

Variations of the circumflex humeral arteries: a cadaveric study

Mohamed Elajnaf^{1,2} , Abdelmenem Alashkham¹ 

¹Anatomy, School of Biomedical Sciences, Edinburgh Medical School, University of Edinburgh, Edinburgh, UK

²Leicester General Hospital, University Hospitals of Leicester NHS Trust, Gwendolen Road, Leicester, UK

Abstract

Objectives: Surgery is the main treatment option of both anatomical and surgical neck humeral fractures, which could result in damage to the circumflex humeral vessels. Current research studies have found that vascular supply to the shoulder is variable. However, the incidence of these variations and how they can affect the blood supply to the shoulder region is still under investigation. The aim of this study is to identify possible variation patterns of the circumflex humeral vessels.

Methods: A total of 10 shoulders (3 males, 2 females; average age of 68.8 years) were dissected in Anatomy, University of Edinburgh, under the regulation of the Human Tissue (Scotland) Act 2006. Each shoulder was dissected, and tissues were removed to identify the axillary artery and its branches.

Results: The anterior and posterior circumflex humeral arteries were observed to arise as single branches from the 3rd part of the axillary artery in 70% (n=7) and 80% (n=8), respectively. In one cadaver, the posterior circumflex humeral artery (PCHA) arose from the subscapular artery in one side (10%, n=1) and from the profunda brachii artery on the contralateral side (10%, n=1). In the remaining 10% (n=1), the anterior circumflex humeral artery (ACHA) was found as a branch from the PCHA, with the latter being a direct branch from the 3rd part of the axillary artery.

Conclusion: Knowledge and awareness of these variations is essential to not only suspect, diagnose and treat possible complications of common fractures and dislocations in the region, but also to prevent iatrogenic injury.

Keywords: anatomical variation; axillary artery; circumflex humeral arteries; profunda brachii artery; quadrangular space

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Introduction

The axillary artery is a large blood vessel that supplies the lateral thorax, axilla and upper limb. It is formed as a continuation of the subclavian artery at the lateral border of the first rib. Anatomically, it is divided into three parts by the pectoralis minor and provides branches from each part that supply the pectoral region, lateral thoracic wall, the shoulder girdle and mammary gland.^[1] The third part of the axillary artery starts at the lateral border of pectoralis minor and terminates at the inferior border of teres major to become the brachial artery. Classically, there are three branches of the third part of the axillary artery, which are the anterior and posterior circumflex humeral arteries and the subscapular artery.^[1–3] According to Standring,^[1] the anterior circumflex humeral artery (ACHA) arises at the

distal border of subscapularis and runs horizontally posterior to coracobrachialis and the short head of biceps brachii. It reaches the surgical neck of the humerus anteriorly and continues laterally inferior to the long head of biceps and deltoid to anastomose with the terminal branches of the posterior circumflex humeral artery (PCHA). The PCHA, which is the larger of the two circumflex humeral branches, additionally originates at the distal border of subscapularis. However, it runs posteriorly through the quadrangular space accompanied by the axillary nerve. It circumflexes around the surgical neck of the humerus to form an anastomosis with branches of the ACHA.^[1,3]

A series of studies has reported variations in the origin of the anterior and posterior circumflex humeral arteries. The ACHA was observed to arise from the profunda brachii

artery (PBA).^[4-6] Whereas Patnaik et al.^[5] reported that the ACHA was found to arise from the brachial artery. A study conducted by Saeed et al.^[7] involving 106 formalin-fixed adult human cadavers concluded that an anomalous topographic pattern of the subclavian-axillary arterial system was found in 7.5% of the samples. The same authors found that the ACHA and PCHA originated from the second part of the axillary artery in 1.9%, which was described as a thoracohumeral trunk giving rise to the lateral thoracic, circumflex humeral, subscapular and thoracodorsal arteries.^[7]

Classical anatomy of the PCHA is described as arising from the third part of the axillary artery.^[4,5,8] However, Huelke et al.^[4] reported that this was the case in only 67.5% of the specimens. They found that the PCHA originated directly from the subscapular artery and the PBA in 15.2% and 2.8% respectively.^[4] In contrast, Hartley and Marquez,^[9] dissected 48 cadaveric upper limbs and reported that the traditional “textbook” branching pattern (Type 1) was only observed in 56% of the sample. Whereas in more than 6% of the cases, the PCHA was found to arise from the subscapular artery.^[9] Based on multidetector-row computed tomography angiography of 62 upper extremities, Hattori et al.^[10] highlighted that the classic origin and branching patterns of the subscapular artery and the PCHA were only observed in 33.9% of cases. Other very rare patterns of origin of the PCHA arising from the lateral thoracic artery, brachial artery and circumflex scapular artery have also been reported.^[8,11]

The incidence of variations of the circumflex humeral arteries is still under investigation, as the branching pattern has shown considerable variation. It is fundamental to report all variations of the ACHA and PCHA as it provides guidance on rare symptomatology of upper limb neurovascular pathology, such as axillary artery occlusion and quadrilateral space syndrome. Additionally, it helps anticipate surgical outcome related to trauma or fixation surrounding the surgical neck of the humerus and expands knowledge for surgical exploration of the region to avoid iatrogenic vascular injury. Therefore, the aim of this study was to identify the variational patterns of the ACHA and PCHA to aid the surgeon, anatomist and radiologist regarding the possible prevalence of this variation.

Materials and Methods

Five Genelyn-fixed cadavers (3 males and 2 females, average age 68.8 years), with 10 shoulders (n=10), were dissected. The cadaveric specimens were obtained from Anatomy, University of Edinburgh, which is under ethical regulation of the Human Tissue (Scotland) Act 2006. Each specimen was clear from any signs of trauma or sur-

gery at the shoulder or axillary region, with the cause of death unrelated to the region being studied. Dissection was performed according to Grant’s Dissector, with a full exposure of the shoulder, axilla and upper arm.^[12] The skin and subcutaneous tissues and muscles around the shoulder have been dissected, appreciated then removed. The axillary artery and its branches were dissected, identified and recorded.

Results

The axillary artery and its branches were detected and recorded in all 10 shoulders. A full exposure and record of the axillary artery and its branches have been performed. The circumflex humeral arteries branched as follows:

- ACHA as single branch from the third part of the axillary artery in 70% (n=7).
- PCHA as single branch from the third part of the axillary artery in 80% (n=8).
- ACHA from the PCHA in 10% (n=1) (**Figure 1**).
- PCHA from the subscapular artery in 10% (n=1) (**Figure 2**).
- PCHA from the PBA in 10% (n=1) (**Figure 3**).

In all the specimens, the ACHA coursed laterally posterior to both the short head of biceps brachii and coracobrachialis to reach the surgical neck of the humerus (**Figure 1**). In 90% (n=9) of the specimens, the PCHA passed posteriorly through the quadrangular space (**Figure 2**), whereas in 10% (n=1), after arising from the PBA, it ran superolaterally between the long and lateral heads of triceps (**Figure 3**) towards the surgical neck of the humerus to anastomose with the ACHA.

Discussion

The origin of ascending branch of the ACHA is quite variable^[13-19] (**Table 1**) and clinically it is the single most important artery in supplying the humeral head.^[20-21] Studies have shown that surgical complications related to proximal humeral fracture (PHF) repair can adversely affect the blood supply to the head of the humerus. In a systematic review by Lanting et al.^[22] involving 2155 patients, who completed follow up with an average age of 62.8 years, open reduction and internal fixation (ORIF) was found to cause avascular necrosis of the humeral head in 37% of the patients. The ACHA is typically a branch from the third part of the axillary artery and runs laterally in a horizontal direction to reach the surgical neck of the humerus.^[1] The current study has shown that in only 90% this classical pattern is observed with the ACHA arising directly from the third part of the axillary artery (**Table 1**). However, in 10% it arose as a branch from the PCHA

(Figure 1). It can be argued that variations in the ACHA origin may contribute to the risk of developing avascular necrosis in patients with PHF. Xu et al.^[23] demonstrated in a meta-analysis involving seven studies with a total number of 291 patients that plate fixation was associated with a higher rate of avascular necrosis than conservative treatment ($p=0.019$). This highlights the importance of recognising that anatomical variations may contribute to clinical outcome related to PHF.

Observations from a study on branches of the axillary artery involving 178 sides by Hulke et al.,^[4] demonstrated that 80.3% arise directly from the third part of the axillary artery. The same study reported that in 11.2% the ACHA arises as a common trunk with the PCHA from the third part of the axillary artery and in 1.7% it arises from the PBA. Other studies have shown similar findings with the most common origin of the ACHA being the third part of the axillary artery.^[5] Rarely, it may arise from the PBA and the second part of the axillary artery, or it can even be absent.^[4-6] Interestingly, Brooks et al.,^[21] had demonstrated the effects of simulated PHF on the arterial supply of the humeral head. In their study with barium sulphate perfusion after simulated PHF in 16 cadavers, they report that blood supply was preserved after the fracture.^[21] However, anastomotic branches with the posteromedial vessels from the PCHA may have a role in preserving the vascularity of the humeral head in certain types of fractures.

Embryologically, the lateral branch of the seventh intersegmental artery (later will become the subclavian artery) is thought to form the arterial trunk that supplies the upper limb during fetal development.^[1] The principal arteries and anastomoses appear according to a sequence and regression of some networks that were initially functionally dominant can lead to anatomical variations and vascular anomalies.^[1] The continuation of the subclavian artery, the axial artery, persists as the axillary and brachial arteries, which supply the upper limb.^[24] A typical axillary

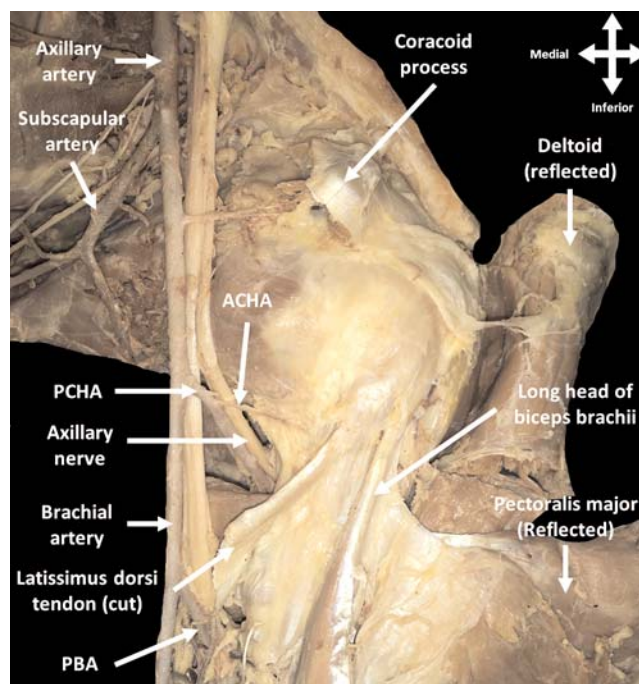


Figure 1. Anterior view of the left shoulder after dissection with exposure of the axillary artery and its branches. The anterior circumflex humeral artery (ACHA) is seen arising from the posterior circumflex humeral artery (PCHA). PBA: Profunda brachii artery.

artery gives origin to six branches: superior thoracic, thoraco-acromial, lateral thoracic, subscapular and anterior and posterior circumflex humeral arteries with other unnamed branches that might additionally be present.^[4] However, the classical description of the axillary artery branches only represents 10% of cases and not all variants incidence is reported in the current literature.^[25]

Variations in the origin of the PCHA are also common (Table 2). The common branching pattern of the PCHA is of the classical type arising from the third part of the axillary artery.^[4,5,8-10] As with the ACHA, variations of the

Table 1

Frequency of distribution of the origin of the ACHA.

Studies	Origin of ACHA (%)					
	2nd part of AA	3rd part of AA	PBA	BA	PCHA	Others
Hulke et al. ^[4]		80.3	1.7			0.65
Saeed et al. ^[7]	1.9	3.8				
Bhat et al. ^[13]	CR					
Patnaik et al. ^[5]			2	2		
Bagoji et al. ^[6]			CR			
Present study		90			10	

AA: Axillary artery; ACHA: anterior circumflex humeral artery; BA: brachial artery; CR: case report; PBA: profunda brachii artery; PCHA: posterior circumflex humeral artery.

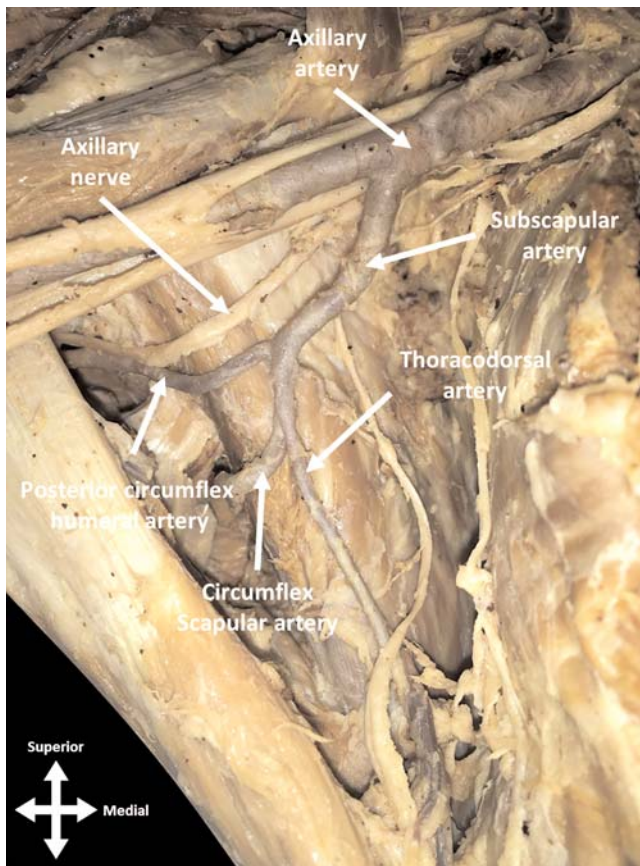


Figure 2. Anterior view of the right shoulder after dissection with exposure of the axillary artery and its branches. The posterior circumflex humeral artery is seen arising from the subscapular artery. It then courses through the quadrilateral space along with the axillary nerve.

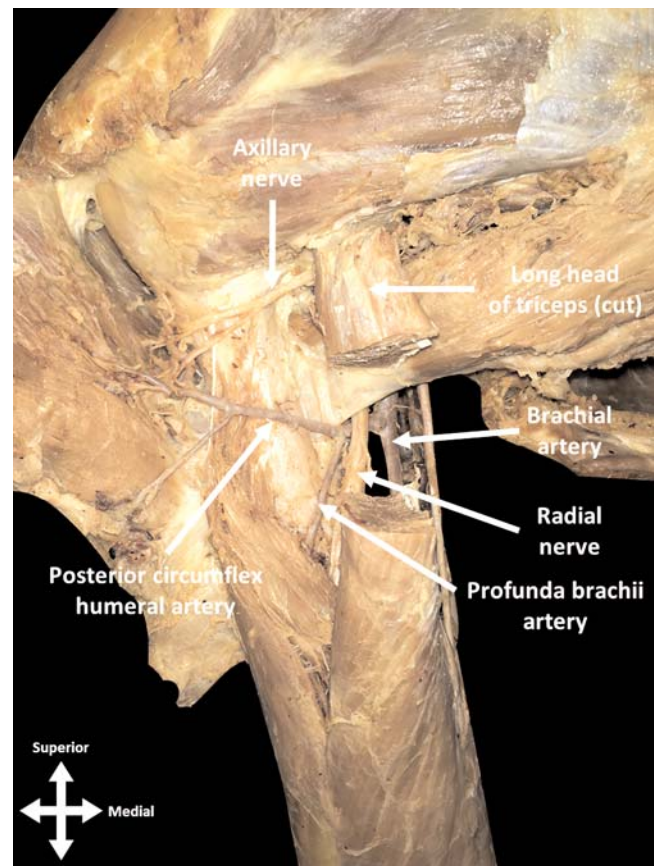


Figure 3. Posterior view of the left shoulder after dissection with exposure of the profunda brachii artery. The long head of triceps was cut to reveal the origin of the posterior circumflex humeral artery as it originates from the profundi brachii artery.

Table 2

Frequency of distribution of the origin of the PCHA.

Studies	Origin of ACHA (%)								
	LT	SS	1st part of AA	2nd part of AA	3rd part of AA	BA	CS	PBA	Others
Farhan and Selman ^[11]	2	11				9			
Saralaya et al. ^[14]			CR						
Goldman ^[5]		CR							
Lee and Kim ^[16]			CR						
Durgun et al. ^[17]		CR							
Swamy et al. ^[18]				CR					
Olinger and Benninger ^[8]	1.2				77.1	8.4	12		
Hartley and Marquez ^[9]		6			56				
Majumdar et al. ^[19]		CR							
Patnaik et al. ^[5]						2		2	
Hattori et al. ^[10]					33.9				
Huelke et al. ^[4]		15.2			67.5			2.8	2.2
Present study		10			80			10	

AA: Axillary artery; BA: brachial artery; CR: case report; CS: circumflex scapular artery; LT: lateral thoracic artery; PBA: profunda brachii artery; PCHA: posterior circumflex humeral artery; SS: subscapular artery.

PCHA may clinically contribute to trauma or surgical intervention for PHF. However, the anatomical course of the PCHA is additionally of clinical importance in relation to sports injuries. Kraan et al.,^[26] reported in a systematic review in relation to PCHA aneurysms, which can lead to ischemic emboli in the upper limb, that an anatomical variation may be protective. If the PCHA is running through the quadrangular space, this poses a risk of the artery being damaged by repetitive muscle contraction as it passed through the narrow space. Interestingly, Huelke et al.,^[4] have reported a rare variation in which the PCHA is observed to originate from the PBA. By following this course, the artery avoids the narrow quadrangular space for which it can be compressed from repetitive muscle contraction, i.e. in boxers, baseball players and professional swimmers. This is thought to be a protective variation of the PCHA in relation to overuse injuries in the dominant shoulder of sport professionals. This variation does not follow the classical anatomical course as it does not enter the quadrangular space. The current study has reported this variation in 10% of the samples (**Figure 3**) and this may provide essential knowledge regarding risk factors for developing PCHA pathology in relation to its anatomical origin.

This study was limited by the sample size of cadavers, which may require further studies on a larger sample size. Additionally, no clinical data was available regarding clinical symptoms, if present, in relation to the anatomical variations studied.

Conclusion

Knowledge of the anatomical variations of the circumflex humeral arteries is of paramount importance in relation to pathology and surgical intervention. Understanding the possible anatomical branching pattern of the vascular structures around the shoulder is clinically relevant to help manage patients with acute shoulder injuries or pathology.

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Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest;

and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Author Contributions

ME: data collection, photography for figures, manuscript writing; AA: data collection, manuscript writing.

Ethics Approval

Cadaveric specimens were obtained with ethical approval of Anatomy, University of Edinburgh, regulated by the Human Tissue (Scotland) Act 2006.

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ORCID ID:

M. Elajnaf 0000-0001-7276-2555;
A. Alashkham 0000-0003-2959-5039



Correspondence to: Abduelmenem Alashkham, PhD, MSc, MBChB
University of Edinburgh, Old Medical School, Doorway 3, Teviot Place,
Edinburgh, EH8 9AG, UK
Phone: +44 131 650 2924
e-mail: abduelmenem.alashkham@ed.ac.uk

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