

# Incidence of Accessory Brachialis Muscle, Variations in its Insertion and Relation with Surrounding Neurovascular Structures

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## SUMMARY

**Background.** Accessory brachialis (AcBr) muscle can compromise the surrounding neurovascular structures due its variable insertion. In this context, the objective of the present study was to determine the incidence of AcBr muscle, variation of its insertion and relation with surrounding neurovascular structures.

**Methods.** The study was performed in 84 formalin fixed human cadaveric upper limb specimens, which were available in the department of anatomy. The insertion pattern of the AcBr muscle was divided into 5 types (type 1, type 2, type 3a, type 3b and type 4).

**Results.** It was observed that, AcBr muscle was present in 46 (54.8%) cases. In 31 cases (67.4%), this muscle inserted into the main tendon of brachialis muscle (type 1). It joined the tendon of biceps brachii (type 2) in 6 cases (13%). In 7 cases (15.2%), it gave a slip which joined the supinator muscle after passing deep to the radial recurrent vessels (type 3a). In a single case (2.2%), the slip merged with the supinator after passing superficial to the radial recurrent vessels (type 3b). In one case (2.2%), it gave muscular fibres which crossed the radial nerve and merged with the brachioradialis muscle (type 4).

**Conclusions.** The present study observed higher frequency of incidence of AcBr muscle, however, the limitation of this study is that the small number of specimens studied. The findings will be more accurate with a larger sample size. The gender-based comparison was not performed, since the study involved disarticulated upper extremities.

## KEY WORDS

*Anatomic variation; biceps brachialis; muscles; nerve compression syndromes; orthopedic disorders.*

## BACKGROUND

Accessory muscles may produce a palpable swelling or could lead to pressure effect on the adjacent neurovascular structures. Accessory muscles at the arm region may contribute to neurovasculopathy by compressing the brachial artery and median nerve (1, 2). In clinical cases, where an apparent cause for such symptoms is unknown, evaluation of accessory muscles might help in the accurate diagnosis. In the radiological setup, study of cross-sectional images can reveal the accessory muscles and help in differentiating them from the soft-tissue tumors (3). Entrapment of the vessels and nerves can happen, because these accessory muscles pass anterior to them. The accessory muscles of the arm region have clinical implications and to be considered as the etiology

in median, ulnar and medial cutaneous nerve of forearm paralysis on few occasions. They can also cause symptoms of compression of brachial vessels (4). In the surgical planning, if there is an anatomical variation, it becomes hard to identify the topographical location of the nerves in the muscular compartments, which complicates the surgical approach (5). It was reported that the variations of brachialis muscle are rare in the scientific literature (6). Accessory brachialis (AcBr) muscle, if present can compress the surrounding neurovascular structures in the supracondylar region (6-8). It can also affect the movements of the elbow joint like flexion, extension, pronation and supination. The AcBr muscles are grouped together as the brachialis anticus (9). The knowledge of unusual insertion of brachialis muscle is

important during the surgical approach to the elbow joint (10). It was reported that the distal tendon of AcBr may split and enclose the median nerve. This could lead to the symptoms of median nerve entrapment (7). Careful examination of the cubital tunnel for an accessory muscle might help, which can be a causative factor in the musculoskeletal problem of the upper limb (3). Because of these clinical relevance, the present anatomical investigation was conducted to determine the incidence of AcBr muscle, variability in its insertion pattern and to study the relation to the surrounding neurovascular structures.

## MATERIALS AND METHODS

This research work was executed in 84 formalin fixed human cadaveric upper extremities. Among them, 48 were right upper limbs and 36 belonged to left upper limbs. The gender of the cadavers was not taken into consideration. The extremities were from the donated cadavers, which were available in the department of anatomy. The present study was assessed and certified as approved (IEC KMC MLR 08-18/190) by the ethics committee of our medical college. We state that the present study is as per the guidelines of international ethical standards suggested by Padulo *et al.* (11). The cubital fossa and arm were meticulously dissect-

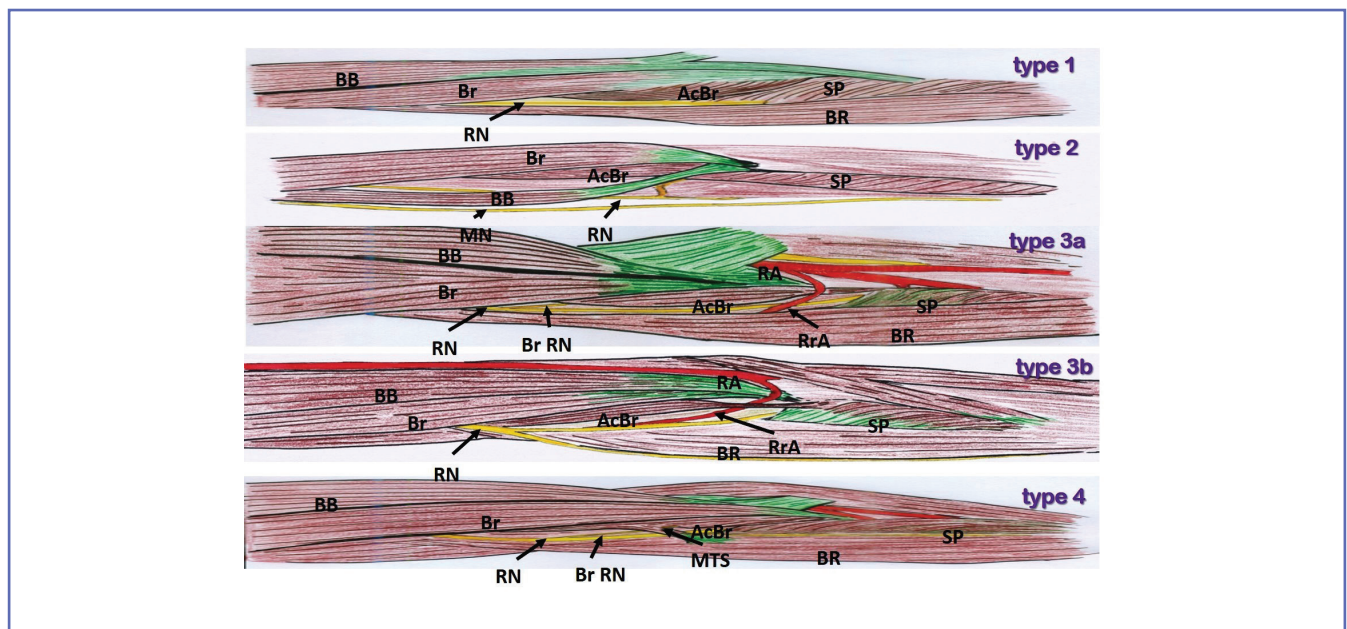
ed and the floor of cubital fossa was reached to expose the brachialis and supinator muscles. The presence of AcBr was checked next to the brachialis in the arm and cubital fossa. If AcBr is present, its distal attachment was dissected and noted. The photographs were taken after cleaning the structures. The relation of AcBr with the surrounding neurovascular structures was also studied.

The present study classified the AcBr into 5 types, depending on its insertion pattern as below (**figure 1**):

- type 1: AcBr inserting into the tendon of brachialis muscle;
- type 2: AcBr inserting into the tendon of biceps brachii;
- type 3a: AcBr inserting into the supinator muscle after passing deep to the radial recurrent vessels;
- type 3b: AcBr inserting into the supinator after passing superficial to the radial recurrent vessels;
- type 4: slip of AcBr crossing the radial nerve and inserting into the brachioradialis muscle.

## RESULTS

According to observations of the present study, AcBr muscle was present in 46 (54.8%) cases. It was observed in 27 right sided and 19 left sided upper extremities. The present study revealed that the AcBr was more prevalent in



**Figure 1.** Various types of AcBr muscle observed in the present study, inserting into brachialis (type 1); biceps brachii (type 2); supinator and passing deep to radial recurrent vessels (type 3a); supinator and passing superficial to radial recurrent vessels (type 3b); brachioradialis (type 4).

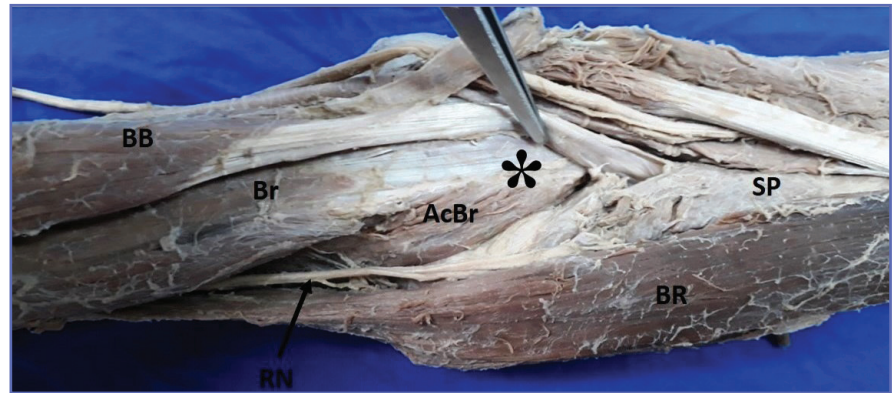
AcBr: accessory brachialis; BB: biceps brachii; Br: brachialis; SP: supinator; BR: brachioradialis; RN: radial nerve; MN: median nerve; Br RN: branch of radial nerve; RA: radial artery; RrA: radial recurrent artery; MTS: musculo-tendinous slip.



the right upper extremity in comparison to the left side (28:18). In 31 cases (67.4%), the AcBr was inserting into the brachialis muscle (type 1, **figure 2**). Among them 16 were right sided and 15 were left sided upper extremities. AcBr joined the tendon of biceps brachii in 6 cases (13%), which included 4 right and 2 left sided upper limbs (type 2, **figure 3**). In 7 (15.2%) specimens (6 right sided and 1 left sided), AcBr gave a slip, which joined the supinator muscle after passing deep to the radial recurrent vessels (type 3a, **figure 4**). In only one case (right sided), the slip merged with the supinator (2.2%) after passing superficial to the radial recurrent vessels (type 3b, **figure 5**). In one right upper limb (2.2%), musculotendinous fibres of AcBr crossed the radial nerve and merged with the brachioradialis muscle (type 4, **figure 6**). The frequency distribution of variability in the insertion of AcBr of this study is represented in **figure 7**. It was observed that, all the cases of AcBr were innervated by the branch of radial nerve, which was originating at the distal part of the arm.

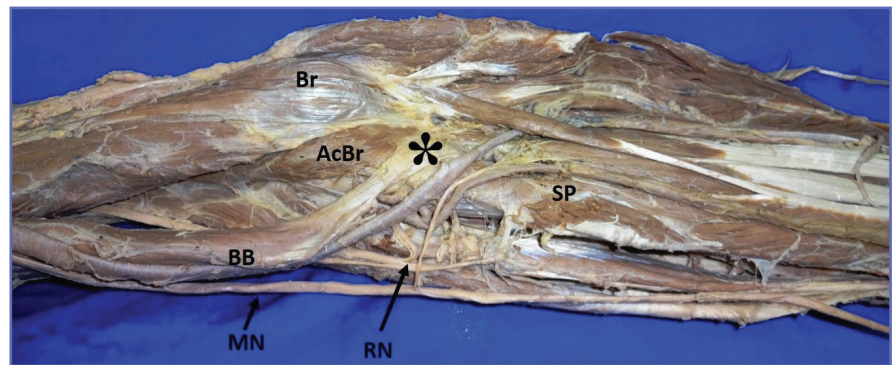
## DISCUSSION

The muscular variations can be understood by studying the embryological development of the muscles. The upper limb musculature develops from the limb bud at the level of lower six cervical and upper two thoracic segments. In the fifth week of gestation, the development of forelimb muscles take place in the mesenchyme of the para-axial mesoderm. The somites will be partitioned into the sclerotome, myotome and dermatome. Muscle primordia develop from the posterolateral side of the somite cells, which migrate into the limb buds around 28<sup>th</sup> day of intrauterine life (12). The myotomes will develop as the muscles as numerous growth factors are secreted by the cells in the proximal limb



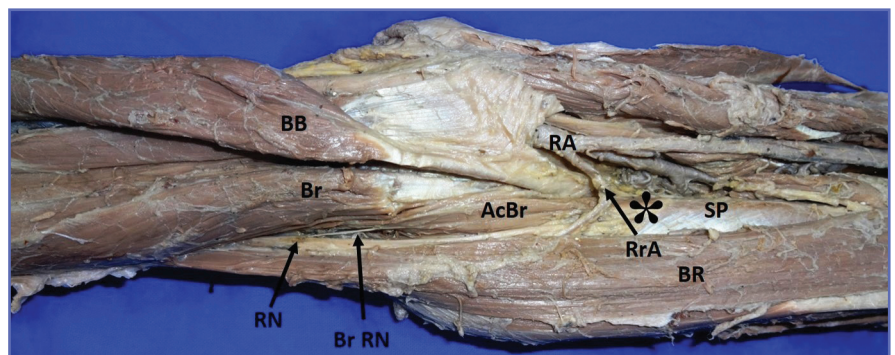
**Figure 2.** AcBr inserting into the tendon of Br (67.4%; type 1).

BB: biceps brachii; Br: brachialis; AcBr: accessory brachialis; BR: brachioradialis; SP: supinator; RN-radial nerve. \*Insertion of AcBr into Br.



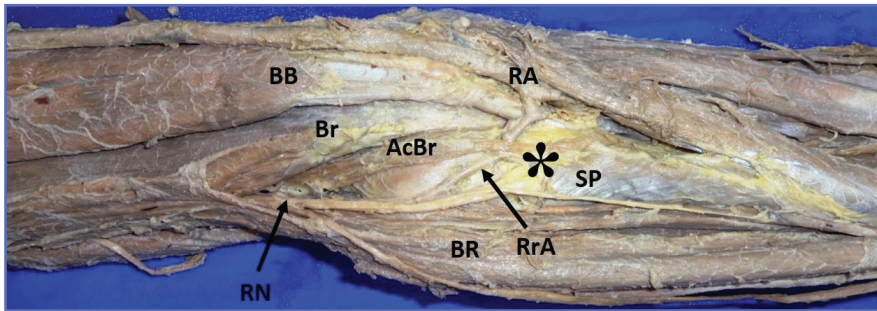
**Figure 3.** AcBr inserting into the tendon of BB (13%; type 2).

BB: biceps brachii; Br: brachialis; AcBr: accessory brachialis; SP: supinator; RN: radial nerve; MN: median nerve. \*Insertion of AcBr into BB.



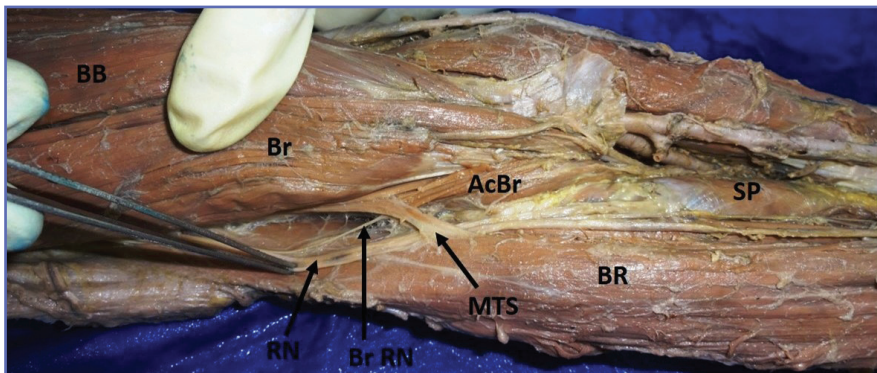
**Figure 4.** AcBr crossing deep to the RrA and inserting into the SP (15.2%; type 3a).

BB: biceps brachii; Br: brachialis; AcBr: accessory brachialis; BR: brachioradialis; SP: supinator; RA: radial artery; RrA: radial recurrent artery; RN: radial nerve; Br RN: branch of radial nerve supplying AcBr. \*Insertion of AcBr into SP.



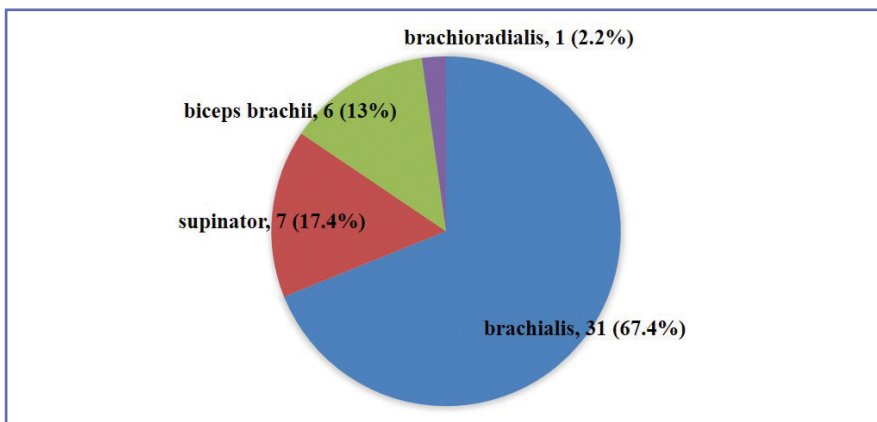
**Figure 5.** AcBr crossing superficial to the RrA and inserting into the SP (2.2%; type 3b).

BB: biceps brachii; Br: brachialis; AcBr: accessory brachialis; BR: brachioradialis; SP: supinator; RA: radial artery; RrA: radial recurrent artery; RN: radial nerve. \*Insertion of AcBr into SP.



**Figure 6.** MTS from AcBr crossing over the RN to join the BR (2.2%; type 4).

BB: biceps brachii; Br: brachialis; AcBr: accessory brachialis; BR: brachioradialis; SP: supinator; RN: radial nerve; Br RN: branch of radial nerve supplying AcBr. MTS: musculotendinous slip.



**Figure 7.** Frequency distribution of variability of insertion of AcBr observed in this study (n = 46).

bud (13). These growth factors will help in the migration of myoblasts into the developing limb buds. The adhesion molecules which are expressed by the myoblasts are involved in the distribution of growth factors in a proper arrangement in the limb (14). The muscle primordia later get split into muscles of flexor and extensor compartments. This division is due to signaling by the connective tissue, which is derived by the lateral plate mesoderm. Postero-anterior development is under the control of WNT7A and the antero-posterior development is due to signalling of sonic hedgehog protein, which is secreted at the zone of polarizing activity in the posterior limb bud (12). Alteration in these pathways can lead to various anatomical variations in the muscular system. The muscle precursors which are found as different layers in the arm fuse to form a single muscle at a particular stage (13, 15). However, some primordial muscle cells go for apoptosis in spite of their contents as myofilaments (13). The failure of their apoptosis may contribute to the development of accessory muscles. It was reported that any changes in the structure of myotome or the somite, or in the distribution of adhesion molecules in the myoblasts may lead to muscular variations, which includes the accessory muscles (16). This is the developmental basis of the presence of accessory muscles.

In the present study, AcBr was observed in 54.8% of cases. AcBr muscle usually originates from the lateral intermuscular septum of arm and the fascia covering deltoid and triceps brachii muscles (17). Disparities in the morphology of brachialis though unusual, but are recorded in the literature that it may be divided into two or more parts, which blend with the brachioradialis, biceps brachii or pronator teres. The distal attachment of the AcBr into the shaft of radius below the bicipital tuberosity can hinder the flexion of the



elbow joint at the ulnar component. This will further lead to difficulty in the pronation and supination of the forearm due to the variant AcBr muscle aponeurosis (9, 17). In the present study the AcBr has joined with the tendons of supinator, brachioradialis, brachialis and biceps brachii muscles. Here the AcBr may be enhancing the actions of the supinators of forearm. The AcBr reported by Pai *et al.* (6) inserted into the supinator and pronator teres after crossing the radial nerve thus contributing to the factors leading to radial tunnel syndrome. In the present study AcBr joined the supinator in 8 upper limbs (17.4%), this insertion pattern may lead to narrowing of the radial tunnel during the supination of forearm thus leading to radial tunnel syndrome. In one of the specimen in the present study, the tendon of AcBr traversed superficial to the radial recurrent artery before inserting into the supinator (2.2%), thus compressing the vessels in certain positions of the forearm. This type 3b variety, may not cause ischemia due to the very good anastomosis around the elbow joint. In one of the specimens of the present study, musculotendinous fibres arising from the AcBr bridged across the radial nerve and merged with brachioradialis (type 4, 2.2%). This bridge also narrows the radial tunnel and may contribute to the radial tunnel syndrome by compressing the radial nerve. In our previous study (18) with different anatomical specimens which was performed few years ago, it was observed that brachialis was giving muscular slips to the brachioradialis muscle. This was observed in 28.5% cases of the upper extremities. In that study (18) we classified the connecting bridges into split type, slip type and tendinous types. In all those cases, the intermuscular connection was oblique and entrapping the radial nerve. There have been instances of AcBr crossing the brachial artery and the median nerve (7, 8). This shows that the presence of AcBr could cause median nerve entrapment in the forearm and compression of the brachial artery. We did not find any such compression pathology in our study. Nelluri *et al.* (17), has reported a case of AcBr, which was crossing the radial artery, thus having the potential to compress it. The brachialis is usually supplied by the musculocutaneous nerve and radial nerve. The AcBr in the present study were all supplied by twigs from the radial nerve. It was described that, brachialis has dual heads of origin, superficial and deep. Between these two an internervous plane can be found, which can be utilized for the anterolateral surgical approach to the cubital articulation (9).

Akhtar *et al.* (16) reported the insertion of AcBr into the pronator teres muscle. But this morphological variant was not observed in the present study. George and Nayak (19) encountered a variation in which few fibres of brachialis merged with superficial muscles of front of forearm and to the olecranon process. Loukas *et al.* (7) observed an AcBr

muscle, which was splitting to envelop the median nerve and finally inserted back to the brachialis tendon. Dharap (20) reported an accessory muscle, which was forming a tunnel for median nerve and brachial artery in the arm. Paraskevas *et al.* (4) and Vadgaonkar *et al.* (21) observed an AcBr muscle, which was merging with the medial intermuscular septum. These type of morphological variants are not observed in the present study. The AcBr inserting into the biceps brachii is termed as brachibicipitalis (14). This was observed in 6 cases (13%) in our specimens. This morphological variant can offer greater supination of the forearm and hand.

Mistry *et al.* (22) observed AcBr in only 5% of their specimens. These muscles were inserting into the brachioradialis and bicipital aponeurosis. Khandey *et al.* (9) observed AcBr in only 3.5% of their cases. The present study is not agreeing with the incidence rate of AcBr with respect to these studies. We observed higher incidence of AcBr (54.8%), which is not as per the descriptions of classical anatomical text books. The morphological knowledge about AcBr is important to understand the conditions like median nerve entrapment. The knowledge is also important during the surgical procedures around the elbow joint and brachial artery catheterization. This will also prevent misinterpretations during the radio diagnostic procedures and angiographic studies around the cubital fossa. It was reported that the tendon of AcBr muscle can be harvested for the reconstruction of annular ligament of the superior radioulnar joint, tibial collateral ligament of the knee joint and also in tendon transfer surgeries (6). The ruptured tendon of biceps brachii can be reconstructed by using the AcBr, by transferring it to the radial tuberosity (22). The fibres of AcBr are also utilized in reconstruction of ulnar collateral ligament of the elbow joint. Since the muscles of forearm are not always available for the tendon transfer, if AcBr is present, this can be used as an alternative donor for the reconstruction of the flexor digitorum profundus and flexor pollicis longus muscles during the brachial plexus injury (23).

AcBr can alter the arthrokinematics of the shoulder joint, leading to pain during the mobility of the rotator cuff. The clinical testing of the brachialis muscle can be misinterpreted due to the presence of AcBr. The accessory muscles in the arm should not be misinterpreted as tumours during the reporting of the MRI in this region (24). They can be misinterpreted as soft tissue tumours like fibroma and neurooma (14). Presence of AcBr and the variations in its insertion is definitely an important factor contributing to nerve compression syndromes like radial tunnel syndrome. The accessory muscles at the arm can be considered as the reason, whenever there is an entrapment neuropathy along with the brachial artery or brachial vein compression. Surgeries in the cubital fossa, especially elbow joint surgeries may get

complicated due to the presence of AcBr. The percutaneous brachial approach is often preferred during the carotid and vertebral angiography. The knowledge about AcBr can prevent the complication in this procedure. The ultrasound guided brachial artery puncture is suggested in these situations and it should be considered (25).

We believe that the present study has provided additional information about the AcBr muscle. However, the limitation of the present study is that, since it is a cadaveric study, the biomechanics of the elbow joint and signs and symptoms of the entrapment neuropathy could not be assessed in this anatomical investigation. Future implications of this study include studying the AcBr in vivo by using ultrasound, MRI and electromyogram methods. Elastography is a newly established North American based technique to assess the tissue stiffness (26). The AcBr can be studied in vivo by using elastography and the stiffness of the arm can be evaluated. Analan and Ozdemir (26) reported that,

neurological disorders are not the only etiological factors for the muscle stiffness, few more factors like anatomical variations, posture, gender and exercise also have a role.

## CONCLUSIONS

The present study offers the information about the incidence of AcBr, variability in its insertion and relation with the surrounding neurovascular structures. The preoperative knowledge about AcBr is important to the orthopedicians, anaesthesiologists and radiologists. This can avoid the misinterpretation and subsequent complications. The details are essential for the accurate diagnosis and management of the musculoskeletal disorders of the arm.

## CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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