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RESEARCH ARTICLE

The arterial supply of the tendon of the long head of the biceps brachii in the human: A combined anatomical and radiological study

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ABSTRACT

Purpose: Arthroscopic repair of superior labral anterior to posterior (SLAP) lesions is often associated with a prolonged period of pain during the rehabilitation process. This might possibly be due to hypoxia in the biceps tendon anchor caused by sutures. The purpose of the study was to investigate the arterial supply of the long head of the biceps brachii tendon (LHBT) that may be impaired by surgery in the region of the biceps tendon anchor.

Methods: On 20 human formalin-fixed bodies, the anterior circumflex humeral artery (ACHA) was located and followed into the intertubercular groove until it reached the LHBT. On 10 fresh-frozen anatomic specimens of the upper extremities, contrast medium was injected into the axillary artery, a 3D scan was performed, and multiplanar reconstructed (MPR) slices were generated. A set of maximum intensity projection (MIP) reconstructions from 10 computed tomography angiographies (CTA) of the upper extremities was used to confirm the findings of the 3D scan.

Results: All anatomical dissections and radiological investigations revealed that the proximal portion of the LHBT was consistently supplied by an ascending branch of the ACHA. No artery was found to supply the biceps tendon anchor from the proximal aspect.

Conclusions: As the arterial supply of the LHBT is mainly provided by the ACHA, which enters the glenohumeral joint from the distal aspect, surgery at the bony origin of the LHBT may not interfere with this specific vessel.

1. Introduction

Due to the increasing number of superior labral anterior to posterior (SLAP) lesions (Onyekwelu et al., 2012; Weber et al., 2012) in athletes throwing overhead, the question arises as to whether factors other than mechanical ones influence the aetiology of the injury and process of rehabilitation after arthroscopic repair. In studies published thus far it was found that the rehabilitation process after surgery is aggravated by a prolonged period of pain (Boesmueller et al., 2012; Cohen et al., 2006; Katz et al., 2009). In contrast, studies addressing biceps tenotomy as an alternative to SLAP repair reported good pain relief (Boileau et al., 2007, 2009; Gill et al., 2001; Walch et al., 2005). One explanation for this fact may be the disturbed blood supply in the transition zone from the long head of the biceps brachii tendon (LHBT) to the labrum after SLAP repair using suture anchors. Pain may thus be a reaction to a lack of arterial supply similar to that found in pathologic conditions as Raynaud's disease and claudicatio intermittens (Cooke and Marshall, 2005; Rüger et al., 2008). Zones of hypovascularity possibly contribute to local tendon weakness and even tendon rupture and may have a negative impact on the healing process (Leversedge et al., 2002; Yepes et al., 2008; Zantop et al., 2003). This fact has also been described in the LHBT by several authors (Hermann and Steiner, 1990; Lindblom, 1939; Rathbun and Macnab, 1970). Particularly the osteotendinous junction is not adequately perfused (Cheng et al., 2010). The superior and anterosuperior portions of the labrum were also found to be less vascularized than the posterior and inferior portions (Cooper et al., 1992). In addition, tendons consume significant quantities of oxygen (Peacock, 1959; Smith, 1965). Oxygen may be compromised by any type of surgical intervention, such as suture anchors used for SLAP repair.

A limited number of publications have dealt with arterial supply of the LHBT (Cheng et al., 2010; Cohen et al., 2006; Hermann and Steiner, 1990; Kanbayashi et al., 1993; Kolts et al., 1994; Korn and Schünke, 1989; Resnick et al., 2007). To our knowledge, ours is the

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first combined anatomical and radiological investigation using 3D scan and computed tomography angiography (CTA), and focusing on arterial supply of the LHBT. In contrast to previous studies, we focused on the proximal part of the supplying arteries, i.e. their source and course within the medial bicipital groove.

2. Materials and methods

The anatomical part of the study was performed on 20 human bodies (10 males, 10 females, 14 left and 6 right upper extremities) aged, on average, 77 years (range, 54–98 years) fixed in a mixture of 1.6% formalin and 5% phenol solution. By careful stratigraphic dissection, the axillary artery and its branches were traced throughout the axillary space. The anterior circumflex humeral artery (ACHA) was located and followed into the intertubercular groove until it reached the fibrous capsule of the shoulder joint. The findings were documented on photographs.

The radiological part of the study was performed on 10 fresh-frozen anatomical specimens (5 males, 5 females) of upper extremities (6 right, 4 left) with a mean age of 75 years (range, 68–85 years). Twenty millilitres of the contrast agent Jopamiro, 300 mg J/ml (Bracco Austria, Vienna), containing 612.4 mg of Iopamidol, was injected into the most proximal segment of the axillary artery, i.e. at the level of the first rib, via a dilatator. To determine whether any grossly visible vessel had derived from more proximal stems, we additionally performed angiography in ten specimens after injecting contrast medium into the suprascapular artery. For all these radiologic examinations, an Arcadis Orbic 3D scanner (Siemens AG, Healthcare Sector, Erlangen, Germany) was positioned over the proximal part of the humerus and centred over the medial bicipital groove. While scanning the specimen, this high-end C-arm performed a 190° isocentric rotation to generate a 3D dataset from a cube covering a volume of approximately 12 cm × 12 cm × 12 cm. This dataset was displayed as multiplanar reconstructed (MPR) slices on coronal, sagittal, and axial views. In total, a series of 256 cross-sections were obtained from each specimen. The slice thickness was 0.5 mm. In a post-processing step, various cross-sectional images (axial or paracoronal in one plane through the bicipital groove, as appropriate) were generated from this dataset.

All specimens were taken from body donors according to a special agreement signed by the individuals before their demise. This study was approved by the ethics committee of the Medical University of Vienna.

In addition, maximum intensity projection (MIP) reconstructions from ten computed tomography angiographies (CTA) (8 males, 2 females) with a mean age of 42 years (range, 20–70 years) of the upper extremity performed at the Department of Trauma Surgery, Medical University of Vienna, were obtained retrospectively. Eight CTA's used had been performed routinely in polytraumatized patients after motor vehicle accidents to survey their circulation. In addition, 3D reconstructions were obtained from two patients suffering from cervico-thoracic disorders. All investigations were performed on a 64-row CT scanner (Philips, Brilliance 64; Philips Best, Netherlands). The 3D datasets were obtained from a series of 664 consecutive axial cross-sections (helical CT scans) with an individual slice thickness of 0.9 mm, using increments of 0.45 mm. The contrast medium Jopamiro 300 mg J/ml (Bracco Austria, Vienna) was applied at a flow rate of 4.0 mm/s with mean of bolus tracking. A Philips Workstation (EBW1) was used for post-processing. All arteries supplying the shoulder region, i.e. the suprascapular, the circumflex scapular as well as the anterior and posterior circumflex humeral arteries were traced on both the 3D reconstructions and series of maximum intensity projection (MIP) reconstructions. In order to visualize even smaller vessels, these additional reconstructions were adjusted to a slice thickness of 5 mm.

Table 1
Distribution of the origin of the anterior circumflex humeral artery (ACHA) as seen on stratigraphic anatomical dissection in comparison with earlier findings by Adachi (1928). Note that Adachi did not differentiate between left and right shoulders.

Distribution of the origin of the ACHA as seen on anatomical dissection			
Findings by Adachi (1928)		Results of our study	
		Left	Right
Posterior circumflex humeral artery	54	2	2
Posterior circumflex humeral artery Subscapular artery Deep brachial artery	18	0	0
Posterior circumflex humeral artery Subscapular artery	14	0	0
Posterior circumflex humeral artery Deep brachial artery	14	0	0
Subscapular artery	3	0	0
Axillary artery	0	12	4

3. Results

The anatomical dissection showed that the proximal part of the LHBT always received its arterial blood through an ascending branch of the ACHA. However, the origin of this artery showed considerable intra- and interindividual variation: In 16 specimens (80%) the ACHA derived directly as a branch of the axillary artery, in 4 specimens (20%) the ACHA formed a common trunk with the posterior circumflex humeral artery (Table 1; Figs. 1 and 2).

Additionally, we dissected a right male shoulder following the regular branches of the thoracoacromial artery, i.e. the clavicular, the pectoral, the deltoid and the acromial branches. None of these branches macroscopically reached the biceps tendon anchor (Fig. 3).

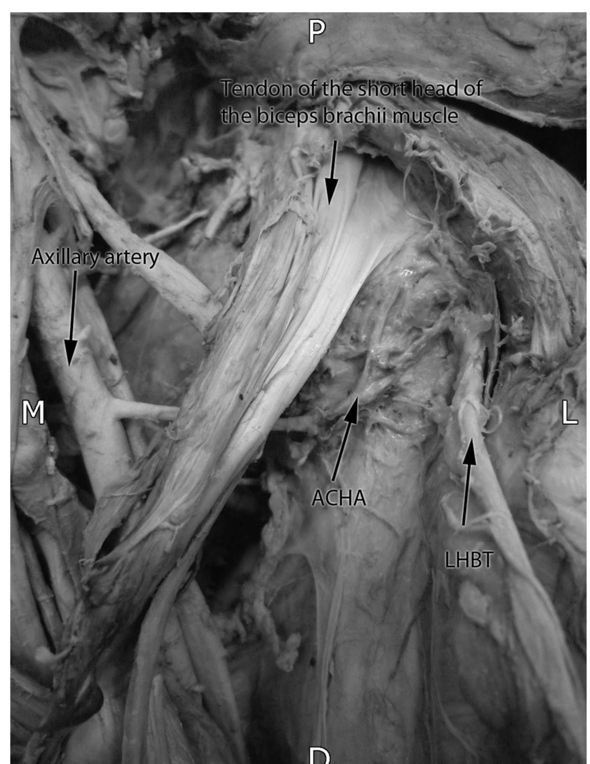

Fig. 1. Macroscopic dissection of the left axillary space in a man. Note that the ACHA branches off as a direct trunk from the axillary artery running beneath the tendon of the short head of the biceps brachii (SHBT). Capitals indicate the anatomical orientation, i.e. D = distal, L = lateral, M = medial, P = proximal.