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Anatomical study of the clavicular branch of the thoracoacromial artery

Abstract

Introduction: The etiology and the complexity of losses of substances from the chest wall cause technical difficulties during their reconstruction. In order to obtain the best possible functional and morphological results, it is important to appreciate the lesions. When considering soft tissue reconstruction, the dimensions, location and shape of losses of substances, as well as the reliability and the arc of rotation of the chosen flap, must be taken into account. The perforator flap of the thoracoacromial artery and its vascular anatomical bases have been recently studied, concerning the pectoral and deltoid branches. The clavicular branch has only been rarely studied. We propose to study anatomically the clavicular branch of the thoracoacromial artery, in terms of constancy, dimensions and direction, in order to give to practitioners an additional option in the surgery of perforator flaps of the cervical region.

Material and methods: We carried out a direct and selective injection of 24 thoracoacromial arteries, on corpses preserved in a low-formalin solution rich in glycerin. The injected solution was made from a mixture of methylene blue and gelatin. Cadaveric dissection was then used to study the location, frequency, and path of the clavicular branch of the thoracoacromial artery.

Results: The clavicular branch was absent in more than half of the dissections. The length of its extrafascial pedicle varied between 0.5 and 2.5cm. The length of the pedicle after transmuscular dissection varied between 3 and 6cm. The general direction of this clavicular branch was ascending and medial.

Conclusion: Our work shows that when it is present the clavicular branch of the thoracoacromial artery has an extrafascial pedicle which measures 0.5 to 2.5cm, and a transmuscular pedicle from 3 to 6cm. And that its vascular skin territory projects slightly below the clavicle.

Keywords: thoracoacromial artery, clavicular branches, anatomical variations, integuments

Volume 7 Issue 3 - 2020

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Received: April 08, 2020 | **Published:** May 13, 2020

Introduction

The etiology and the complexity of losses of substances from the chest wall leads to technical difficulties during their reconstruction. In order to obtain the best possible functional and morphological results, it is important to appreciate the lesions. These lesions are mostly due to burn scars that have not been well managed. The main functional consequences result in a significant limitation of articular amplitudes. When considering soft tissue reconstruction, the dimensions, location and shape of losses of substances, as well as the reliability and the arc of rotation of the chosen flap, must be taken into account.[1,2] Numerous arteries have already been used to produce perforator flaps in this region, including the thoracoacromial artery.[2] Because of the anatomy and the configuration of this artery it is possible to use its 2-constant branches during the surgery of perforator flaps: the pectoral and deltoid branches. However, the thoracoacromial artery presents 2 other inconstant branches which have been insufficiently studied in the literature: the acromial and clavicular branches.[3,4]

Several studies have already described the thoracoacromial artery and its terminal branches, however few of these works have described in detail the clavicular branch. The authors of this work propose to study anatomically the clavicular branch of the thoracoacromial artery, in terms of constancy, dimensions and direction, in order to give to surgeons an additional option during the surgery of perforator flaps of the cervical region.

Surgical anatomy

The surgical anatomy of the thoracoacromial artery is important to know for any surgery of the shoulder region. The thoracoacromial artery represents one of the 7 typical collateral branches of the axillary artery (Figure 1). It arises below the junction between the middle and lateral thirds of the clavicle. It appears as a large vessel originating from the anterior surface of the axillary artery, whose origin is hidden by the cranial edge of the pectoralis minor muscle.[5,6] At the level of the cranial edge of the pectoralis minor muscle, it pierces the coraco-clavicular fascia and gives 4 branches.

It gives rise to two large, constant branches (Figure 2): one deltoid and the other pectoral. It also gives two other inconstant branches with a variable anatomy: a clavicular branch which arises directly from the thoraco-acromial axis, and an acromial branch which (when present) arises directly from the deltoid branch in almost all cases.[3–6] These branches, accompanied by their satellite veins, arise from the thoracoacromial artery just below the clavicle, then they penetrate into the pectoralis major muscle by its deep face just below the clavicle, at a point corresponding to half its length. Veins are satellites of arteries.

The clavicular insertion of the pectoralis major muscle is medially irrigated by the clavicular branch and laterally by the deltoid and acromial branches.[3–6] These last two arteries give musculocutaneous perforators which supply the integuments located in the cranial part of the pectoral wall. It is frequent that the deltoid branch directly gives the acromial branch which in turn provides a musculocutaneous perforator in the direction of the integuments covering the deltoid muscle and the lateral extremity of the clavicle.[3–6]

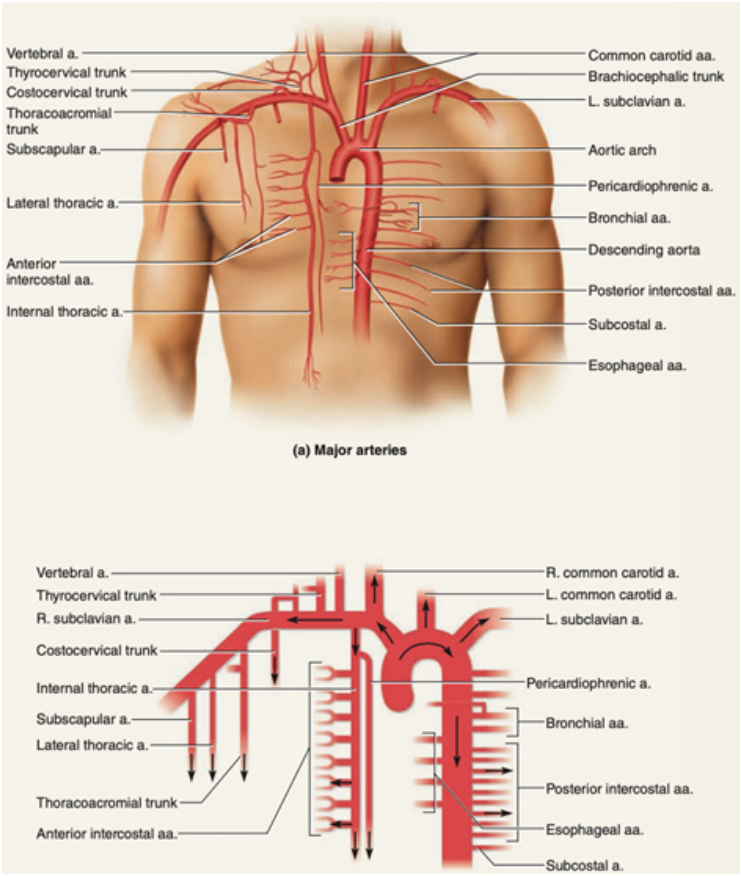

Figure 1 Regional anatomy of the subclavian and axillary arteries.

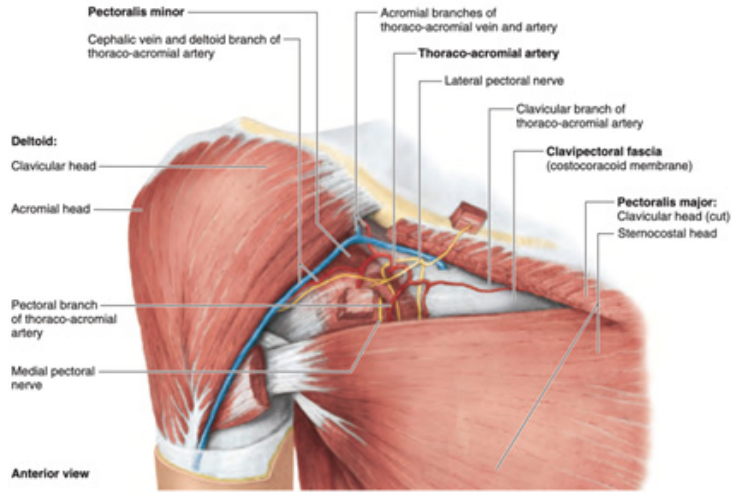

Figure 2 Anatomy of the terminal branches of the thoracoacromial artery.

The pectoral branch runs between the 2 pectoral muscles and is distributed to these muscles and to the mammary gland. It anastomoses with the intercostal branches of the internal thoracic artery and with the external thoracic artery. It irrigates in particular the sterno-costal portion of the pectoralis major muscle.[3–5] It quickly divides into 3 branches: a lateral branch which runs in the direction of the lateral thoracic artery, and two medial and caudal branches which goes towards the 4th intercostal space and anastomose with the anterior intercostal arteries and the perforators of the internal mammary artery.[5,6] This description can present many anatomical variations; however, the pectoral branch generally travels along a line joining the acromion to the xiphoid process.[4] Many musculocutaneous perforators

Citation: Manyacka Ma Nyemb P, Fontaine C, Duquennoy-Martinot V, et al. Anatomical study of the clavicular branch of the thoracoacromial artery. *MOJ Anat Physiol.* 2020;7(3):59–64. DOI: 10.15406/mojap.2020.07.00291

arise from this pectoral branch, but in general they are considered to have a caliber too small to be surgically exploitable.[5] Injections have shown that the cutaneous vascular territory of the pectoral branch extends transversely from the nipple to the axillary fossa, beyond the lateral edge of the pectoralis major muscle.[3,4]

The deltoid branch crosses the upper part of the deltopectoral groove and is generally divided into two branches, one deep and the other superficial.[3–6] The deep branch travels in the groove itself, inside a small channel formed by the doubling of the fascia. Arriving at the lower end of the intermuscular space, this deep branch perforates the superficial layer of the facial canal in which it is located. It thus arrives in the subcutaneous plane and quickly branches into the skin which covers the tendon of the pectoralis major and the distal insertion of the deltoid muscle.[3–5] It irrigates the pectoralis major and deltoid muscles with numerous small branches.

The superficial branch (which represents the acromial branch proper) goes obliquely down and laterally; its size is sometimes important and its length can reach 12cm.[3,4] The acromial branch is directed above the coracoid process and under the deltoid muscle, to which it gives several branches. It pierces the deltoid muscle towards the acromion to participate in an arterial network to which the suprascapular artery, the deltoid branch and the posterior humeral circumflex artery contribute. It ends at the lateral part of the deltoid region. Along its route, it gives a series of small branches on both sides of its trunk that quickly join the skin. This acromial branch presents many variations: it can be short from 2 to 3cm, or very long and reach the posterior face of the deltoid region; it remains deep in 25% of cases and then pierces the deltoid at a greater or lesser distance from its anterior border.[3,4]

The clavicular branch moves cranially and medially towards the sternoclavicular joint which it irrigates, as well as the subclavian muscle. It is usually of small caliber. In our work we plan to study the exact direction and dimensions of the clavicular branch of the thoracoacromial artery, in order to compare our results with those of the literature. We also want to provide practitioners with anatomical bases for the dissection and exploitation of this clavicular branch in the perforating flaps of the shoulder region.

Materials and methods

Prior to our work, all the institutional procedures concerning cadaverous dissection were respected, as well as the ethical framework. Dissection was performed in 24 anatomical regions from 12 non-formalin fixed cadavers. The mean age was 69 years (range 47–88); there were 9 males and 3 females. The cadavers had no history of surgery or deformity in the areas targeted for dissection (supraclavicular, pectoral and deltoid regions). They were embalmed using a glycerin-rich, formalin-free solution to preserve tissue suppleness. The solution used for embalming corpses was called "BIOMET". It is the solution usually used in the anatomy laboratory of the University of Lille (France) for the conservation of cadavers before dissection. The composition for obtaining 13.7 liters of BIOMET is as follows: 4.75 liters of methanol + 4.75 liters of distilled water + 3 liters of glycerin +1.2 liters of phenol.

For the first phase, the cadaver was placed in dorsal decubitus and the posterior triangle was approached to remove the clavicle. The subclavian artery and its collateral arteries were dissected, identified and marked. The dissection was extended to expose the origin of the TAA on the anterior side of the initial portion of the axillary artery. The TAA was injected with a mixture of gelatin, methylene blue and iron powder. The cadaver was then refrozen for 24hours.

In the second phase, the cadaver was thawed out at room temperature and then placed in dorsal decubitus to dissect the integuments. For this dissection, a superficial incision was made on the lateral, caudal and cranial margins of the cutaneous perforasome, making sure not to breach the muscle layer. Next, the superficial plane was separated from the muscle layer from the periphery to the center of each perforasome. This dissection was performed meticulously so as to prevent damaging the satellite veins accompanying each perforating artery. During this procedure, the perforators were dissected and inventoried based on their location, dimensions, orientation, frequency and size of the cutaneous perforasome. Dissection of the largest perforators was then continued through the muscle while preserving the integrity of the pectoralis major muscle. The superficial layer (perforator flap) was then harvested completely with its pedicle (Figure 3).

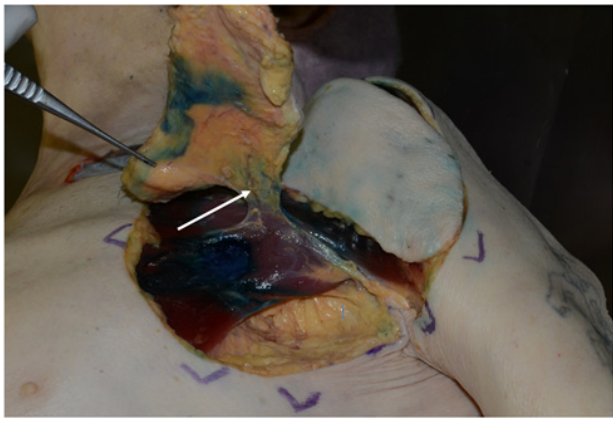

Figure 3 Dissection of the clavicular and pectoral branches of the left thoracoacromial artery (white arrow).

Results

The objective of this work was to bring out the configuration and dimensions of the clavicular branch of the thoracoacromial artery. The average diameter of the TAA was 2.0mm. An average of 3 terminal branches were found on the thoracoacromial artery. The deltoid branch was present in all subjects, the average length of its pedicle was 7cm, the average diameter of the deltoid perforators was 0.92mm. The pectoral branch was also present in all subjects, the average pedicle length was 7.83cm, and the average perforator diameter was 0.92mm. The acromial branch was absent in 13 subjects out of 24, when it was present the average length of its pedicle was 4.5cm. The clavicular branch was absent in 9 subjects out of 24, when it was present the average length of its pedicle was 4.5cm. No significant differences by sex were noted concerning configuration or size.

Dimensions and course of the clavicular branch: the clavicular branch was absent in less than half of dissections. The length of its extrafascial pedicle varied between 0.5 and 2.5cm. The length of the pedicle after transmuscular dissection varied between 3 and 6cm. And the general direction of this clavicular branch was ascending and medial (Figure 4). More detailed findings are given in Table 1.

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Table 1 Summary of the findings in the 24 dissected specimens clavicular branch

Specimen number by order of dissection	Age	Sex	Diameter of the thoracoacromial artery (mm)	Number of terminal branches of the thoracoacromial artery	Clavicular branch of the thoraco-acromial artery	
					Length of extrafascial pedicle (cm)	Length of pedicle after transmuscular dissection (cm)
1	72	H	2	2	Absent	
2	72	H	2	2	Absent	
3	58	H	2	4	2.5	6
4	58	H	1.5	3	2	5
5	63	H	2	3	2.5	6
6	63	H	2.5	2	Absent	
7	88	H	1	4	1	4
8	88	H	1	4	1.5	3
9	67	H	2	2	Absent	
10	67	H	2	2	Absent	
11	64	H	2	4	1.5	4
12	64	H	1.5	4	1.5	4
13	75	H	1.5	3	Absent	
14	75	H	1.5	3	0.5	5
15	87	F	2	3	Absent	
16	87	F	2	3	1	4
17	82	H	2.5	4	2.5	5
18	82	H	2.5	4	1.5	6
19	69	F	2.5	3	Absent	
20	69	F	2	2	Absent	
21	57	H	3	4	1	3
22	57	H	3	3	2	5
23	47	H	1.5	3	1	5
24	47	H	2	3	0.5	3

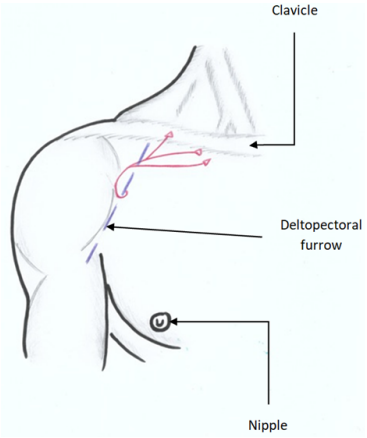

Figure 4 Projection of the origin and path of the clavicular branch (in red) of the thoracoacromial artery.

Discussion

The musculocutaneous flap of the pectoralis major muscle has been performed in numerous series of patients. However, recent studies show that homologous perforators in the same region can be used for the same indications.[7–9] The perforator flap of the thoracoacromial artery and its vascular anatomical bases have been recently studied, concerning the pectoral and deltoid branches. The clavicular branch has only been rarely studied in this indication. Hallock[10] independently described 2 patients who underwent a perforator flap of the thoracoacromial artery, for head and neck reconstructions. Recently, Okada et al.[2] reported a propeller flap based on the perforators of the thoracoacromial artery to cover a loss of substance in the neck. The perforator flap based on the branches of the thoracoacromial artery is thin and flexible and can easily adapt to the contour and mobility of the neck and maxillofacial structures. And the donor site can be sutured directly in almost all cases.[11–13] The perforator flap based on the branches of the thoracoacromial artery therefore has the advantage

of this direct suturing of the donor site during the lifting of small and medium-sized flaps. In the same way as in the supraclavicular perforator flaps and the internal thoracic perforator flaps, the perforator flap of the thoracoacromial artery allows a better correspondence with head and neck structures in terms of coloring and skin texture. This is not always the case with the pectoralis major muscle flap, which also has other drawbacks: bulging effect, functional sacrifice of the donor site, functional impotence, difficult closure of the donor site.[7–9] The absence of hair in the lateral region of the trunk makes the use of the thoracoacromial perforator flap very interesting in covering intraoral defects, compared to other flaps in the region. In addition, the thoracoacromial perforator flap offers more technical flexibility, and it is less time consuming, due to the configuration of its different pedicles, and the absence of micro-vascular anastomoses. This makes it an ideal perforator flap for patients with co-morbidities or in the elderly.

In practice, when a thoracoacromial perforator flap is performed, it is still possible to use the internal thoracic perforating flaps or the pectoralis major muscle flap as backup flaps. Despite the fact that the pectoralis major muscle flap remains a workhorse in terms of reconstruction, some authors consider it now as a backup flap,[7–9] because significant advances have been made in the field of microsurgery. The pectoralis major muscle flap is used more and more mainly in reconstructions of the chest wall and the arm. In contrast, there are not many reports on the clinical use of the thoracoacromial perforator flap. And yet a free flap can represent an interesting option for covering large losses of substances, and the thoracoacromial trunk can be used as a recipient vessel. Despite notable progress in microsurgery, free flap surgery has negative consequences on operating time. And if the free flap fails, reconstruction options are limited. However, with the failure of the thoracoacromial perforating flap, the possibility of pediculated or free flaps is still possible.

The thoracoacromial artery is traditionally described with 4 terminal branches, however the deltoid and pectoral branches are the most voluminous, with a clavicular branch of variable origin, and an acromial branch which most often arises from the deltoid branch.[3–6,10] This assertion of Hallock[10] is verified in our work. Our dissection work carried out on 12 corpses shows the existence of an inconstant clavicular branch of the thoracoacromial artery in most of the subjects studied. It appears that this clavicular branch, when it is present, goes cranially and medially towards the sternoclavicular joint and the subclavian muscle. Our work also shows that this clavicular branch of the thoracoacromial artery has an extrafascial pedicle measuring 0.5 to 2.5cm, and a 3 to 6cm transmuscular pedicle. Its vascular skin territory projects slightly below the clavicle. More detailed works should be performed to determine the average surface area of the perforasome. Zhang et al.[11] have also worked on a series of 12 corpses. They illustrated the potential clinical applications of the thoracoacromial perforator flap, emphasizing the pectoral branch which pierces the fascia in the space separating the clavicular and sterno-costal heads from the pectoralis major muscle. They found significant anatomical variations in the number of perforators dissected. In contrast to the result of Zhang, Geddes et al.[14] studied the perforators of the anterior wall of the thorax. Firstly, they found the inconsistent nature of the pectoral branch of the thoracoacromial artery, and of its small musculocutaneous perforators on the infero-lateral and intermediate regions of the pectoralis major muscle. Secondly, they demonstrated the feasibility of flaps supplied by the musculo-cutaneous perforators of the clavicular and deltoid branches of the thoracoacromial artery. The data of Geddes[14] also go against our results, and what is admitted in the literature concerning the thoracoacromial artery branches: it has 2 constant branches (deltoid and pectoral) and 2 inconstant branches (clavicular and acromial). Zhang[11] has not reported any experience with the use of a flap based on the other branches of the thoracoacromial artery (except the pectoral branch) and specially on the clavicular branch. However, he explains that the small size of the respective pedicles would limit the indication of such flaps in clinical practice. Our results show, however, that the clavicular branch of the thoracoacromial artery can be dissected over a length of 6 cm, and that using the pedicle mobility; it is possible to reach cervical regions.

In the study of Hamel et al.[15] the thoracoacromial artery was constantly a branch of the first portion of the axillary artery. Its origin was localized on the cranio-medial edge of the pectoralis minor muscle. After a short path, the thoracoacromial artery was divided into 2 branches: a medial thoracic branch and a lateral acromial branch. The acromial branch was directed up and out, passing over the coracoid process. This acromial branch did not give a branch on the anterior side of the coracoid process, but it gave a branch at the level of the coracoid insertion of the coracoacromial ligament. This collateral branch of the acromial branch of the thoraco-acromial artery passed under the coraco-acromial ligament and supplied the horizontal portion of the coracoid process. In our work we found like Hamel[15] an origin of the thoracoacromial artery frequently hidden behind the cranial edge of the pectoralis minor muscle. The precise origin of the thoracoacromial artery, however, is a point to be clarified for other authors. According to Loukas et al.[16] the thoracoacromial artery arises from the second portion of the axillary artery. However, DeGaris et al.[17] noted that in most of their dissections the thoracoacromial artery arises from the first portion of the axillary artery. Our dissections have shown that it can invariably arise from the middle third or the lateral third of the clavicle. In the study carried out by Huelke[18] the thoracoacromial artery was a branch of the second portion of the axillary artery in 2/3 of the cases, and it arose medially to the tendon of the pectoralis muscle in 1/3 cases. The thoracoacromial artery usually arise opposite to the medial edge of the pectoralis minor muscle, rather than directly behind the muscle or opposite its lateral edge. Other origins are rare. In one case the thoracoacromial artery even originated from the brachial artery. These findings concerning the origin of the thoracoacromial artery do not agree with the results of DeGaris et al.,[17] Indeed, DeGaris et al.[17] report that the thoracoacromial artery arises more frequently from the first (86%) and the second portions (12%) of the axillary artery. The division of the axillary artery into 3 portions is borrowed from Huelke[18] The 1st portion is located medially to the medial edge of the pectoralis minor muscle, the 2nd portion is located behind the muscle and the 3rd portion located laterally to the lateral edge of this same muscle.

There are new reports regarding the clinical benefit concerning the use of the thoracoacromial perforator flap to cover losses substances around the cephalic, cervical and axillary regions. It appears undeniable that the internal thoracic perforator flap, whose technique has improved over time, is very popular in covering losses of substances from the head and neck, compared to the thoracoacromial perforator flap. Despite the fact that the dissection of the internal thoracic flap sometimes requires removal of the first costal cartilage (with leading to a chest deformation), the primary closure of the donor site, the possibility of pre-expansion, and the absence of asymmetry in the final position of the nipple makes this flap an excellent choice. Not only the perforator flap of the different

branches of the thoraco-acromial artery do not have such benefits, but in addition the dissection of branches of the thoracoacromial artery (and in particular the clavicular branch) can be laborious and time consuming. Furthermore, due to the location of the clavicular branch of the thoracoacromial artery between the lateral 1/3 and the middle 1/3 of the anterior wall of the chest, possible skin expansion will only be performed in a limited area.

The thoracoacromial perforator flap has only been used in rare clinical cases, such as head, neck and axillary regions reconstructions, due to the variability in the vascular anatomy.[3–6] However, Zhang et al.[11] recently discussed the case reported by Kosutic et al.,[19] who described an axillary contracture, reconstructed using a free flap based on pectoral perforators. Despite the fact that major perforators are supplied by the pectoral and deltoid branches, some authors have reported the use of the clavicular branch of the thoracoacromial artery. The case reported by Yildiz[1] is the perfect illustration of a case of sternal reconstruction using a pedicled flap on the clavicular branch of the thoracoacromial artery.

Conclusion

Our dissection work carried out on 12 corpses shows the existence of a clavicular branch of the thoracoacromial artery in most of the subjects studied. It appears that this clavicular branch, when it is present, goes cranially and medially towards the sternoclavicular joint and the subclavian muscle. Our work shows that the clavicular branch of the thoracoacromial artery has an extrafascial pedicle which measures 0.5 to 2.5cm, and a transmuscular pedicle measuring 3 to 6cm. We also discovered that its vascular skin territory projects slightly below the clavicle.

Acknowledgments

None.

Conflicts of interest

The authors declare there are no conflicts of interest.

Funding

None.

References

1. Yildiz K, Baygol EG, Ergun SS, et al. Thoracoacromial artery perforator flap based on the clavicular branch: A new option in regional reconstruction. *Surgical Practice*. 2014;18(1):42–45.
2. Okada M, Ikeda M, Uemura T, et al. A propeller flap based on the thoracoacromial artery for reconstruction of a skin defect in the cervical region: a case report. *J Plast Reconstr Aesthet Surg*. 2013;66(5):720–722.
3. Salmon M, Grégoire R. *Skin arteries*. Paris: Masson; 1936:123–131.
4. Salmon M, Dor J. *The arteries of the limb and trunk muscles*. Paris: Masson; 1933.
5. Moore KL, Dalley AF, Agur AM. *Clinically Oriented Anatomy*. 7th ed. 2014.
6. Saladin KS, Mcfarland RK. *Human anatomy*. New York: McGraw-Hill; 2008.
7. Ariyan S. The pectoralis major myocutaneous flap. A versatile flap for reconstruction in the head and neck. *Plast Reconstr Surg*. 1979;63(1):73–81.
8. Ariyan S. Further experiences with the pectoralis major myocutaneous flap for the immediate repair of defects from excisions of head and neck cancers. *Plast Reconstr Surg*. 1979;64(5):605–612.
9. McLean JN, Carlson GW, Losken A. The pectoralis major myocutaneous flap revisited: a reliable technique for head and neck reconstruction. *Ann Plast Surg*. 2010;64(5):570–573.
10. Hallock GG. The island thoracoacromial artery muscle perforator flap. *Ann plast surg*. 2011;66(2):168–171.
11. Zhang YX, Yongjie H, Messmer C, et al. Thoracoacromial artery perforator flap: anatomical basis and clinical applications. *Plast Reconstr Surg*. 2013;131(5):759e–770e.
12. Song D, Pafitanis G, Pont LEP, et al. Chimeric thoracoacromial artery perforator flap for one-staged reconstruction of complex pharyngoesophageal defects: A single unit experience. *Head neck*. 2018;40(2):302–311.
13. Rout DK, Nayak BB, Choudhury AK, et al. Reconstruction of high voltage electric burn wound with exposed shoulder joint by thoracoacromial artery perforator propeller flap. *Indian J Plast Surg*. 2014;47(2):256–258.
14. Geddes CR, Tang M, Yang D et al. An assessment of the anatomical basis of the thoracoacromial artery perforator flap. *Can J Plast Surg*. 2003;11(1):23–27.
15. Hamel A, Hamel O, Ploteau S, et al. The arterial supply of the coracoid process. *Surg Radiol Anat*. 2012;34(7):599–607.
16. Loukas M, Louis RG, Almond J, et al. A case of an anomalous radial artery arising from the thoracoacromial trunk. *Surg Radiol Anat*. 2005;27(5):463–466.
17. De Garis CF, Swartley WB. The axillary artery in white and Negro stocks. *Developmental Dynamics*. 1928;41(2):353–397.
18. Huelke DF. Variation in the origins of the branches of the axillary artery. *The Anatomical Record*. 1959;135(1):33–41.
19. Kosutic D, Krajnc I, Pejkovic B, et al. Thoraco-acromial artery perforator 'propeller' flap. *Journal of Plastic, Reconstructive & Aesthetic Surgery*. 2010;63(5):e491–e493.