

An anatomical study on the three-headed biceps brachii in human fetuses, and clinical relevance

P. Kervancioglu, M. Orhan

Anatomy Department, Gaziantep University Medical Faculty, Gaziantep, Turkey

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The biceps brachii (BB) is as one of the most variable muscles in the human body in terms of number and morphology of its heads. The most frequent variation is the presence of a third head, which has been reported by several authors in different populations. Our aim was to find the occurrence of the supernumerary head of BB in Turkish fetuses. Out of the 24 upper limbs of the fetuses, two (8.33%) arms were found to have a three-headed BB. The variations were present unilaterally in the right arm of one male fetus and one female fetus. In one of the cases, the third head of BB originated from the anteromedial aspect of the humerus just distal to the insertion of the coracobrachialis, medial to the brachialis, and in the other the third head was a thin muscle bundle, which arose on the lateral side of the insertion of coracobrachialis and over the origin of the brachialis. Both of them were extended distally and joined the common tendon. The occasional presence of the three-headed BB in the fetuses observed in the present study was similar to those of adults reported in previous studies. In conclusion, these variations are not rare and are interesting not only to anatomists but also to orthopaedic surgeons, plastic surgeons, traumatologists, physiotherapists, doctors dealing with sports medicine, and radiologists. (Folia Morphol 2011; 70, 2: 116–120)

Key words: arm, variation, supernumerary head, upper limb, third head, Turkish

INTRODUCTION

The biceps brachii (BB) is known as one of the muscles with most frequent anatomical variations in the human body in terms of number and morphology of its heads. It is classically described as a double-headed muscle which originates from two heads: the long and the short heads. Proximally, the long head originates from the supraglenoid tubercle of the scapula, and the short head originates from the coracoid process of the scapula together with the coracobrachialis. In the distal part, these two heads unite to form

a common tendon, which inserts into the posterior area of the radial tuberosity and some aponeurotic and tendinous fibres form the bicipital aponeurosis which joins the deep fascia of the forearm [20].

The most frequent variation of BB is the presence of a third head, which has been reported in several articles. The third head of BB variations may present as a group of accessory fascicles arising from the coracoid process, the tendon of the pectoralis major, the head or corpus of the humerus, and the articular capsule of the shoulder [1, 2, 8, 18].

Address for correspondence: P. Kervancioglu, Department of Anatomy, the University of Gaziantep, Medical Faculty, University Avenue 27310, Sehitkamil/Gaziantep, Turkey, tel: +90 05057769756, fax: +90 0342 3601617, e-mail: pkervancioglu@gantep.edu.tr, pirayek@hotmail.com

In the vast majority of cases, accessory heads are asymptomatic and represent incidental findings at surgery or imaging. In some cases, however, accessory heads may produce clinical symptoms [11]. Clinicians should be aware of the accessory heads of the BB as they may be confusing for a surgeon performing procedures on the arm and may lead to iatrogenic injuries. Consequently, knowledge of such variations may become significant in preoperative diagnosis and during surgery. Additionally, they may cause compression of important neurovascular structures in the upper limb [11, 14, 22]. If the variation is unilateral, this can be the cause of asymmetry between two arms, and they can easily be confused with pathological conditions such as tumours [8, 11, 12, 14, 19].

The aim of this study was to find the occurrence of the third head of BB in Turkish fetuses and to compare this with previous reports. To our knowledge, the present study is the first foetal study about this variation of BB. By studying fetuses, the pure structure without any usage of the muscle can be observed. Thus, any difference or correlation between foetal structure and that in the adult might better help to understand the anatomy of the muscle. In addition, we planned to mention the clinical and functional importance of the third head of BB.

MATERIAL AND METHODS

Examinations were carried out on 24 upper limbs of 10% formalin-fixed fetuses of both sexes (7 male and 5 female) from spontaneously aborted human fetuses with no macroscopic malformations. The foetal age was established by measurement of individual crown-rump length. Their gestational age ranged from 16 to 36 weeks. The respective ages of the specimens are summarised in Table 1. The fetuses were from the collection of the Department of Human Anatomy of the Medical Faculty of Gaziantep University. The material was collected and examined in accordance with Turkish legislation. Both sides of the upper limbs of each foetus were dissected from the axillary fossa to the elbow joint. Dissections were carried out under a stereomicroscope (8 × magnification, Leica S4E) and photographed. During the dissection, the fetuses were examined for the incidence, origin, insertion, and innervation of the supernumerary head of BB.

RESULTS

Among the 24 upper limbs studied, 2 (8.33%) arms were found to have a three-headed BB. The variations were present unilaterally in the right arm

Table 1. Number of the studied fetuses according to the number of gestational weeks

No. of foetus	Gestational age (weeks)	CRL [mm]
1	16	144
2	19	184
3	19	187
4	23	225
5	23	227
6	24	236
7	26	252
8	28	271
9	28	273
10	29	279
11	30	285
12	36	342

CRL — crown-rump length

of one male foetus and one female foetus. In the first case, the third head of BB originated from the anteromedial aspect of the humerus just distal to the insertion of the coracobrachialis, medial to the brachialis. The third head descended and joined the common tendon, which inserted into the radial tuberosity and bicipital aponeurosis (Fig. 1). The second case was a thin muscle bundle, which arose on the lateral side of the insertion of coracobrachialis and over the origin of the brachialis, then extended to join the common tendon (Fig. 2).

Both of the BBs with a third head were innervated by a motor branch of the musculocutaneous nerve (Figs. 1, 2). Usual short and long heads of BB had their normal attachments and courses.

DISCUSSION

Even though the frequency of a third head of the BB has been widely examined in several articles, to our knowledge the occurrence of this variation has not been previously studied in fetuses [1, 5–7, 11, 14, 17]. Apart from adult studies, there exists only a study about the third headed BB in neonates by Kopuz et al. [6].

The BB is known as one of the muscles with the most frequent anatomical variations in the human body in terms of origin, number, and morphology of its heads [9]. These variations may present as a group of accessory fascicles arising from the cora-

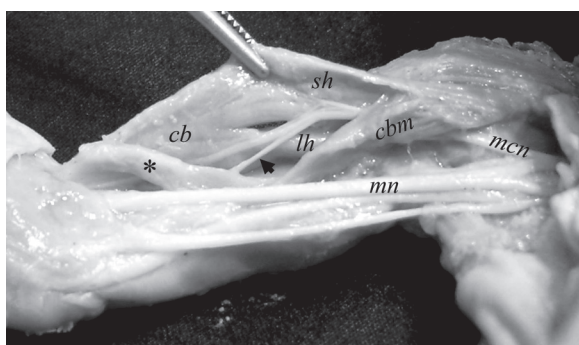


Figure 1. The third head of biceps brachii Specimen 2, right side; sh — short head of biceps brachii; lh — long head of biceps brachii; cb — common belly of biceps brachii; asterisk — third head of biceps brachii; arrowhead — innervation of the third head of biceps brachii; mn — median nerve; cbm — coracobrachialis.

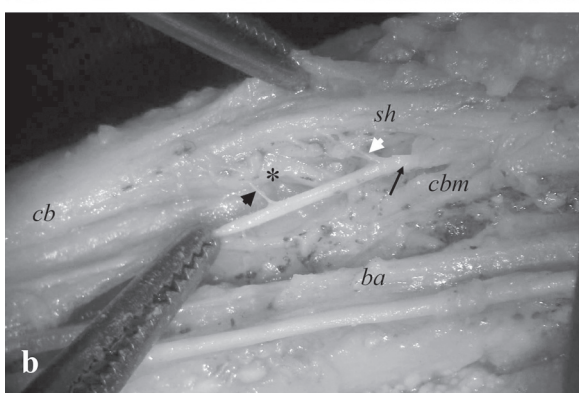
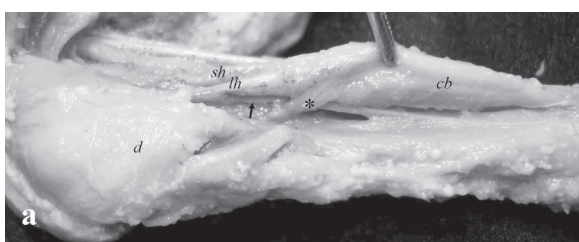


Figure 2. Specimen 1, right side. **A.** Third head of biceps brachii (from lateral view); **B.** Innervation of third head of biceps brachii (from medial view); sh — short head of biceps brachii; lh — long head of biceps brachii; cb — common belly of biceps brachii; d — deltoid; asterisk — third head of biceps brachii, arrow — musculocutaneous nerve; ba — brachial artery; cbm — coracobrachialis; black arrowhead — innervation of the third head of biceps brachii; white arrowhead — innervation of sh and lh.

roid process, the pectoralis major tendon, the head of the humerus, the articular capsule of the humerus, or from the shaft of the humerus itself [2, 4, 7, 8, 11, 18]. However, the absence of the long or short head, complete separateness, or complete fusion of heads and variations in the insertion are rare varia-

tions of this muscle [2, 4]. The most common variation is a third humeral head, although four, five, or even seven heads have been reported [1, 2, 7].

In literature, the overall prevalence of supernumerary heads of BB ranges from 0.25% to 37.5% [1–3, 5–7, 13–17]. According to Bergman et al. [2] in 1926 da Silva Leal summarised the entire literature (148 reports) until that day and reported that supernumerary heads of the BB occurred in about 10% of 1453 individuals [2]. The occasional presence of supernumerary heads varies according to the population. Also, the reported frequency varies according to whether the prevalence was calculated for individuals or arms. The reported frequency ranges from 0.5% to 37.5% of cadavers, and from 0.25% to 25% of upper limbs [1–3, 5–7, 13–17]. The results of previous reports are summarised in Table 2, with regard to the population, individuals, and arms. Some of the authors suggested that there were no clear racial differences, although some of them mention significant differences between the populations [1, 2, 5, 16].

Kopuz et al. [6] studied Turkish neonates and adult cadavers. They found the presence of a third head in 18.3% of the neonates and in 16.7% of the arms of the neonates. In the present study on Turkish foetuses, three-headed BB were revealed in 16.6% of the foetuses and in 8.3% of the arms. Regarding the individuals, our result is compatible with Kopuz et al. [6]. Several authors have demonstrated that the prevalence of variations on BB is greater in males than in females [1, 2, 16], but in this study the variations were present unilaterally in the right arm of one male foetus and one female foetus.

Recently, Rodriguez-Niedenfuhr et al. [17] studied a series of 350 arms and classified the humeral heads of BB according to their origin and location. They identified three different types: superior, inferomedial, and inferolateral humeral heads. They observed the presence of a supernumerary head in 9.1% of the arms. They found 1.5% of cases with superior humeral head, 9% of cases with inferomedial humeral head, and 0.3% of cases with inferolateral humeral head [17]. In the present study, one of the third heads of BB corresponds to the inferomedial type and the other corresponds to the inferolateral type of humeral head.

Studies have shown that the innervation and vascularisation to the third head of BB is supplied as the normal structures of the anterior compartment of the arm, mainly the musculocutaneous nerve and brachial artery. This is consistent with normal

Table 2. Occasional presence of supernumerary heads of biceps brachii (BB) in different populations

Authors	Population	Percentage (per arm)	Arm with supernumerary head of BB/total arm	Percentage (per subject)	Subject with supernumerary head of BB/total subject
Khaledpour, 1985 [5]	Iranian	0.25	1/400	0.5	1/200
Khaledpour, 1985 [5]	European	0.65	1/52	1.3	1/76
Kosugi et al., 1992 [7]	Japanese	13.7	75/546	21.2	58/273
Asvat et al., 1993 [1]	South African blacks	16.4	24/146	20.5	15/73
Asvat et al., 1993 [1]	South African whites	4.16	1/24	8.3	1/12
Kopuz et al., 1999 [6]	Turkish (N)	16.7	20/120	15	11/60
Kopuz et al., 1999 [6]	Turkish	10	4/40	10	2/20
Rincon et al., 2002 [16]	Colombians	25	8/32	37.5	6/16
Paraskevas et al., 2002 [13]	Greek	1.6	1/62	3.22	1/31
Rodríguez-Niedenführ et al., 2003 [17]	–	9.1	32/350	15.4	27/175
Rai et al., 2007 [15]	Indians	3.57	3/84	7.14	3/42
Nayak et al., 2008 [12]	Indians	2.08	2/92	2.08	1/48
Poudel and Bhattarai, 2009 [14]	Nepalese	6.25	2/32	12.5	2/16
Chauhan, 2010 [3]	–	0.65	1/154	1.29	1/77
Our study	Turkish (F)	8.33	2/24	16.66	2/12

N — neonate study; F — fetus study; others are adult studies

embryological development of the related myotomes as mentioned previously by other authors [1]. Kopuz et al. [6] stated that the difference between the rates of the third head of BB in the published series is possibly caused by evolutionary and/or racial trends in different studied populations. However, it is still not known whether the supernumerary head of BB represents a specific functional adaptation of the population characterised for continuous moderate physical activity, or not.

Swieter and Carmichael [21] reported that the presence of a third head originating from the mid-shaft of the humerus may confer a mechanical advantage in pronation of the forearm and may enhance the strength of elbow flexion dependant on the size of the supernumerary head. So, the presence of supernumerary heads is an important factor to take into consideration when assessing BB function and potential dysfunction such as bicipital injury. Additionally, these variations are important for surgeons, when there is an unusual bone displacement subsequent to humeral fracture due to the alteration of the biomechanical forces applied on the humerus [21]. Although the long and short heads of the BB are not suitable

for coverage of soft tissue defects in the arm, accessory heads would be expandable and possibly have more value in flap surgery by plastic surgeons, rather than the two main heads [10, 23]. Although accessory heads of BB are typically asymptomatic and are encountered as incidental findings, these heads have been implicated as a potential source of clinical symptoms, and they become a surgical problem when they produce symptoms. The supernumerary heads may cause compression of neurovascular structures because of their close relationship with the brachial artery and median nerve and may lead to unexplained upper arm and/or shoulder pain syndromes and nerve compression syndromes [11, 22].

Understanding the anomalies of BB will also help doctors dealing with sports medicine. The BB is a strong flexor and a powerful supinator of the forearm. It acts on shoulder joint, elbow joint, and proximal radioulnar joint. The action of BB at these three joints makes it suitable for pitching. Repetitive overhead throwing produces a significant mechanical stress on the shoulder and elbow joint. As the accessory head of BB is attached to the anteromedial surface of the humerus, anatomical changes can also

occur at this site of the humerus. Hence, BB can give rise to pain not only in the anterior of the shoulder in softball pitching but also towards the medial aspect of the arm origin of the accessory head of BB [3].

Additionally, unilateral supernumerary heads may cause an asymmetric appearance, and in some cases it can be difficult to differentiate muscle from soft tissue tumours. Cross-sectional imaging can accurately demonstrate accessory muscles and help differentiate them from other soft-tissue masses. Magnetic resonance imaging and computed tomography scans play an important role in distinguishing the normal anatomical structures from pathological lesions of the upper extremity, as well as serving as a guide for planning surgical resections. Thus, the presence of an accessory head may lead to confusion. Therefore, a thorough anatomical insight into the variations of this region is extremely important while interpreting computed tomography and magnetic resonance imaging scans of upper extremities [19].

CONCLUSIONS

The results of the present study about the supernumerary heads of BB in the limbs of fetuses is important for understanding the anatomy of the third head of BB and will provide knowledge for surgeons to avoid some iatrogenic injuries. In conclusion, the occasional presence and the type of the supernumerary heads in fetuses observed in the present study were similar those among adults reported in previous studies. In addition, these variations are not rare and are interesting not only to anatomists but also to orthopaedic surgeons, plastic surgeons, traumatologists, physiotherapists, doctors dealing with sports medicine, and radiologists.

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