%).

AHB was positioned deep to the main belly of biceps brachii. It joined with the tendon of BB in 73.3% and with the belly in four 26.7%. The extra head joining the tendon, fused with it on the inferomedial aspect and formed most of the bicipital aponeurosis. AHB fused with BB in the lower part of arm near the elbow in 86.7% and in the middle of the arm in 13.3%.

All the additional heads were humeral in origin. The origin was fleshy and vertically positioned in 93.3%, and tendinous and transversely placed in 6.7% [Figure 1B]. The most common site of origin was on the medial side of the shaft of humerus close to CB. The humeral origin was classified on the basis of its location: O1- anterolateral (between CB insertion and brachialis), O2- posteromedial (medial to CB insertion), and O3- high humeral. The types O1, O2 and O3 were observed in 60%, 26.7% and 13.3% respectively. The type O2 in one muscle extended to the medial intermuscular septum and fascia over brachialis, and covered the median nerve and brachial artery in the lower half of the arm [Figure 1C]. Type O3 was either on the anterior aspect of humerus shaft just above brachialis attachment, or on the medial aspect of shaft below teres major insertion. All the type O2 cases were right-sided, whereas, type O3 were left-sided. Type O1 was left-sided in 88.9%.

On the basis of morphology, three types of AHB were encountered: I- long, thin and narrow [Figure 1B]; II- long, thick and broad; III- short, thick and broad [Figure 1A]. Type I appeared in six (40%), type II in seven (46.7%), and type III in two (13.3%) limbs. All type I cases and 57.1% of type II were left-sided, and type III was equally distributed on both the sides. The length of AHB varied from 4.7 to 18.1 cm, the average being 11.6 ± 4.0 cm. The mean length on the right and left sides was 9.8 ± 3.3 cm and 12.4 ± 3.9 cm, respectively. In males, mean length on the right side was 9.8 ± 3.3 cm and that on the left was 12.3 ± 4.2 cm. The length of AHB in specimen from the female cadaver was 13.6 cm.

MCN supplied the AHB in all cases except one where MCN was absent, and a branch from the lateral cord supplied it [Figure 2F]. An added innervation to AHB from MN was observed in three (21.4%). In the presence of AHB, MCN was posterior to it in 92.3%, and anterior to it in 7.7%.

Incidence of concurrent AHB and MCN variations was 42.8% [Table 2]. Two types of variations were seen: absence of MCN, and COBs between MCN and MN [Fig 2]. COBs were directed from MCN to MN in 80%, and in opposite direction in others. All the nerve variants were unilateral and were on the same side as AHB. Four out of six (80%) were located on the left side. The COBs were given off in proximal third of arm either before entry of MCN into CB [Figure 2E] or during its passage through CB [Figure 2A]. The distal COBs were more common (66.7%), and their position was between AHB and BB [Figure 2B], between AHB and brachialis [Figure 2C], and medial to AHB [Figure 2D and 2E].

Table 1: Incidence of additional heads of biceps brachii

Number of heads in biceps brachii	Male		Female	
	Right N=50 (%)	Left N=50 (%)	Right N=10 (%)	Left N=10 (%)
Two heads	46 (92)	41 (82)	10 (100)	9 (90)
Three heads	4 (8)	8 (16)	0	1 (10)
Four heads	0	1 (2)	0	0

Table 2: Incidence of musculocutaneous nerve (MCN) variations associated with additional head of biceps brachii.

	Type of MCN Variation	Incidence (%) N=14
1	No MCN variation	8(57.2)
2	Absence of MCN	1(7.1)
3	One communicating branch between MCN and median nerve	4(28.6)
4	Two communicating branches between MCN and median nerve	1(7.1)

Table 3: Incidence of additional head of biceps brachii in various populations.

S.no.	Study	Year	No. of cadavers	POPULATION	INCIDENCE (%)
1	Kosugi	1992	273	Japanese	21.2
2	Asvat	1993	85	South Africa	20.5 (Blacks) 8.3 (Whites)
3	Neto	1998	100	Brazil	White-20 Black- 9
4	Rodriguez	2003	175	Spain	15.4
5	Nayak	2006	48	India	2.08
6	Rai	2007	42	India	7.1
7	Kumar	2008	48	India	3.33
8	Cheema	2011	63	India	2.3
9	Ilayperuma	2011	135	Sri Lanka	3.7
10	Pakhale	2012	40	India	3.75
11	Nasr	2013	50	Saudi Arabia	10
12	Ballesteros	2014	53	Columbia	19.8
13	Da Silva	2016	74	Brazil	13.5
14	Techataweewan	2016	162	Thailand	35
15	Present study	2019	60	India	18.3

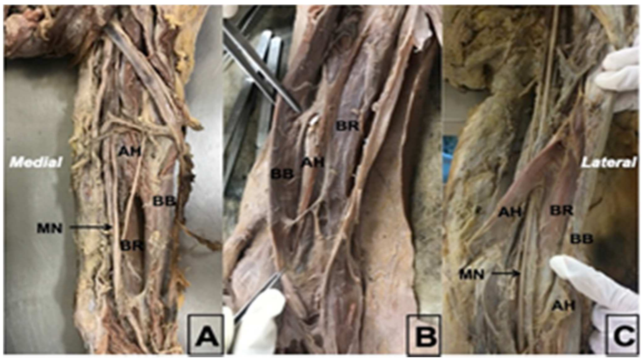

Figure 1: Morphology of additional head. A- Left upper limb with short, thick and broad AH (type III). B- Left upper limb showing long, thin and narrow AH (type I) with tendinous origin. C- Left upper limb with type II AH (MN and brachial artery passing under AH). AH: additional head; BB: biceps brachii; BR: brachialis; MN: median nerve.

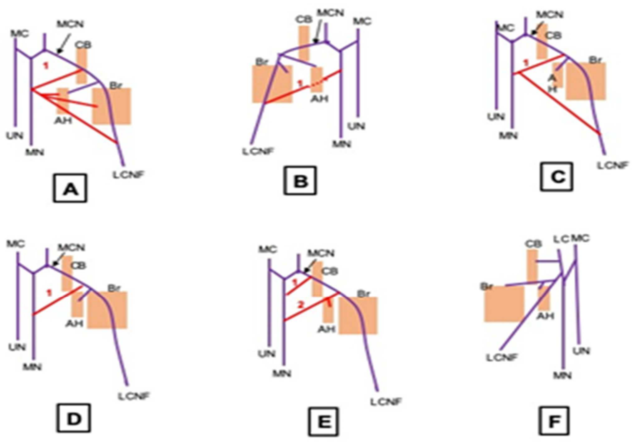

Figure 2: Variations in MCN. A: (left) one communicating branch (COB) from MCN to MN. Branches to AH and Br arise where COB joined MN. B: (right) one COB passing between AH and Br. C: (left) one COB passing between CB and upper margin of AH. D: (left) one COB passing from MCN to MN and related medial to AH. E: (left) two COBs, first arises from MCN before it enters CB. Second COB supplied AH. F: (right) MCN absent and all the muscles are supplied by lateral cord. MCN: musculocutaneous nerve; CB: coracobrachialis; AH: additional head; Br: brachialis; MN: median nerve; LCNF: lateral cutaneous nerve of forearm; LC: lateral cord; UN: ulnar nerve; BB: branch to biceps brachii; 1, 2: communicating branches between median and musculocutaneous nerves.

Discussion

AHB was noted in 18.3% cadavers and 54.5% (six) of these had MCN variants in this study from the Indian population. The variable incidence of the AHB in the different populations is well documented (Table 3). The incidence is high in the Thai and Colombian than in the South Asian population from India and Sri Lanka.[4,17] Ethnic differences are presumed to be due to the morphological adaptations in the BB.[7,17,18] However, compared to other Indian studies, our study revealed a higher incidence of AHB.

In study by Asvat et al., extra head was more common in the black (20.5%) compared to the whites (8.3%), and in a study by Neto et al., extra head was seen in 20% white and 9% black,[11,19] suggesting that the incidence of AHB may not always be related to the race.

AHB is predominantly humeral in origin, and the medial side of shaft near CB is the most frequent site of attachment.[3,4,6,9,11,16-23] We found the humeral origin from area close to CB insertion in 86.7%. The other sites of AHB attachment can be pectoralis major,[3,16,19,20,24] shoulder joint capsule,[3,6,16] lesser tubercle,[20] greater tubercle,[5,16] deltoid tuberosity,[8] bicipital groove margins, and medial intermuscular septum.[16] Accessory fibers can also come from brachialis, long and short heads of BB, CB, coracoid process,[4,6] and origin from the deltoid fascia or insertion is rare.[11] The origin near deltoid tuberosity, CB and pectoralis major insertion is seen in 8%, 6% and 4%, respectively.[3] The surgical approach to shoulder can be affected if accessory muscle attaches close to the upper end of the humerus.[14]

The knowledge of muscle origin is relevant to interpret cases with suspected soft tissue injury to differentiate traumatic muscle split from the other causes.[5] Rincon et al., classified the origin as superior, inferomedial, and inferolateral.[17] The inferomedial type or origin from the medial side of humerus shaft is the most common.[17,25] We identified anterolateral, posteromedial and high humeral origins on the basis of its relation to CB insertion, and anterolateral was the most common type.

The variations in insertion are believed to be due to factors affecting the muscle development.[6] Kosugi et al. classified the insertion into four types according to the fusion of AHB to the belly, tendon, short head, and long head.[16] The insertion to the belly was found to be the most common.

This is similar to the study by Nasr and Hussein.[6] However, according to Rincon et al., the muscle rarely joins the biceps belly.[17] As per our observation, the extra head mostly fused with the tendon. This is supported by reports from several other authors.[4,7,10,11,17,20,26]

Comparable to our description, other studies have described AHB as a male dominated condition.[4,9-11,17,18,20,27] However, our sample had the limitation of being comprised of a much smaller number of female specimens. It is more prevalent in the female cadavers from Japan and North America,[16,22] and Techataweewan et al. have reported equal incidence in both the sexes.[4]

Additional head is usually unilateral in presentation.[4,9,18,20,25] A unilateral presentation could present as an asymmetric lump in the upper limb and should be considered while arriving at a diagnosis.[26] As most people are right-handed, AHB is mainly believed to be a right-sided condition.[7,15,17,21,25,27,28] Though some studies have identified it to be more common on the left.[4,6,9,11,20] Unilateral cases are common on the right side in males and on the left side in females.[16] In Thai, unilateral cases are common on left side in both sexes.[4] Bilateral cases are usually more common in males.[11,16] In Thai population, it was found to be equal in both sexes.[4] We observed that unilateral cases were more common, and were mostly observed on the left. Also, the third head was present in majority (92.3%) of cases with AHB, which concurs with many earlier studies.[3,4,6,7,9,11,17-19,25,27] More than four heads in BB did not appear in our sample.

The morphology of extra head is variable. It is usually well developed in the males where it is thicker on the left side and longer on the right side. In females, it is considered to be thin, and also longer on the left but thicker on the right.[4,16,21] Average length of an additional head is 11.8 cm,[6,7] which is analogous to our observation. However, Cheema and Singla found it be the 12.9 cm in sample from north India that was comparable to the findings in Sri Lankan and Colombian populations.[9,17,18]

The specific influence of AHB on joint movements is likely to depend on attachments. Muscle fibers from the humerus will act only on the elbow joint and medial origin on the shaft would work in the favor of pronation unlike the long and short heads.[11] The overall muscle power will be enhanced at the insertion site where AHB joins with the main BB tendon. This is likely to reflect in the movements of flexion at the elbow and supination.[8,29]

During muscle development in the fetal life, myotome of each somite forms epimere and hypomere. At the location of limb buds, myogenic cells from hypomeres move into the limbs in the fifth week of the intrauterine life. The ventral mass derived from these myoblasts forms muscles of the anterior compartment of the arm including BB.[30] The definitive structure of muscles depends on various factors like the segmentation of muscle mass, effect of T-box factors, and apoptosis during morphogenesis.[31] A disturbance in these factors could lead to the formation of accessory muscles. As spinal nerves grow into the limb buds, muscle cell surface molecules direct the growth and distribution of axons.[31] This provides a likely explanation for variation in the nerve course and branching seen with the accessory muscle heads.

Additional head is related superficially to MCN.[7,17] MCN passing beneath a large accessory muscle is vulnerable to compression.[18] Though extra head is innocuous in the majority, it becomes clinically relevant in instances of accessory head arching over the neurovascular structures in the arm where compressive symptoms can appear.[8,14,32] We observed one case of accessory muscle covering median nerve and brachial artery, similar to a case reported by Nakatani et al.[33] In cases where MCN is absent, the accessory head is supplied by MN.[3,12,27] Communication between MN and MCN are clinically significant in the cases of nerve entrapment and also place the nerve at risk during surgical procedures in the arm. The connecting branches should be carefully pursued and approached to avoid complications related to loss of nerve fibers.[13,33] It has also been proposed that presence of MCN variation influences the development of extra head.[3] We observed communicating branches with an additional head of BB in 35.7% cadavers, all unilateral and on the same side as the extra muscle. In comparison to classification by Choi et al.,[34] three cases [Figure 2A, 2B, 2C] were similar to pattern 2a and one case [Figure 2 E] was similar to pattern 3, and we observed most COBs on left. Cases shown in Figs 2B and 2C in our study were type II, and case 2E had both types I and II variations as per the description from Venieratos and Anagnostopoulou, whereas, according to the classification proposed by Guerri-Guttenberg and Ingolotti, cases in figures 2B and 2C are similar to type I-A-1-D, and case 2E is comparable to type I-A-2-PD. Case 2A, however, did not fit these two classifications. Also, the simultaneous presence of an additional head of BB was not noticed in any these studies.[12,13]

Conclusion

Based on the present study, incidence of additional head in biceps brachii is 18.3% in the Indian population. AHB is more common in males and is most likely to be seen as a third head on the left side. AHB can be associated with ipsilateral nerve communications, which would possibly complicate surgical procedures in arm. Awareness of these variations is also important for the interpretation of radiological scans.

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