MULTIDETECTOR-ROW COMPUTED TOMOGRAPHY ANALYSIS OF THE ANATOMICAL CHARACTERISTICS OF THORACOACROMIAL ARTERY PERFORATOR

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SUMMARY

Objectives: *To analyze the anatomical characteristics of thoracoacromial artery perforators by using multidetector-row computed tomography (MDCT).* ***Subjects and methods:*** *The study was performed in 11 cases. For all cases, the origin of perforator vessel, the direction and the course also were determined. The concern of origin of perforator with local anatomical landmarks (acromion, clavicle) was described. Length of perforator, diameter of perforators at their origin, diameter of perforators at the point where the perforator pierces the fascia into overlying skin were also measured.* ***Results:*** *The perforator vessels were divided into deltoid branch of thoracoacromial axis (66.7%), acromial branch (23.8%) or pectoral branch (9.5%). As a result, the perforators ran to the humeral region in subdermal tissue in direction. The length from the origin of perforator artery to acromion was 66.53 ± 11.57 mm to acromion (69.30 ± 9.31 mm on the right side and 63.49 ± 13.48 mm on the left) and was 54.72 ± 17.57 mm to clavicle (64.37 ± 11.11 mm on the right side and 44.11 ± 17.59 mm on the left). The mean diameter of perforator vessel at its origin was 1.63 ± 0.26 mm and that of the perforator piercing the fascia into overlying skin was 1.22 ± 0.23 mm. Our study also identified the mean length of artery pedicled perforator was 49.06 ± 17.86 mm (50.60 ± 22.22 mm on the right, 47.37 ± 12.42 mm on the left).* ***Conclusion:*** *Multidetector-row computed tomography is the powerful procedure to determine the anatomical features of perforator vessels. This is the first time in literature, we have also applied successfully this technique to analyze the characteristics of thoracoacromial artery perforators.*

** Keywords: Thoracoacromial artery; Perforator; Multidetector computed tomography.*

INTRODUCTION

The thoracoacromial artery arises below the junction of the middle and lateral thirds of the clavicle as a large-caliber vessel from the forepart of the axillary artery, with its origin being generally overlapped by the upper edge of the pectoralis minor. It gives rise to two large constant branches, the deltoid and pectoral branches, and two further branches with highly variable anatomy, of which the clavicular branch sometimes arises from the main thoracoacromial trunk itself and the acromial branch originates in almost all cases from the deltoid branch. These branches are probably the most commonly used perforator flaps for reconstruction [1].

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A number of perforator-based flaps have been described in the previous articles. Although there have been in-depth studies on this issue, there are no reports on the anatomical study for the effective and safe flap design [2]. To the best of my knowledge, research on the use of MDCT in identifying the anatomical characteristics of thoracoacromial artery perforators. Consequently, we conducted this study: *To analyze the anatomical characteristics of perforators of thoracoacromial artery by using MDCT.*

SUBJECTS AND METHODS

1. Subjects

A total of 21 thoracoacromial artery perforators from 11 patients that were stored in the Department of Radiology, Hoa Hao Medical Centre, Ho Chi Minh city, Viet Nam between April, 2019 and July, 2020 underwent the anatomy by using the MDCT. These 11 cases were randomly selected for the purpose of examining the chest wall. Patients with acquired anatomical anomalies of the thoracoacromial artery and its branches and those who suffered from trauma and/or chest wall ulcers were excluded in this study.

2. Methods

The CT examination was performed by using a 320-slice MDCT scanner (Aquilion 320, Toshiba, Japan) and Ultravist 300 as the contrast material. The patients were instructed to hold their breath during the CT-scan, which was performed with a rotation speed of 0.5 s/rot, a detector coverage of 100 mm. This acquisition protocol allowed for a table speed of 5 mm/s and a scan time of about 10s for CT angiography, axial images of 0.625mm thickness. The CT angiographic images were reconstructed by using the maximum intensity projection (MIP) technique of Vitrea software.

The anatomical characteristics of perforator arteries consisted of the origin of perforator, its origin with local anatomical landmarks, the direction of perforator artery, the length and diameter of perforator vessel.

RESULTS

1. General characteristics of the patients

There was a total of 11 patients including 21 perforator arteries with 11 arteries on the right and 10 on the left. The average age of the patients was 57.1 years (ranging 25 - 77 years).

2. The anatomical characteristics of perforators of thoracoacromial artery

** The origin of perforator artery:*

Table 1: The origin of perforator artery.

Branches of thoracoacromial artery	Acromial branch	Deltoid branch	Pectoral branch	Clavicular branch
Right	0	10	1	0
Left	5	4	1	0
Total (n, %)	5 (23.8)	14 (66.7)	2 (9.5)	0

The perforator originating from the deltoid branch was seen in most patients (66.7%).

** The direction of perforator vessel:*

On MDCT images, the perforator ran to the humeral region in subdermal tissue in most cases.

3. The association between the origin of perforator with local anatomical landmarks

In our study, we identified the distance from the origin of perforators to acromion and clavicle - the important landmarks which is usually used in clinical practice.

Table 2: The distance from origin to acromion (mm)

Distance (mm)	Maximum	Minimum	Average	p
Right (n = 11)	81.0	51.9	69.30 ± 9.31	0.2949
Left (n = 10)	79.5	39.6	63.49 ± 13.48	
Total (n = 21)	81.0	39.6	66.53 ± 11.57	

This distance was measured from the origin of thoracoacromial artery perforator to the tip of acromion, which was 66.53 ± 11.57 mm (69.30 ± 9.31 mm on the right side and 63.49 ± 13.48 mm on the left). This length did not depend on the the source of perforator artery.

Table 3: The distance from the origin to clavicle.

Distance (mm)	Maximum	Minimum	Average	p
Right (n = 11)	82.2	47.8	64.37 ± 11.11	0.0048
Left (n = 10)	73.9	20.2	44.11 ± 17.59	
Total (n = 21)	82.2	20.2	54.72 ± 17.57	

The distance from the origin to clavicle was 54.72 ± 17.57 mm (64.37 ± 11.11 mm on the side and 44.11 ± 17.59 mm on the left).

** The length of perforators:*

Table 4: The length of perforator

Length (mm)	Maximum	Minimum	Average	p
Right (n = 11)	104.0	25.2	50.60 ± 22.22	0.6899
Left (n = 10)	66.7	25.6	47.37 ± 12.42	
Total (n = 21)	104	25.2	49.06 ± 17.86	

The length was identified by measuring the distance between the origin of perforator and the point where the perforator pierces the fascia into the skin. Mean length was 49.06 ± 17.86 mm (50.60 ± 22.22 mm on the right and 47.37 ± 12.42 mm on the left).

** The diameter of perforators:*

Table 5: Diameter of perforators at their origin

Diameter (mm)	Maximum	Minimum	Average	p
Right (n = 11)	2	1.2	1.58 ± 0.22	0.3369
Left (n = 10)	2.1	1.1	1.69 ± 0.29	
Total (n = 21)	2.1	1.1	1.63 ± 0.26	

Table 6: Diameter of perforators at the point where the perforator pierces the fascia into overlying skin.

Diameter (mm)	Maximum	Minimum	Average	p
Right (n = 11)	1.8	1.0	1.24 ± 0.22	0.7730
Left (n = 10)	1.8	1.0	1.21 ± 0.25	
Total (n = 21)	1.8	1.0	1.22 ± 0.23	

DISCUSSION

1. Anatomy of branches of thoracoacromial artery

The thoracoacromial artery arises below the junction of the middle and lateral thirds of the clavicle as a large-caliber vessel from the forepart of the axillary artery, with its origin being generally overlapped by the upper edge of the pectoralis minor. It gives rise to two large constant branches, the deltoid and pectoral branches, and two further branches with highly variable anatomy, of which the clavicular branch sometimes arises from the main thoracoacromial trunk itself and the acromial branch originates in almost all cases from the deltoid branch [1].

** The pectoral branch:*

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. 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 go towards the 4th intercostal space and anastomose with the anterior intercostal arteries and the perforators of the internal mammary artery [3].

** The deltoid branch:*

The deltoid branch crosses the upper part of the deltopectoral groove and is generally divided into two branches, one deep and the other superficial. 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. 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 12 cm [3]. Geddes et al identified the dominant perforator from the deltoid branch with an average length of 7.9 ± 2.0 cm [4].

** The acromial branch:*

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 3 cm, 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.

** The clavicular branch:*

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. Nyemb PMM et al [5] researched in 24 thoracoacromial arteries showed that the clavicular branch was absent in more than half of the dissections. The length of its extrafascial pedicle varied between 0.5 and 2.5 cm. The length of the pedicle after transmuscular dissection varied between 3 and 6 cm. The general direction of this clavicular branch was ascending and medial. Geddes et al [4] measured the average pedicle length of the clavicular perforators being 6.0 ± 2.1 cm.

2. Clinical application

In clinical application, the pectoralis major and the deltopectoral have been two workhorse flaps in reconstruction based on the pectoral artery [1]. Although, both flaps have demonstrated several advantages, they have shown several shortcomings. Geddes CR et al in 2003 [4] had found the perforators through the pectoralis muscle to the overlying skin separated from perforators of the thoracoacromial axis; perforators of the medial intercostal vessels; and perforators of the lateral thoracic artery. However, author believed that the pectoral branch of the thoracoacromial artery was not a good donor site for pedicled perforator flaps. However, musculocutaneous perforator flaps are possible from the clavicular and deltoid branches of the thoracoacromial artery.

In a study by Portenard AC et al [6], the mean distances from the origin of the perforator artery on the abTAA were 14.25 cm to the sternum, 3.45 cm to the acromion, 5.65 cm to the clavicle. The mean diameter of the abTAA was 1.20 ± 0.2 mm and the length of the perforator pedicle could be extended to 7.46 cm ± 1.15 mm. Authors also suggest that the acromial branch of the TAA perforator is constant and provides a reliable blood supply to a cutaneous flap.

3. Role of multidetector-row computed tomographic angiography in the study of the perforator flap

The introduction of perforator flaps into the surgical practice over the last decades has expanded the reach of plastic surgery. The use of these flaps greatly simplifies the reconstruction procedures and decreases the number of surgical stages and minimizes the amount of trauma at the site of the flap harvesting. In addition, the utilization of the perforator flaps shortens the duration of operations and allows for the maintenance of the intactness of the great vessels at both the donor and the recipient sites. However, surgery challenges remain, as the perforator vessels are highly variable in number, localization type, hemodynamic specifications, and their anatomical interactions with other structures. For these reasons, the identification of the best perforator before the procedure is very important for the choice of the main feed vessel and the design of the perforator flap [7].

In recent years, the flap design techniques have begun to incorporate the preoperative evaluation, localization, and calibration of the perforator. Such approach enables the best perforator to be selected before the dissection has begun. Therefore, the diagnostic value of the ultrasound and radiological methods for the preoperative flap evaluations has been widely discussed in the plastic surgery community lately [7].

In the last 15 years, the development of MDCT has radically changed the way the computed tomography angiography is used for the study of the vascular pathology. Interestingly, over the years, MDCT proved to be not only a very useful tool for the study of aorta and peripheral arteries but also a very promising noninvasive method for the localization, visualization, and characterization of the coronary artery stenosis. Moreover, MDCT allows for the investigation of the coronary vessels, the lumen diameter, and the occlusion site. Consequently, the idea of studying the perforator vessels by MDCT has emerged as a natural extension of its current applications and as a reliable method for the precise localization of the vessels most suitable for the flap formation.

Indeed, since 2003, MDCT has been proving itself as a highly reliable technique for the preoperative planning of Deep Inferior Epigastric Perforator (DIEP) flap for breast reconstruction. Notably, this application of MDCT has been shown to yield great results, including the significant decrease in the duration of the surgery and the amount of the postsurgical complications. Consequently, over the past few years, a number of reports have mentioned the possibility of employing MDCT for the planning of various flap types, and/or the identification of perforators

in various body parts, even including those that are smaller in diameter than the perforators in the front abdominal wall. Herein, we share our experience of using MDCT with 3-dimensional (3D) visualization in the planning of the local perforator flaps in various body parts and demonstrate the effectiveness and precision of this method.

4. Anatomical characteristics of thoracoacromial artery perforators on MDCT

Identifying the anatomical features of the perforator vessels of flap is important before taking surgical procedures. For perforator skin flap based on thoracoacromial artery, the numerous reseaches have showed the characteristics of perforator vessels reported in literature. Although these studies just restrictedly provided information in basic features, other features have not showed. Nowadays, MDCT technique is a new powerful procedure to provide the hidden information applied in clinical practice. As far as we know, there have been no reports on the use of MDCT in identifying the anatomical characteristics of thoracoacromial artery perforators. Because there were no previous studies to compare, we have just introduced again the features of this perforator vessel.

The origin of perforator vessel: Our data showed that the perforator vessels were divided into deltoid branch of thoracoacromial axis (66.7%), acromial branch (23.8%) or pectoral branch (9.5%). As a result, the perforators ran to the humeral region in subdermal tissue in direction.

The original point of perforator was 66.53 ± 11.57 mm to acromion (69.30 ± 9.31 mm on the right side and 63.49 ± 13.48 mm on the left), and 54.72 ± 17.57 mm to clavicle (64.37 ± 11.11 mm on the right side and 44.11 ± 17.59 mm on the left). The mean diameter of perforator vessel at its origin was 1.63 ± 0.26 mm, and 1.22 ± 0.23 mm at the point where the perforator pierces the fascia into overlying skin. Our study also identified the mean length of perforator vessel being 49.06 ± 17.86 mm (50.60 ± 22.22 mm on the right and 47.37 ± 12.42 mm on the left).

CONCLUSION

Multidetector-row computed tomography is a powerful procedure to determine the anatomical features of perforator vessels. This is the first time in literature, we have also applied successfully this technique to analyze the characteristics of thoracoacromial artery perforators. This technique provided the significant information in clinical application.

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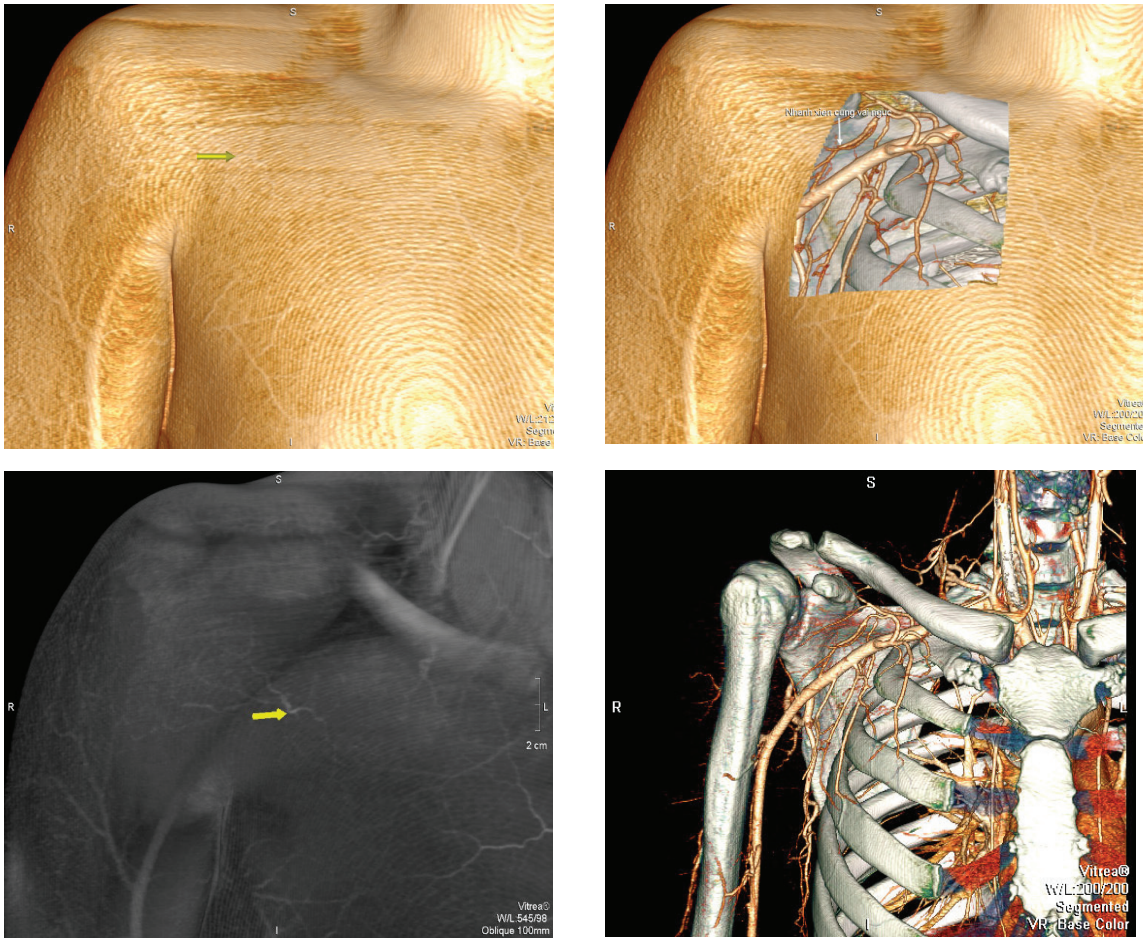
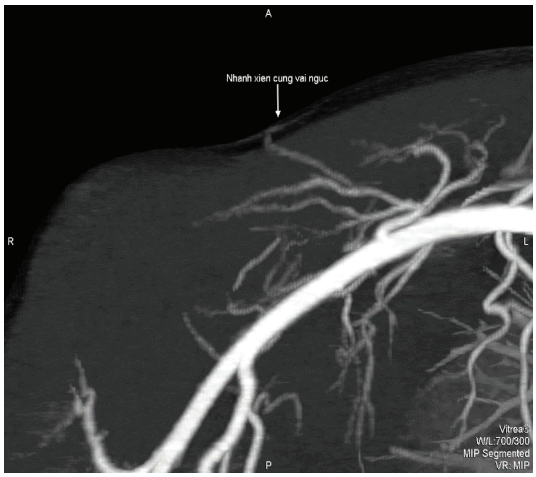
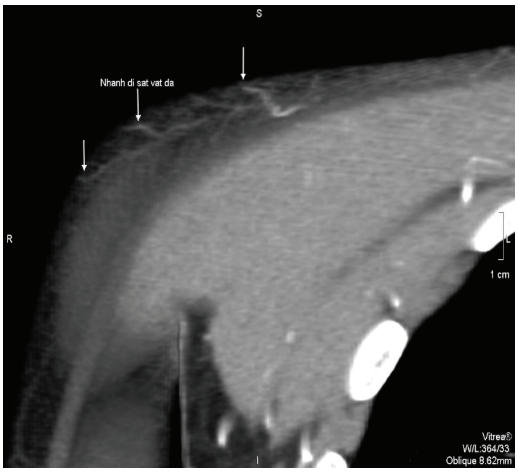
CASE REPORT

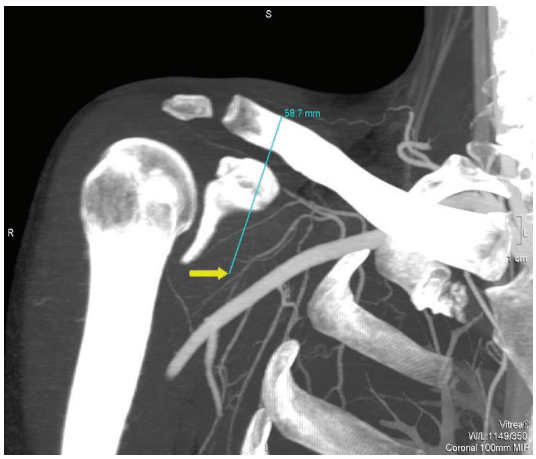


The perforator vessel of thoracoacromial artery.

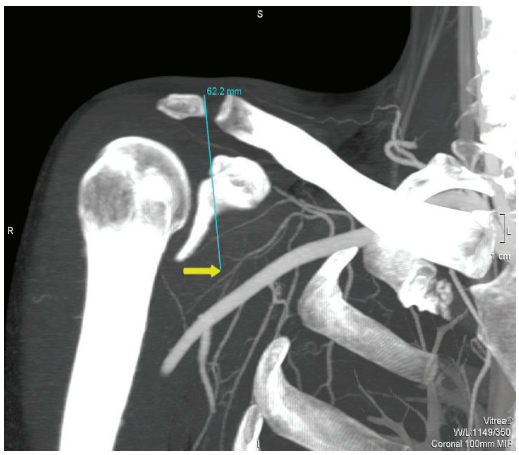




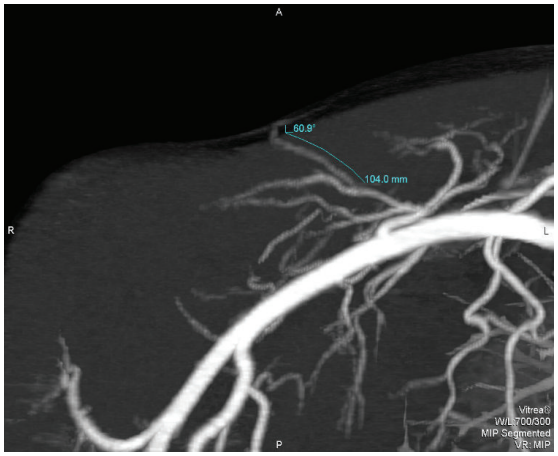
The source, direction and course of perforator vessel.



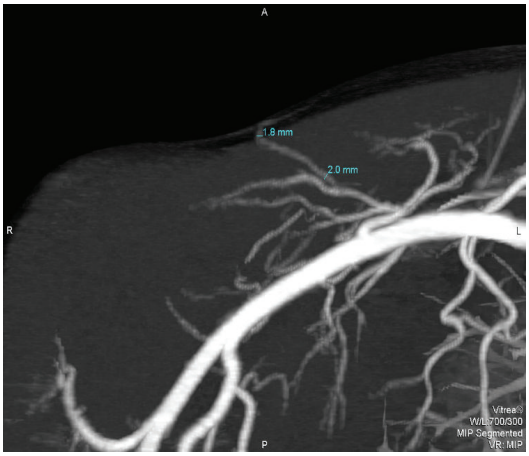
The distance from its origin to clavicle



The distance between its origin and acromion



The length of perforator.



Diameter of perforator.

Brand tree of perforator.