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Original article

Bicipital aponeurosis. Anatomical study and clinical implications☆

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ABSTRACT

Objective: The aim of this study was to analyze the anatomic variations of the bicipital aponeurosis (BA) (*lacertus fibrosus*) and its implications for the compression of the median nerve, which is positioned medially to the brachial artery, passing under the bicipital aponeurosis.

Methods: Sixty upper limbs of 30 cadavers were dissected, 26 of which were male and four, female; of the total, 15 had been previously preserved in formalin and glycerine and 15 were dissected fresh in the Laboratory of Anatomy.

Results: In 55 limbs, short and long heads of the biceps muscle contributed to the formation of the BA, and the most significant contribution was always from the short head. In three limbs, only the short head contributed to the formation of the BA. In two limbs, the BA was absent. The length of the bicipital aponeurosis from its origin to its insertion ranged from 4.5 to 6.2 cm and its width, from 0.5 to 2.6 cm. In 42 limbs, the BA was thickened; of these, in 27 it was resting directly on the median nerve, and in 17 a high insertion of the humeral head of the pronator teres muscle was found, and the muscle was interposed between the BA and the median nerve.

Conclusion: These results suggest that a thickened BA may be a potential factor for nerve compression, by narrowing the space through which the median nerve passes.

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☆ Study conducted at the Faculdade de Ciências Médicas e da Saúde, Pontifícia Universidade Católica de São Paulo (PUC-SP), Sorocaba, SP, Brazil.

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Aponeurose bicipital. Estudo anatômico e implicações clínicas

RESUMO

Objetivo: Analisar as variações anatômicas da aponeurose bicipital (*lacertus fibrosus*) e suas implicações na compressão do nervo mediano, que passa sob a aponeurose bicipital (AB) e se posiciona medialmente à artéria braquial.

Método: Foram dissecados 60 membros superiores de 30 cadáveres adultos, 26 do sexo masculino e quatro do feminino; 15 haviam sido previamente preservados em formol e glicerina e 15 foram dissecados a fresco no Laboratório de Anatomia.

Resultados: Em 55 membros, a AB recebia contribuição das cabeças curta e longa do musculo bíceps braquial, a contribuição mais significativa foi sempre da cabeça curta. Em três membros recebia contribuição exclusiva da cabeça curta. Em dois membros, a AB estava ausente. O comprimento da AB desde sua origem até sua inserção variou entre 4,5 e 6,2 cm e sua largura entre 0,5 e 2,6 cm. Em 42 membros, a AB apresentava-se espessada, em 27 apoiava-se diretamente sobre o nervo mediano e em 17 havia inserção alta da cabeça umeral do músculo pronador redondo, de forma que o músculo ficava interposto entre a AB e o nervo mediano.

Conclusão: Esses resultados sugerem que a AB espessada pode ser um dos fatores potenciais da compressão nervosa, por estreitar o espaço no qual passa o nervo mediano.

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Palavras-chave:
Anormalidades músculo-esqueléticas
Síndromes de compressão nervosa
Cadáver

Introduction

The median nerve is formed by the junction of the lateral and medial fascicles of the brachial plexus. In the middle third of the arm, it crosses laterally to medially, in front of the brachial artery, both enveloped by a neurovascular sheath.[1] It proceeds toward the cubital fossa, where it is located medially to the brachial artery and tendon of the biceps brachii muscle, then passes posteriorly to the bicipital aponeurosis (BA), and then usually continues between the humeral and ulnar heads of the pronator teres muscle.[2]

The biceps brachii is an important muscle of the anterior compartment of the arm. It is formed by its long and short heads that are inserted on the bicipital tuberosity of the radius. The BA is a thickening of the brachial fascia that joins the biceps brachii to the ulna, covering the proximal portion of the flexor-pronator muscle group. There are multiple theories to explain the function of the BA[3]: (1) To protect the underlying neurovascular bundle in the cubital fossa. (2) To provide proprioceptive information for the biceps brachii muscle, based on muscle activity in the forearm. (3) To serve as an additional anatomical anchorage for the biceps tendon.[3]

Variations in origin, dimensions, and thickening of the BA have been described.[1,4] Some authors[5,6] consider that a thickened BA can compress the median nerve and cause motor and sensory symptoms. It is one of the causes of the pronator teres syndrome, one of the three compressive syndromes that affect the median nerve; the other two are anterior interosseous nerve syndrome and the much more common carpal tunnel syndrome. Compression is called pronator teres syndrome, regardless of the site, because it is between the two heads of this muscle that it occurs more frequently.[7,8]

Compression of the median nerve in the elbow region is a condition usually caused by the presence of fibrous bands, which can be observed at four anatomical sites in the following order of frequency[7]: between the superficial and deep heads of the pronator teres muscle; in the arcade formed by the proximal insertions of the superficial flexor muscle; in the BA; and in Struthers ligament, associated or unassociated with the humeral supracondylar process. Clinically, it is not easy to identify the exact location of the compression. Tinel's sign may be useful to identify the location of the compression. The results of electrophysiological tests are consistent with nerve compression in the elbow region, suggesting (but not confirming) the exact location of the compression. Identification of the structure responsible for nerve compression is only possible through surgical exploration of the nerve in the antecubital fossa.[2,6,9]

This study is aimed at analyzing, through anatomical dissections of 60 limbs of 30 cadavers, the relationship between the BA and the median nerve and thus contributing to a better understanding of the possible role of the BA in nerve compression at this site.

Material and methods

In the present study, 60 forearms of 30 adult cadavers belonging to the Laboratory of the Department of Anatomy were dissected, of which 26 were male and four were female; 15 had been previously preserved in formaldehyde and glycerin and 15 were fresh dissected cadavers. Age ranged from 28 to 77 years; 17 of the cadavers were white and 13 were non-white. Cadavers whose forearms were deformed by traumas, malformations, and scars were excluded. Dissection was performed through a midline incision in the arm and forearm; two flaps, including the skin and subcutaneous tissue, were folded to the radial and ulnar sides, respectively. The same was performed in the fascia of the arm and forearm, so as to expose the entire musculature. The median nerve was identified in the proximal third of the arm on the medial border of the biceps brachii muscle and dissected distally to analyze the presence of possible fibrous bands and anomalous structures, such as Struthers ligament, that could narrow its passage. The authors also analyzed the possibility of the median nerve sending out some innervation to the arm. The brachialis and biceps brachii muscles were dissected to their insertions. The role of the short and long heads of the biceps brachii muscle in the composition of the BA, as well as the measurements of its width and length, were recorded. The dissection continued distally into the forearm, assessing the presence of nerve compressions between the humeral and ulnar heads of the pronator teres muscle and in the arcade formed between the radial and ulnar insertions of the superficial flexor muscles, as well as identification of the Gantzer muscle, of the Martin-Gruber anastomosis, and eventual anatomical variations. These are part of studies that have already been or will be published. The observed anatomical variations were recorded and photographed. A Keller 2.5× magnifying glass was used for magnification. This study was approved by the Ethics Committee under opinion No. 1,611,295.

Results

The short and long heads of the biceps brachii muscle were identified in all limbs. In 55 limbs, both the short and long heads contributed to the BA; the most significant contribution was always from the short head (Fig. 1A). The BA was attached to the antebrachial fascia, covered the flexor-pronator group, and was inserted into the proximal third of the ulna. In three limbs (one bilateral case), it was observed that the long and short heads were completely separated: the short head continued with the BA and the long head, with the bicipital tendon (Fig. 1B). The length of the BA, from its origin to its insertion, ranged from 4.5 to 6.2 cm, and its width ranged from 0.5 to 2.5 cm In most cases it had a rectangular conformation (Fig. 2A), while in some cases it was trapezoidal (Fig. 2B). The BA was thickened in 44 limbs; in 27, it was resting directly on the median nerve (Fig. 3A and B) and in 17, a high insertion of the humeral head of the pronator teres muscle was observed, so that the muscle was interposed between the BA and the median nerve (Fig. 4A and B). In one limb of a cadaver with hypertrophied muscles, it was observed that the thickened BA caused an indentation on the median nerve (Fig. 5A). In 14 limbs, the BA was very narrow and thin (Fig. 5B). The presence of an accessory head of the biceps brachii muscle (Fig. 6A and B) was observed in five limbs, but did not interfere with the formation of the BA. The bicipital tendon was identified in all cases, forming an alterable angle with the BA. In two limbs, the absence of the BA was recorded, one of which was replaced by a fibromuscular component that originated in the biceps brachii and extended distally to be inserted into the flexor digitorum superficialis muscle (Fig. 7A), while in the other the aponeurosis was formed by the brachialis muscle (Fig. 7B). The presence of an accessory aponeurosis of the brachialis muscle, located proximally to the BA, was identified in three limbs, one bilateral (Fig. 8A and B).

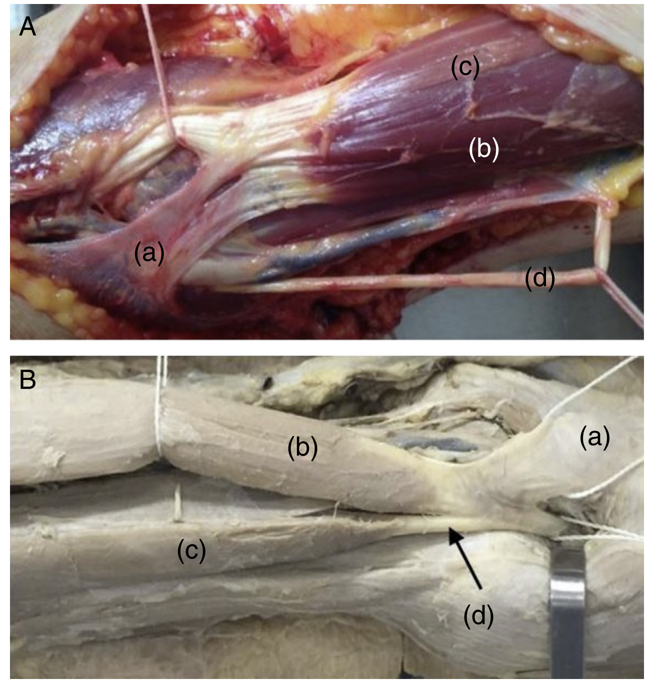

Fig. 1 – (A) In 55 limbs, the BA (a) received contribution from the short (b) and long (c) heads; the most significant contribution was always from the short head. Median nerve (d). (B) In three limbs, one bilateral, it was observed that the short (b) and long (c) heads were completely separated; the short head continued with the BA (a) and the long head, with the bicipital tendon (d).

Discussion

Regardless of where nerve compression occurs in the elbow region, it is generically called the pronator teres syndrome, since it is between the two heads of this muscle that compression occurs more frequently.[7–9] Some authors disagree with the fact that compressions in locations other than between the humeral and ulnar heads of the pronator teres muscle are also referred to as pronator teres syndrome.[2,10] Tubbs et al.[10] consider this denomination to be incorrect when compression occurs at Struthers ligament, the BA, or the arch of the superficial flexor muscles, and suggest that the correct name would be proximal compressive neuropathy of the median nerve rather than pronator teres syndrome.

A literature review presented different points of view on the morphology of the BA and the quantity of fiber contribution of the short and long head in its formation. Athwal et al.[11] dissected 15 limbs from fresh cadavers and demonstrated that the long head of the biceps brachii muscle was inserted into the proximal surface of the bicipital tuberosity and the short head was inserted distally into this tuberosity. In all limbs, the BA was found to originate from the short head of the biceps brachii muscle, so that the short head contributed to the formation of the biceps tendon and the BA, and the long head contributed only to the formation of the bicipital tendon. Dirim et al.[12] reported that the BA consists of fibers from the short and long heads of the biceps brachii muscle;

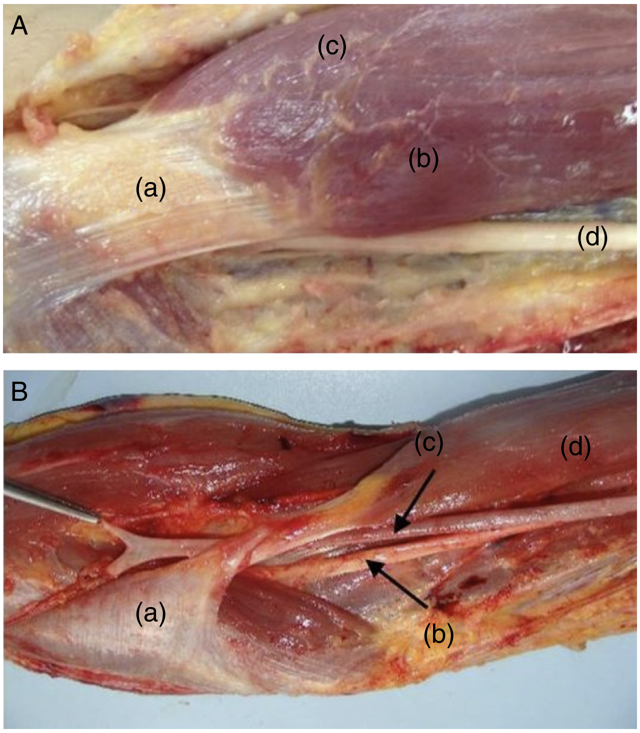

Fig. 2 – (A) In most cases the BA (a) had a rectangular anatomical conformation. Short head (b), long head (c), median nerve (d). (B) At other times, the BA had a trapezoidal conformation (a). The median nerve (b) is positioned medially to the brachial artery (c) and the biceps brachii muscle (d).

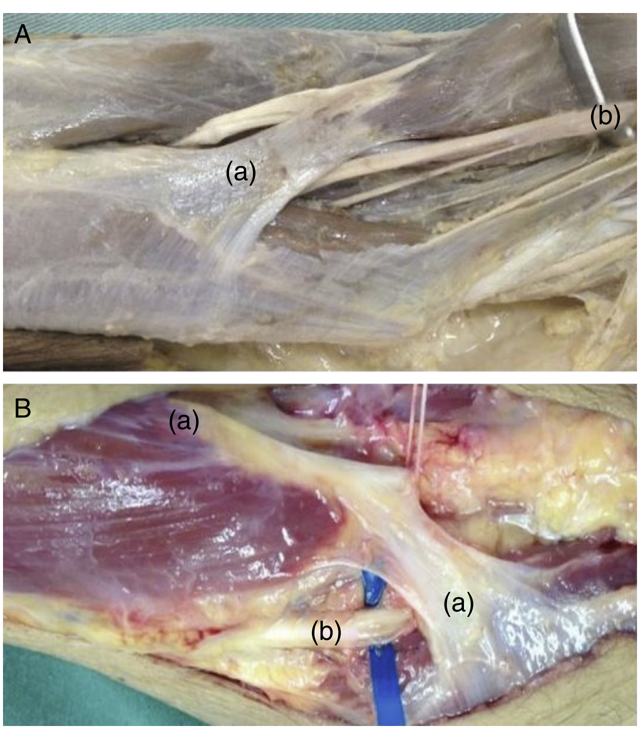

Fig. 3 – In 44 limbs, the BA (a) was thickened; in 27, it was resting directly on the median nerve (b).

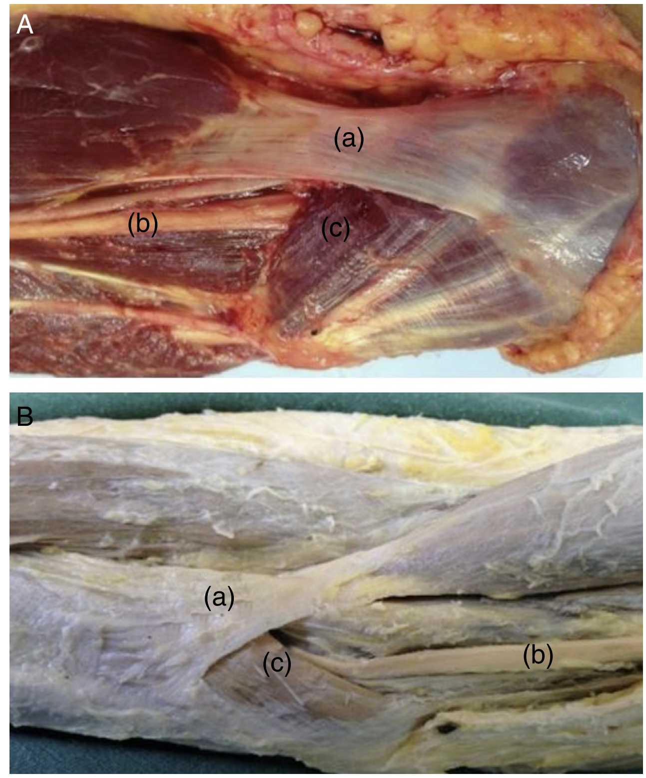

Fig. 4 – In 17 limbs, there was a high insertion of the humeral head of the pronator teres muscle (c) so that the muscle was interposed between the BA (a) and the median nerve (b).

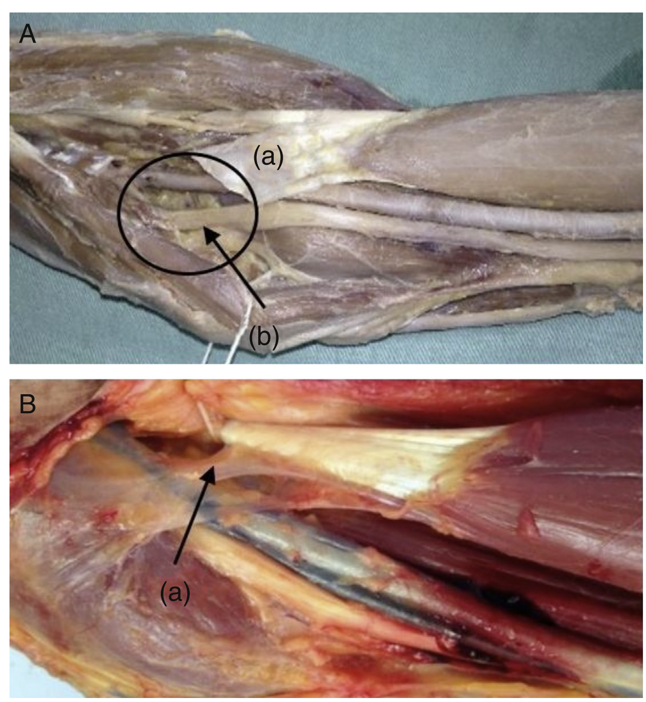

Fig. 5 – (A) In one limb with hypertrophied musculature, the thick BA (a) caused an indentation on the median nerve (b). (B) In 14 limbs, the BA (a) was very narrow and of little thickness.

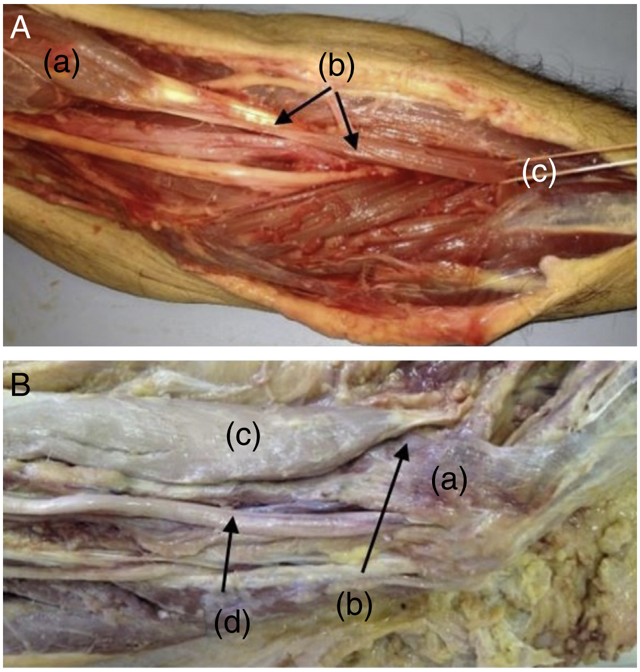

Fig. 6 – In two limbs, the AB was not present. (A) AB was replaced by a fibromuscular component (b) that originated in the biceps brachii (a) and extended distally to be inserted into the flexor digitorum superficialis (c). (B) The AB (a) originated in the brachialis muscle (b). Biceps (c). Median nerve (d).

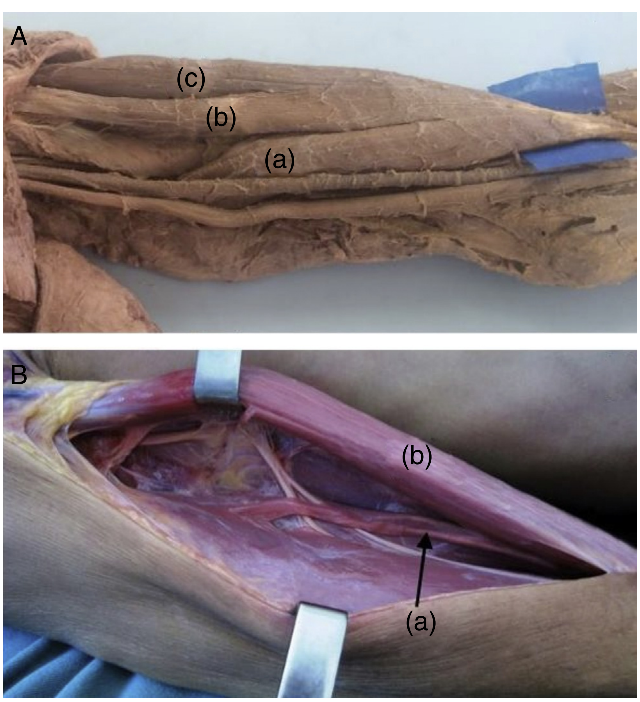

Fig. 7 – In five limbs, the presence of an accessory head (a) of the biceps brachii muscle (b) was observed. (A) Short head (b). Long head (c). (B) Accessory head (a) Long head (b).

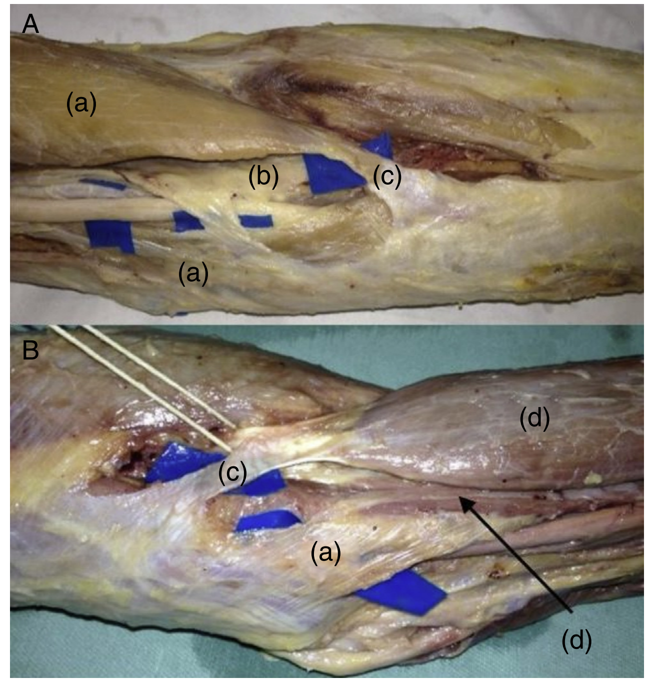

Fig. 8 – In three limbs, the presence of accessory aponeurosis (a) of the brachial muscle (b) located close to the BA (c) was identified. Biceps brachii (d).

in one of 17 dissected limbs, these authors observed that only the short head contributed to BA formation. Joshi et al.[13] studied 30 cadaveric limbs, 16 from the right side and 14 from the left. These authors observed that the fibers that formed the distal portion of the BA originated from the short head, while those that formed the proximal portion of the BA originated from the long head of the biceps brachii muscle. In the present study, it was observed that, in 55 limbs, the BA received a contribution from the short and long heads, and that the most significant contribution was always from the short head. The BA was attached to the antebrachial fascia, covered the flexor-pronator group, and inserted into the proximal third of the ulna. In three limbs (one bilateral), it was observed that the long and short heads were completely separated: the short head continued with the BA and the long head, with the bicipital tendon. From its origin until its insertion, the length of the BA ranged from 4.5 to 6.2 cm and its width from 0.5 to 2.6 cm. El Maraghy et al.[3] define the BA as a trapezoidal structure formed by parallel fibers that originate from the short head and the bicipital tendon, radiate distally and envelop and fit into the pronator flexor group of the forearm. In the present study, the BA presented a rectangular form in most cases, although in a few cases the BA had a trapezoidal conformation.

Kopell and Thompson[5] report that a thickened BA may compress the median nerve, causing motor and sensory symptoms. Laha and Lunsford[6] described the case of a musician who lost the ability to play as a result of weakness and paresthesia in his right hand. The clinical examination and electrophysiological test suggested compression of the median nerve at the elbow. During surgery, it was observed that tension caused by the thickened BA caused the symptoms, which were relieved quickly after its resection, which resulted in rapid functional recovery. Bassett et al.[14] reported the case of five patients with intermittent symptoms, which were exacerbated with excessive physical activity. The examination demonstrated localized a painful sensation over the BA, as well as increased pain and decreased pulse with forearm pronation and resisted elbow flexion. All five patients were athletes with hypertrophied muscles and a diagnosis of compression of the brachial artery by the BA was made. The release of the aponeurosis resulted in improvement of pain and return of the radial pulse to normal levels in four patients. Those authors consider that although the BA has been well described as a cause of nervous compression, in athletes with muscular hypertrophy and thickened BA, it can also cause symptoms of nervous and/or vascular compression. Swiggett and Ruby[15] presented the cases of three patients showing clinical signs of medial nerve compression in the elbow region. They report that the patients complained of forearm pain and muscle weakness of the pronator teres, the flexor pollicis longus, the flexor digitorum profundus of the middle and index fingers, and the pronator quadratus, evidenced by an electrophysiological test, but they had no sensory loss. During surgery, those authors identified excess tension in the thickened BA. They reported that the preservation of sensation indicated a partial nerve compression, insufficient to compress the nerve fibers destined for the hand that are positioned more deeply into the median nerve. BA release led to immediate symptom relief in all three patients. Martinelli et al.[16] reported the clinical case of a 55-year-old patient with decreased muscle strength of all muscles innervated by the median nerve, including the pronator teres. These authors also observed sensory changes in the area of innervation of the median nerve. The electromyographic test confirmed the diagnosis of nerve compression above the elbow. During the surgical procedure, it was confirmed that a thick and well-developed BA caused the nerve compression. The patient presented symptomatic relief after the BA was released. Hill et al.[17] described a case of incomplete anterior interosseous nerve syndrome, which during the surgical procedure proved to be caused by a double BA. In 44 of the 60 limbs dissected in the present study, it was observed that the BA was thickened; in 27, it was resting directly on the median nerve, and could be responsible for nerve compression. In one case, it was observed that the median nerve showed signs of nerve compression (Fig. 5A); in 17, there was a high insertion of the humeral head of the pronator teres muscle, so that the muscle was interposed between the BA and the median nerve. In 14 cases, the BA was very narrow, with little thickness, and it was unlikely that it could compress the nerve.

Spinner et al.[7] reported four cases of medial nerve compressive neuropathy caused by an accessory BA, which originated in the distal third of the forearm. Two of these cases were associated with the third head of the biceps brachii muscle. In the present study, the third head of the biceps brachii muscle was identified in five limbs. The present findings are in agreement with Spinner et al.,[7] because the accessory head did not seem to interfere with BA formation. In the present study, the presence of a double BA was not observed. In two limbs, the aponeurosis originated from the brachialis muscle. The BA was absent in two limbs. In one of them, it was replaced by a fibromuscular component that originated in the biceps brachii and extended distally to insert into the flexor digitorum superficialis; in the other, the aponeurosis was formed by the brachialis muscle. In three limbs (one bilateral), the presence of an accessory aponeurosis of the brachialis muscle was observed, located proximally to the BA. Eames et al.[18] recommend that BA lesions should be repaired with the forearm in extension and pronation, in order to avoid tension on the aponeurosis that may cause compression of the neurovascular bundle.

Chronic pronator teres syndrome caused by hypertrophy of the BA should be differentiated from acute compression. In the latter, the sudden onset of pain associated with partial paralysis of the median nerve, which rapidly develops into complete paralysis, occurs after an overload of the biceps muscle caused by prolonged and excessive exertion, or after venipuncture.[2] Seitz et al.[19] reported seven cases of acute medial nerve compressive syndrome caused by excessive elbow flexion exertion. In all seven cases, compression was the result of a sudden and excessive effort attempting to overcome substantial resistance, resulting in immediate and intense pain radiating from the elbow to the forearm. Urgent decompression disclosed the presence of tension in the arm fascia and in the BA with hemorrhage, evidencing partial rupture of the biceps muscle at the myotendinous junction, caused by compartmental pressure. Decompression, which included the resection of the BA, resulted in symptom relief in all cases. Gessini et al.[20] published two clinical cases in which compression of the median nerve was caused by the BA. In the first case, it was observed that tension was caused by a hematoma; in the other, the median nerve was compressed between the BA and the hypertrophic brachialis muscle. In a series of patients with medial nerve compressive syndromes, these authors reported 201 cases of carpal tunnel syndrome, 21 of the pronator teres muscle, and three of the anterior interosseous nerve. Only three cases occurred above the elbow (one case caused by Struthers ligament and two cases by the BA).

Conclusion

The BA is composed of fibers from the short and long heads of the biceps brachii muscle. The thickened BA can compress the median nerve against deep structures and alter the normal course of the nerve, therefore being one of the potential locations for nerve compression by narrowing the nerve passage space and thus causing motor and sensory symptoms.

Conflicts of interest

The authors declare no conflicts of interest.

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