



ELSEVIER



The coracoid process is supplied by a direct branch of the 2nd part of the axillary artery permitting use of the coracoid as a vascularised bone flap, and improving it's viability in Latarjet or Bristow procedures

R. Khundkar^{a,*}, H. Giele^b

^aNuffield Department of Surgery, University of Oxford, Headley Way, Oxford, OX3 9DU, United Kingdom

^bDepartment of Plastic Surgery, West Wing, John Radcliffe Hospital, Oxford University Hospitals, Oxford, OX3 9DU, United Kingdom

Received 10 August 2017; accepted 6 January 2019

KEYWORDS

Coracoid blood supply;
Coracoid artery;
Vascularised bone graft;
Axillary artery;
Coracoid transfer;
Coracoid process,
Latarjet, Bristow,
shoulder stabilisation

Summary Background: A comprehensive understanding of the anatomy of the vascular supply of the coracoid is needed to ensure that the coracoid remains vascularised in order to optimize bone union during any coracoid transfer procedures. It is the purpose of this study to present an anatomical overview of the blood supply of the coracoid process, describing a previously unidentified vessel that arises directly from the axillary artery and nourishes the coracoid process, permitting the coracoid to be used as a free bone flap.

Methods: An anatomical study examining the blood supply to the coracoid process of the scapula was performed in 14 shoulders from 7 fresh frozen (unembalmed) adult cadavers. In addition, the vascular supply to the coracoid was studied in 22 shoulders in patients during operations around the anterior shoulder.

Results: In all the cadaveric shoulders studied there was a single consistent direct branch of the second part of the axillary artery that supplied the distal 2–3 cm of the coracoid process with a corresponding vein. The mean pedicle length for the artery was 4.46 cm (range 3.1–5.6 cm). This artery originated from the axillary artery from the antero-lateral position in 6, lateral position in 3 and posterolateral position in 5 shoulders. The mean pedicle length for the vein was 5.8 cm (range 4.5–7.8 cm). The vein joined directly to the axillary vein in 3 shoulders and via another tributary (parallel to the axillary vein) in 9 shoulders. The diameter of the artery and vein averaged 1–1.5 mm. The clinical study confirmed the findings of the cadaveric study.

* Corresponding author.

E-mail address: roba.khundkar@nds.ox.ac.uk (R. Khundkar).

Conclusion: Our anatomical cadaveric and clinical studies demonstrate the presence of a previously unidentified direct arterial branch from the second part of the axillary artery supplying the anterior 2-3 cm of the coracoid process of the scapula. This consistent vessel and accompanying vein should be preserved for any surgical procedure that involves transfer of the coracoid process, such as the Latarjet and Bristow procedures for shoulder dislocation and can be used for free transfer of the coracoid where a small vascularised bone flap may be required.

Crown Copyright © 2019 Published by Elsevier Ltd on behalf of British Association of Plastic, Reconstructive and Aesthetic Surgeons. All rights reserved.

Introduction

The coracoid process is the beak-like structure on the anterior part of the scapula that serves as the attachment site for the coracobrachialis, short head of the biceps, and pectoralis minor muscles as well as the coracoclavicular, the coracoacromial and the coracohumeral ligaments, providing stability to the shoulder.

A comprehensive understanding of the anatomy of the vascular supply of the coracoid is needed to ensure that the coracoid remains vascularised in order to optimize bone union when it is transferred to the anterior glenoid rim to stabilise the shoulder in the Latarjet or Bankart procedure.¹¹ In these procedures the coracoid is transferred with the conjoint tendon relying on retrograde blood perfusion through the muscle into the bone.^{9,8}

Given the scarcity of literature on this matter, it is the purpose of this study to present an anatomical overview of the blood supply in the coracoid process as well as to describe the previously unidentified vessel that arises from the axillary artery and nourishes the coracoid process, and to determine if the coracoid can be used as a free vascularised bone flap.

Methods

An anatomical study examining the blood supply to the coracoid process of the scapula was performed in 14 shoulders from 7 fresh frozen (unembalmed) adult cadavers. There were 4 males and 3 females. These bodies were voluntarily donated to the Oxford University Department of Human Anatomy and Genetics.

Ink Injection studies were performed with blue ink in 2 shoulders. It was difficult to achieve enough intra-vascular pressure to make perfusion uniform.

In addition, the vascular supply to the coracoid was studied in 22 shoulders in patients during operations around the shoulder, mainly infra-clavicular brachial plexus explorations and anterior subscapular releases for anterior shoulder contractures following obstetrical brachial plexus palsy.

Dissection technique

The coracoid process was identified by palpation. A skin incision was then made over this, extending into the deltopectoral groove (Figure 1). The cephalic vein was identified in the deltopectoral groove, retracted laterally and dissection

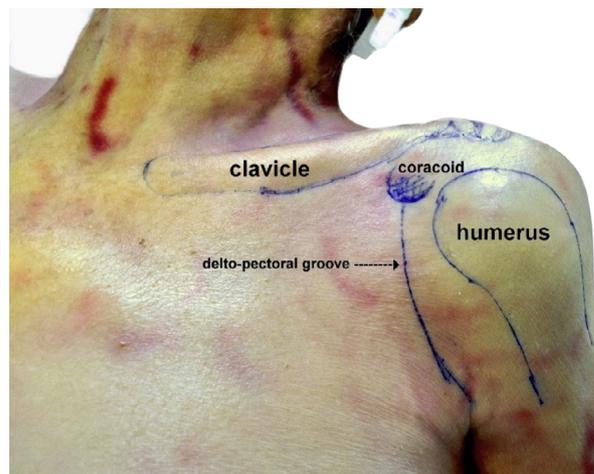


Figure 1 Surface markings and skin incision.

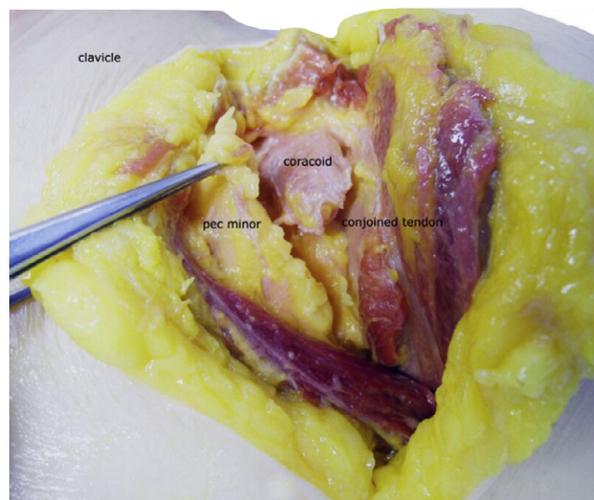


Figure 2 Exposure of the coracoid process by release of pectoralis minor muscle and conjoined tendon of the short head of biceps and the coracobrachialis muscles.

performed between and under the pectoralis major and deltoid muscles to expose the clavipectoral fascia.

The coracoid process and conjoined tendon of the short head of biceps and the coracobrachialis muscles attached to it were identified. The origin of pectoralis minor muscle was released from the medial edge of the coracoid process and the muscle retracted medially. The conjoined tendon was also released and the coracoid process exposed completely (Figure 2).

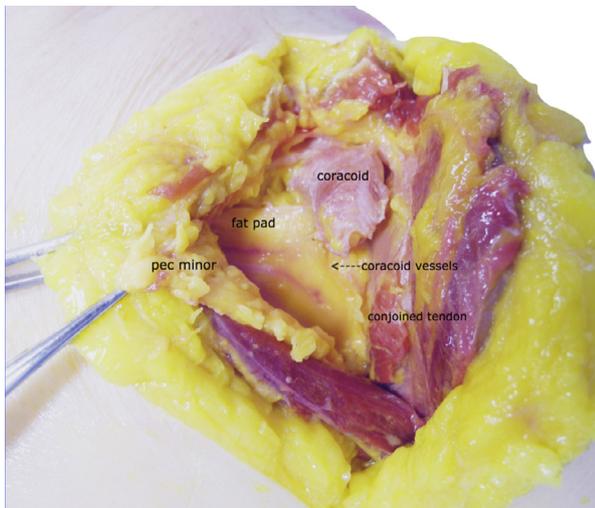


Figure 3 Vessels to coracoid process within fat pad.

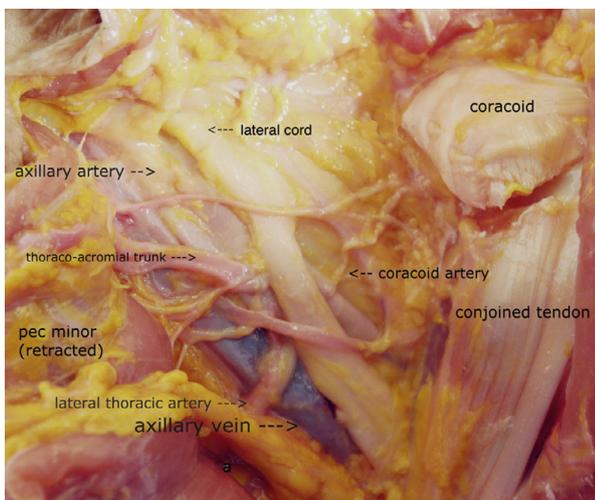


Figure 4 Lateral cord of brachial plexus and 2nd part of the axillary artery in relation to the coracoid process and conjoined tendon of the short head of biceps and the coracobrachialis muscles.

The coracoid vessels are found in the neurovascular plane within the fat pad under the pectoralis minor muscle (Figure 3). Once identified the vessels are dissected free from the surrounding adipose tissue. Dissection is continued from the coracoid process towards the axillary vessels medially. The lateral cord of the brachial plexus (Figure 4) is identified and retracted medially to expose the axillary artery and vein. At the end of the dissection, in the cadavers, the distal 2.5-3 cm of the coracoid process was detached to examine the vessels further.

The clinical study was performed in 22 patients undergoing routine exposure of the anterior shoulder, coracoid and infra-clavicular brachial plexus by detachment of the pectoralis minor, and exploring for the presence, site and origin of the coracoid artery and vein.

Results

Cadaveric study

In all the shoulders studied there was a single consistent direct branch of the second part of the axillary artery that supplies the coracoid process with a corresponding vein (Figures 5 and 6). We have labelled this the coracoid artery.

The artery to the coracoid process was identified in all 14 shoulders. It arose from the 2nd part of the axillary artery, behind pectoralis minor, in every case. The coracoid artery originated from the axillary artery from the anterolateral position in 6, lateral position in 3 and posterolateral position in 5 shoulders.

The course of the artery from the axillary artery to the coracoid process was either horizontal or at angle of 30°-45° above horizontal (Figure 7). The vein draining the coracoid process is usually situated superficial to the artery (Figure 8), however in one shoulder the artery was found sitting alongside the vein in the same plane.

The position of the coracoid artery in relation to the thoracoacromial and lateral thoracic arteries of the 2nd part of axillary artery was highly variable (Figures 9 and 10). The mean pedicle length for the artery (under-surface of coracoid process to axillary artery) was 4.46 cm (range 3.1-5.6 cm). Occasionally, after arising from the axillary artery, the coracoid artery gave off a branch towards fascia/subscapular muscle (Figure 10).

The main vessel continues towards the deep surface of the coracoid and gives several small branches to the coracoid. It then proceeds to give branches towards ligamentous structures around the head of the humerus (Figure 11).

There was one vein draining the coracoid in all but one shoulder, which had 2 veins (Figure 12). The mean pedicle length was 5.8 cm (range 4.5-7.8 cm). The vein joined directly to the axillary vein in 3 shoulders and via another tributary (parallel to the axillary vein) in 9 shoulders. This tributary was normally found running lateral to the lateral cord of the brachial plexus and then crossing over the axillary artery to join the axillary vein (Figures 6 and 12). The diameter of the artery to the coracoid ranged between 1 and 1.5 mm (Figure 13). The vein is of similar size however joins onto larger tributaries which then join onto the axillary vein.

Ink injection studies confirmed an interosseous supply from the coracoid artery. Blue ink can be seen permeating through to the tip of the coracoid and also inside the bone when sectioned (Figure 14).

Clinical study

In-vivo dissections were performed in 22 shoulders (8 males, average age 27, range 8-65 years) during operations around the coracoid process including infra-clavicular brachial plexus exploration, anterior shoulder release by coracoidectomy and subscapularis lengthening, and clavicle reconstruction procedures. The artery (and corresponding vein) to the coracoid process was consistently identified in all.

The findings of a direct vessel supplying the coracoid of sufficient length and diameter for microvascular

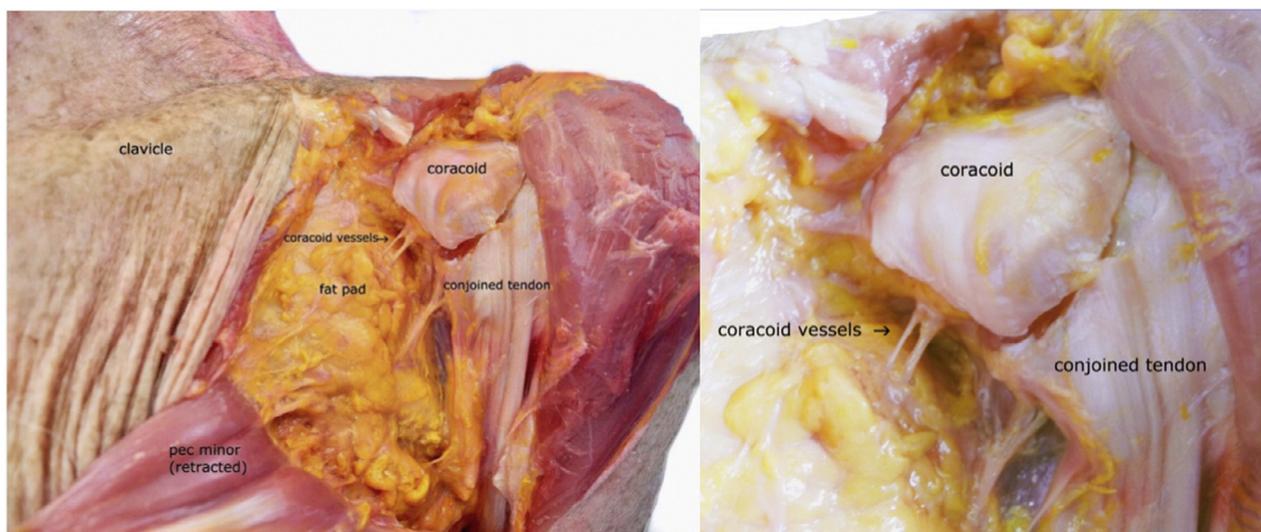


Figure 5 Branch of axillary artery and vein to coracoid process.

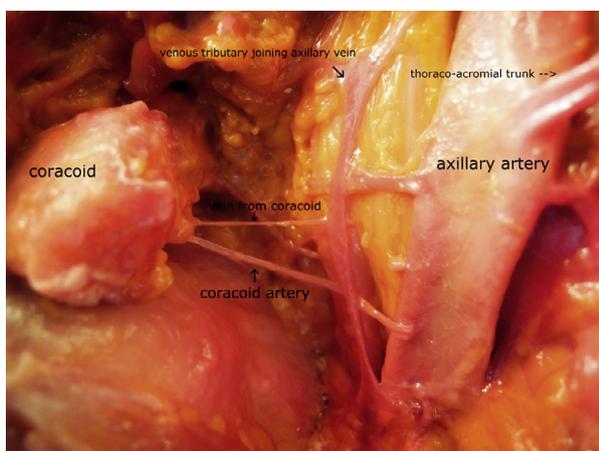


Figure 6 Direct branch of axillary artery supplying the coracoid process with accompanying vein.

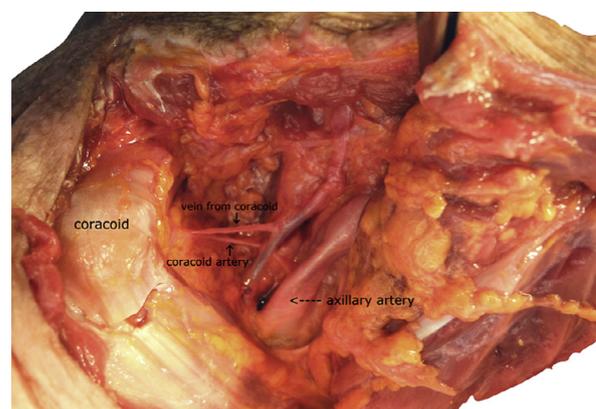


Figure 8 Vein from coracoid lies superficial to coracoid artery.

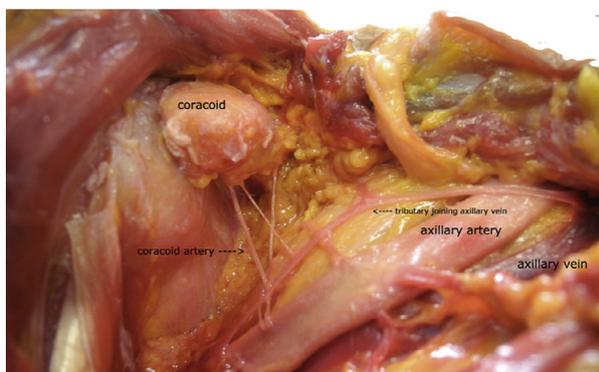


Figure 7 Course of coracoid artery.

anastomosis, with ease of harvest and the absence of significant morbidity associated with loss of the tip of the coracoid permits the coracoid to be used as a free vascularised bone flap for example when one requires reconstruction of the

proximal pole of the scaphoid following fracture non-union with avascular necrosis.

For such a harvest of the coracoid process a standard anterior (delto-pectoral) approach to the shoulder is utilised, with an incision in the delto-pectoral groove extending over the coracoid process, followed by retraction of the deltoid muscle laterally and pectoralis major muscle medially. The coracoid process is identified and the pectoralis minor muscle and conjoined tendon (of short head of biceps and coracobrachialis) detached from it. The coracoid vessels are identified within the fat pad under the pectoralis minor muscle and carefully dissected free and divided at their origin. Transection of the coracoid process to the required length completes the harvest, allowing it to be detached and transferred to the recipient site.

Discussion

In spite of the abundant descriptions about the vascular supply of the humeral head rotator cuff, as well as glenohumeral capsule, glenoid¹ and the shoulder in general, it is difficult to find an accurate description of the vascula-

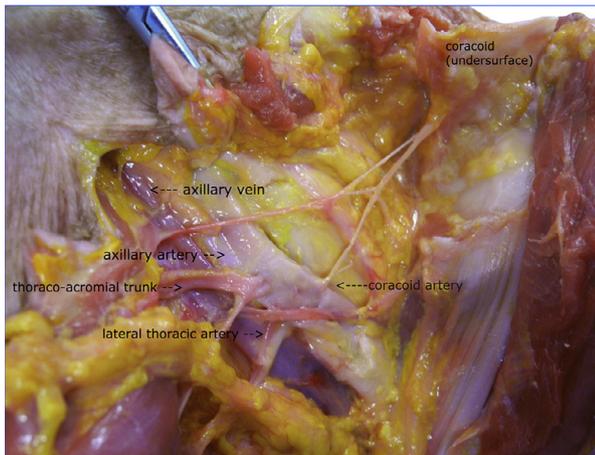


Figure 9 Coracoid artery in relation to thoracoacromial and lateral thoracic arteries.

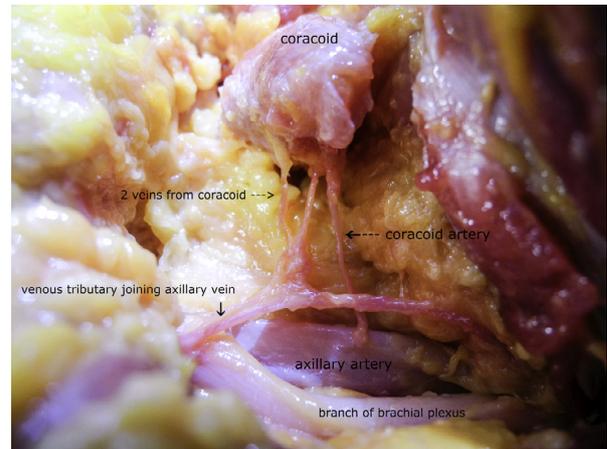


Figure 12 2 veins draining the coracoid process.

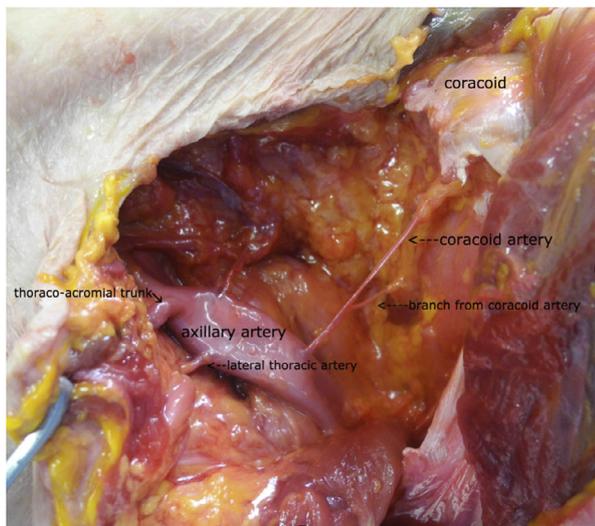


Figure 10 Branch from coracoid artery to deeper structures.



Figure 13 Diameter of artery to coracoid.

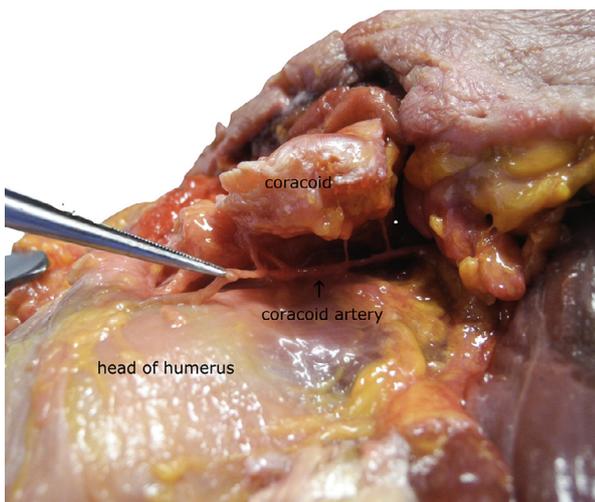


Figure 11 Branches to coracoid, then to structures around the head of the humerus.

ture present specifically in the coracoid process.^{3,10} Earlier reports suggest considerable variability of the branches of the axillary artery itself^{2,4}. There are only a few reports available in the literature and the results of prior research addressing the variability of the blood supply in the coracoid process are inconsistent. Therefore, the present work focused on the vascularisation of the coracoid.

The blood supply to the coracoid process has been categorised as extra-osseous supply (EoS) and intraosseous supply (IoS) by Hamel et al.⁵ The EoS is described as arising from the suprascapular and thoracoacromial arteries. The acromial branch of the thoracoacromial axis follows a trajectory over the base of the coracoid process and it does not perfuse the anterior portion of the coracoid process, although a branch approaching the coracoid insertion of the coracoacromial ligament can be present. This collateral vessel follows the inferior border of the coracoacromial ligament and brings blood supply to the horizontal portion of the coracoid process. The IoS is a vascular network derived from the acromial branch of the thoracoacromial artery.⁵ In this study of 5 embalmed cadaveric dissections, Hamel describes an ‘inconsistent’ branch from the second part of the vessel was seen in 3 of their dissections and confirmed by arteriography. They named it the pectoralis minor artery (PMA) as branches were given to this muscle. This vessel was seen behind the pectoralis minor tendon, either from the posterolateral edge or the lateral edge of the axillary artery.

The description of the course of this artery and the photographs from Hamel’s study suggests this may be the same

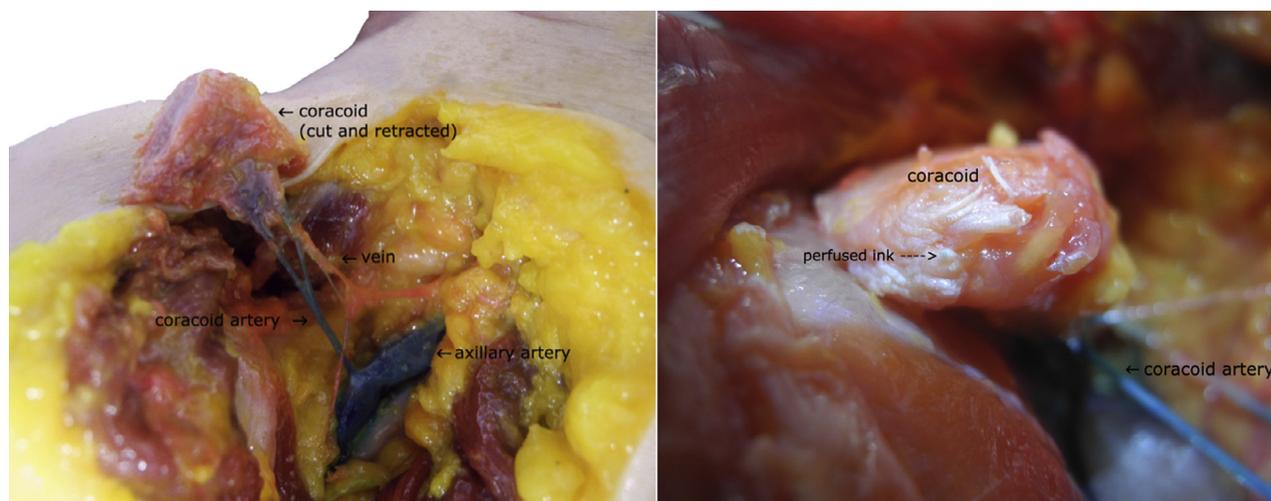


Figure 14 Blue ink permeating to under and superior surfaces of the coracoid.

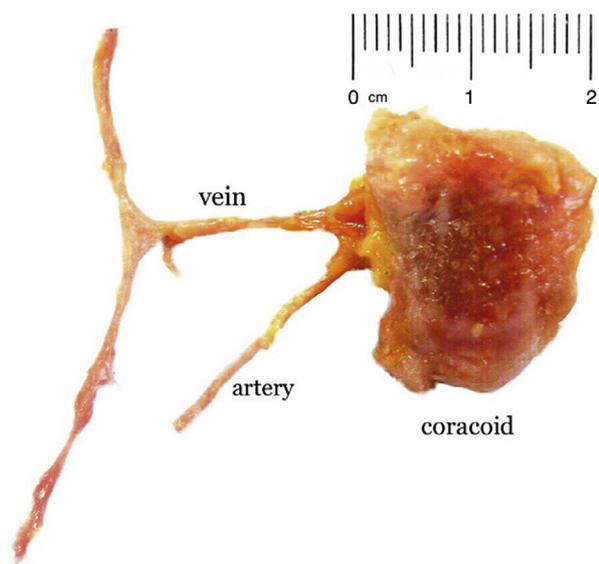


Figure 15 Coracoid as free vascularised bone graft.

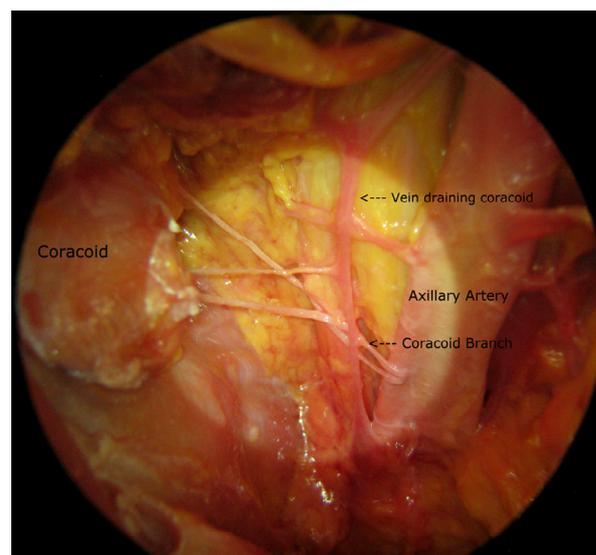


Figure 16 Artery supplying the coracoid process from the 2nd part of the axillary artery and accompanying vein.

vessel that we have identified. However, our study in fresh frozen cadavers found this vessel to be consistent in all 14 shoulders and we did not observe any branches to the pectoralis minor muscle.

Huelke⁶ in 89 cadavers identified up to 7 direct branches from the axillary artery, mainly from the 3rd part. These were identified as passing to the subscapularis and the conjoined tendon of the short head of biceps and the coracobrachialis muscles. It is the blood supply from this conjoined tendon upon which coracoid transfer to augment the glenoid rim in shoulder dislocation is based (Latarjet/Bristow). Defective union and lysis are relatively frequent complications of this procedure 1% to 28%.⁷ The complications after coracoid transfer to augment the glenoid rim to prevent recurrent dislocation may be due to the fact that, even under normal conditions, the blood flow from the conjoined tendon of the short head of biceps and the coracobrachialis muscles into the bone across the enthesis is restricted and

is further compromised following the surgical procedure due to additional tension or torsion. The understanding of the arterial vascularisation of the coracoid process is important to determine how one might improve the outcomes of the coracoid transfer.

We found the existence of an artery that is consistently present and supplies the tip of the coracoid process. In contrast with other studies in which the specimens were embalmed, this study was performed in fresh frozen cadavers and live subjects, which enhances the quality of the vascular dissection.

The clinical significance of our finding is that the coracoid artery and vein should be preserved and the bone pedicled on this vascular supply in addition to or instead of the conjoined tendon, in order to reduce the postoperative complications such as non-union following pedicled coracoid transfer. The presence of this vessel supplying the coracoid also

allows free vascularised transfer of the coracoid as a vascularised bone graft/flap (Figure 15).

Conclusions

Our anatomical and clinical studies demonstrate the presence of a previously unidentified direct arterial branch from the lateral aspect of the second part of the axillary artery supplying the anterior 2-3 cm of the coracoid process of the scapula (Figure 16).

The coracoid artery, along with a vein was seen consistently and reliably in all our cadaveric specimens and clinical patients. This blood supply should be preserved for any surgical procedure that involves transfer of the coracoid process.

Acknowledgements

We would like to thank the Oxford University Department of Human Anatomy for their support for the study.

Conflict of interest

None.

Funding

None.

References

1. Abrassart S, Stern R, Hoffmeyer P. Arterial supply of the glenoid: an anatomic study. *J Shoulder Elbow Surg* 2006;15(2):232-8.
2. De Garis CF, Swartley WB. The axillary artery in White and Negro stocks. *Am J Anat* 1928;41(41):353-97.
3. Fealy S, Adler R, Drakos M, Kelly A, Allen A, Cordasco F, Warren R, O'Brien S. Patterns of vascular and anatomical response after rotator cuff repair. *Am J Sports Med* 2006;34(1):120-7.
4. Paturet, G. (1951). *Traité d'anatomie humaine* Tome 1, Tome 1. *Traité D'anatomie Humaine*. Paris, Masson.
5. Hamel A, Hamel O, Ploteau S, Robert R, Rogez JM, Malinge M. The arterial supply of the coracoid process. *Surg Radiol Anat* 2012;34(7):599-607.
6. Huelke DF. Variation in the origins of the branches of the axillary artery. *Anat Record* 1959;135:33-41.
7. Kane P, Bifano SM, DODSON CC, Freedman KB. Approach to the treatment of primary anterior shoulder dislocation: a review. *Phys Sportsmed* 2015;43(1):54-64.
8. Longo UG, Loppini M, Rizzello G, Ciuffreda M, Maffulli N, Denaro V. Management of primary acute anterior shoulder dislocation: systematic review and quantitative synthesis of the literature. *Arthroscopy* 2014;30(4):506-22.
9. Matsen, F. A., Lippitt, S. B., & DeBartolo, S. E. (2004). *Shoulder surgery: principles and procedures*. Philadelphia, Pa, Saunders.
10. Meyer C, Alt V, Krous R, Giebel G, Koebke J, Schnettler R. The arteries of the humerus and their relevance in fracture treatment. *Zentralbl Chir* 2005;130(6):562-7.
11. van der Heiden R, Bruinsma WE, Kerkhoffs GM, Goslings JC, Schep NW. Treatment of primary anterior shoulder dislocation; do not always treat conservatively. *Ned Tijdschr Geneesk* 2013;157(37):A5526.