ANATOMIC STUDY OF LATERAL ARM FLAP WITH RETROGRADE FLOW

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ABSTRACT

Objective: To conduct an anatomic study of the middle collateral artery, analyzing its frequency, origin and possibility of use of lateral flap in extended arm with elongated pedicle in "Y-V" retrograde flow. Materials and Methods: thirteen arms of thirteen male cadavers were dissected, extracting humerus length, origin of middle collateral artery, length of middle collateral artery, from its origin up to the lateral triceps and the artery diameter. Results: The presence of middle collateral artery was observed in all limbs, and the average nlength of humerus was 31.89 cm. In 61.5% of cases, the middle collateral artery originated from the posterior radial collateral artery, while in 38.5% the origin was in the profunda brachii artery. The length of the middle collateral artery ranged from 3.2 to 6.8 cm (average of 4.97). The average diameter was 1.27mm. Conclusion: the middle collateral artery is constant, and in the majority of cases originates from the posterior radial collateral artery, making clinical application of the lateral arm flap extended with retrograde blood flow with elongated pedicle in "Y-V" viable.

Keywords: Wounds and injuries. Anatomy, regional. Arm.

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INTRODUCTION

The cutaneous coverage of extensive lesions of the forearm, from its middle third to the wrist, is still a challenge in reconstructive surgery.[1-4] The flexor and extensor tendons of the fingers and of the wrist, the median, ulnar and radial nerves, the radius and the ulna are vulnerable to lesions of greater energy, such as exposed fractures and extensive wounds. Coverage procedures through rotation of local flaps represent a solution that is often impracticable due to the lesions of the vessels that supply them. The microsurgical free flaps of the arm, the contralateral forearm, the back or the abdomen were described in an attempt to resolve this problem. These procedures require ample dissections in two different surgical fields and the sacrifice of important vessels. There is a need for vascular microanastomoses, with their technical difficulties and vulnerability.[1]

One option for the coverage of distal forearm and wrist lesions is the lateral arm flap, with the proximal pedicle elongated by the "Y-V" technique, described by Martin.[2] (Figure 1) The flap is described as capable of covering defects up to the hand, using the retrograde flow of a muscular branch of the profunda brachii artery, called middle collateral artery.[1,2]

OBJECTIVE

The aim of the study is to evaluate the frequency, origin, dimensions of the middle collateral artery and possibility of elongation of the lateral flap pedicle in extended arm by Martin's "Y-V" technique.[2]

MATERIALS AND METHODS

The study involved the evaluation of 13 arms of 13 patients from the Coroner's Service of the Capital City of Universidade of São Paulo (SVOC).

The study was conducted using a dissection authorization protocol from SVOC itself.

All the cadavers were fresh and of the male gender, with age ranging between 33 and 69 years.

All the authors declare that there is no potential conflict of interest referring to this article.

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Study conducted at the Institute of Orthopedics and Traumatology of Hospital das Clínicas of Universidade de São Paulo and in the Coroner's Service of the Capital City of Universidade de São Paulo (SVOC).
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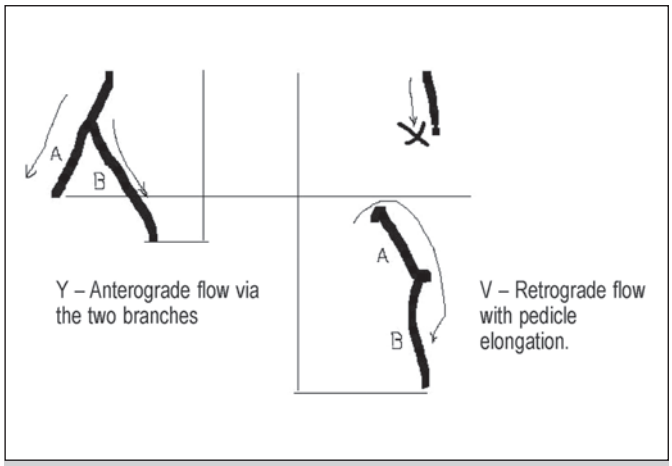

Figure 1 – *Diagram of pedicle elongation by the "Y-V" technique.*

The inclusion criteria were:

– arms of male cadavers

– absence of apparent lesion on the arm examined

The only exclusion criterion would be the presence of deep lesion on the arm.

The cadavers were dissected according to the following technique:

1. Positioning in dorsal decubitus, with cushion on the back of the operated side.
2. Lateral incision on the arm, from the insertion of the deltoid muscle to the lateral epicondyle of the elbow.
3. Dissection through to muscle plane.
4. Exposure of profunda brachii artery and its branches. (Figure 2)
5. Dissection of the middle collateral artery up to the anastomotic network of the elbow. (Figure 3)
6. Performance of measurements.
7. Elevation of lateral arm flap with extended pedicle, ligature and proximal section of the posterior radial collateral (or profunda brachii) artery and rotation up to the distal third of the forearm and wrist (Figures 4 and 5).

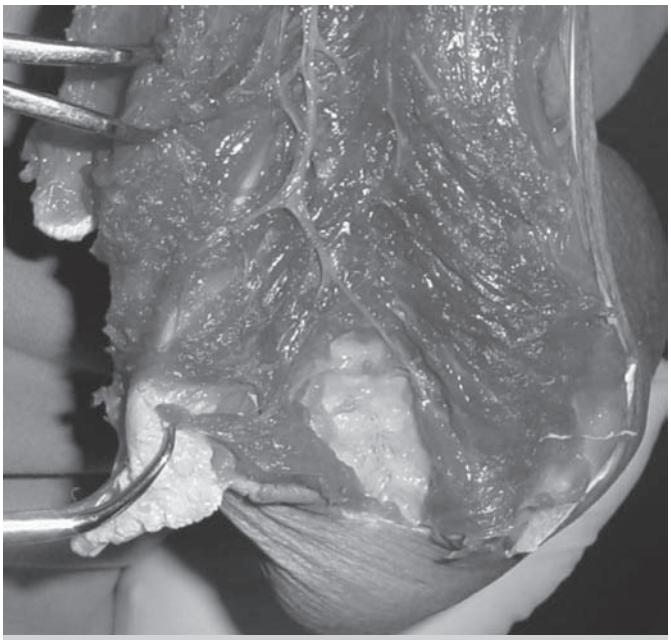

Figure 3 – *Terminal branches of the middle collateral artery in the olecranon fossa.*

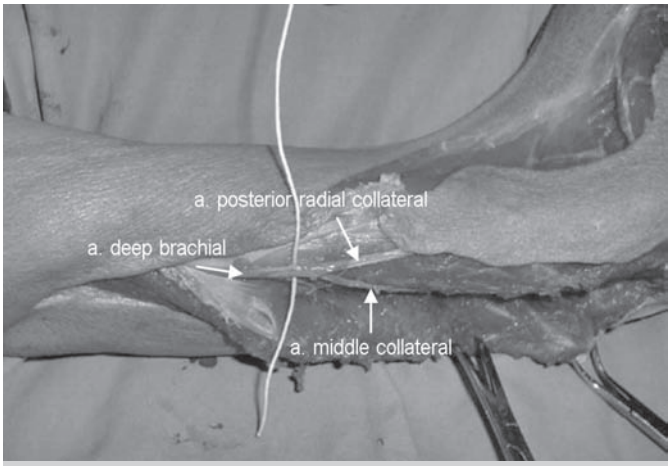

Figure 4 – *Section of the posterior radial collateral a. proximally to its origin of the middle collateral artery.*

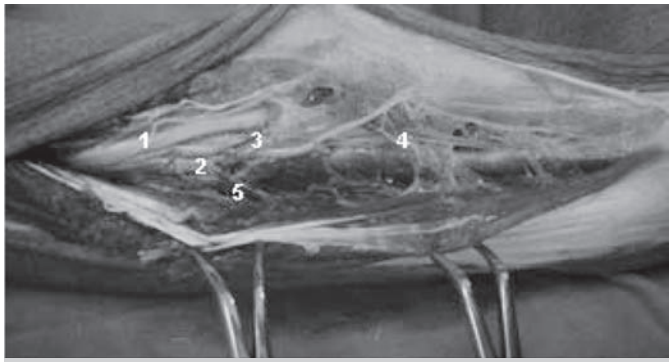

Figure 2 – *Exposure of profunda brachii artery ramifications.*
1 – radial nerve; 2 – profunda brachii a.; 3 – anterior radial collateral a.; 4 – posterior radial collateral a.; 5 – middle collateral a.

Figure 5 – *Possibility of flap rotation.*

8. Skin suture.

The measurements taken were:

1 – Apparent length of the humerus, from the acromion to the lateral epicondyle.

2 – Distance between the lateral epicondyle and the origin of the middle collateral artery.

3 – Length of the middle collateral artery up to its penetration in the lateral head of the triceps.

4 – Diameter of the middle collateral artery, at its origin.

The study also evaluated the possibility of elongation of the pedicle by the "Y-V" technique.

RESULTS

The mean age of the dissected cadavers was 52.9 (±12.5) years. (Table 1) All the cadavers were male.

The middle collateral artery was identified in all thirteen arms.

The average length of the humerus was 31.89 (±1.62) cm. (Table 1)

The average distance from the origins of the middle collateral artery of the lateral epicondyle can be observed in Table 2 and in Figures 6 and 7.

Two pedicle patterns were observed, classified according to the point of origin of the middle collateral artery: a distal group, at a distance of less than 15 cm from the lateral epicondyle, in 8 arms (61.5%) and another proximal, at a distance of more than 17 cm from the lateral epicondyle, in 5 arms (38.5%). In the distal group, the middle collateral arteries originated from the posterior radial collateral artery, while in the proximal group they originated from the deep brachial artery.

The length of the middle collateral arteries, from their origin to their penetration in the lateral head of the triceps, ranged from 3.2 cm to 6.8 cm and the mean value found was 4.97 (±1.96) cm. It was observed that the middle collateral artery was longer in the group with proximal origin, whose mean value was 5.68 (± 1.62) cm, as opposed to 4.53 (± 0.85) cm of the distal group.

Table 1 – *Age of the cadavers and apparent length of the humerus.*

Number	Age (years)	Length of humerus (cm)
1	33	32.2
2	33	32.4
3	54	30.6
4	61	31.8
5	51	33.1
6	67	28.5
7	59	33.2
8	43	31.5
9	69	29.3
10	64	33.4
11	39	32.8
12	52	31.7
13	63	34.1
Mean	**52.92**	**31.89**
SD	**12.50**	**1.62**

SD = standard deviation

Table 2 – *Anatomical characteristics of the medial collateral artery.*

Number	Distance from the lateral epicondyle (cm)	Origin	Diameter (mm)	Length of branch (cm)
1	11.3	DISTAL	1.2	3.2
2	11.5	DISTAL	1.3	4.4
3	19.8	PROXIMAL	0.9	4.8
4	12.2	DISTAL	1.3	3.9
5	17.8	PROXIMAL	1.4	6.6
6	20.3	PROXIMAL	1.2	3.8
7	10.1	DISTAL	0.8	5.9
8	13.3	DISTAL	1.6	4.2
9	9.8	DISTAL	1.1	4.8
10	19.5	PROXIMAL	1.5	6.4
11	14.2	DISTAL	1.4	5.4
12	13.6	DISTAL	1.1	4.4
13	20.9	PROXIMAL	1.7	6.8
Mean	**14.95**		**1.27**	**4.97**
SD	**4.13**		**0.26**	**1.16**

SD = standard deviation

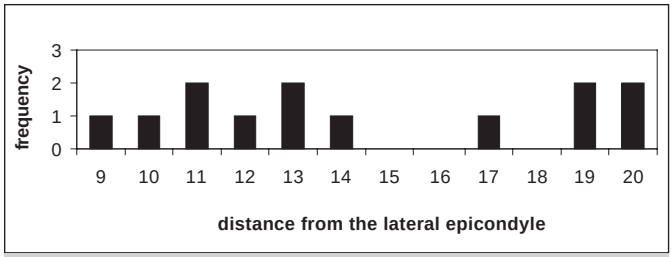

Figure 6 – *Distribution of the origin of middle collateral arteries*

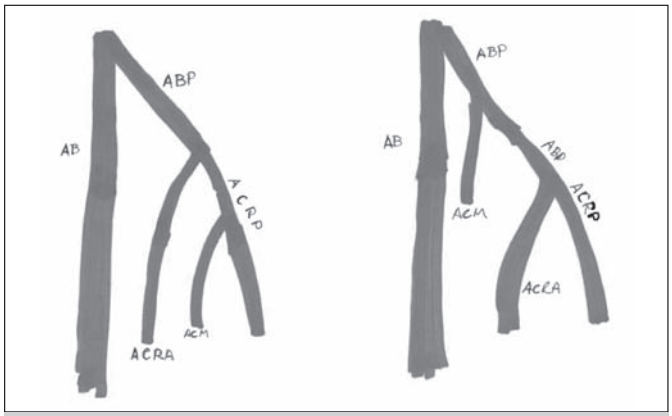

Figure 7 – *Two emergence patterns of the middle collateral a.: branch of the posterior radial collateral artery (LEFT) or right branch of the profunda brachii artery.*
BA – brachial a.; PBA – Profunda brachii artery a.; PRCA – posterior radial collateral a. (lateral flap of the arm); ARCA –anterior radial collateral a. (radial n.); MCA – middle collateral a. (allows reverse flow).

The average diameter of the middle collateral artery was 1.27 (±0.26) mm.

The lateral flap of the extended arm with elongated pedicle could be elevated, demonstrating the possibility of coverage of the distal forearm and wrist.

DISCUSSION

The cutaneous coverage of the forearm is still a challenge in reconstructive surgery. The procedures currently described, such as rotation of the Chinese and posterior interosseous flap, depend on the integrity of other vessels in the same region, or the integral palmar arch, a situation often not found in severe trauma of the wrist and distal forearm.[5] The transportation of tissue at a distance is capable of accomplishing cutaneous coverage, yet it requires the vascular microanastomosis technique, with the inconvenience of anastomosis vulnerability, the need for teams in different surgical fields and the sacrifice of regions of the body far from the lesion site.[1,6] The lateral arm flap, in its pedicular or retrograde form, has limitation of coverage for the proximal region of the forearm. The flap elevation technique on the lateral side of the elbow, a position that is more distal than usual, is not sufficient to cover a distal lesion.[6,7] The coverage of such a region is only possible in the free flap form.[1,8-10]

The elbow region presents an extensive anastomotic network, which allows the retrograde flow of flaps dissected in this region. This network enables the rotation of the reverse lateral arm flap, supplied by fascial vessels. The flap can advance in the elbow region, yet like the conventional lateral arm flap, it does not reach the distal region of the forearm.

Martin, studying the anastomotic network of the elbow, identified the middle collateral artery, originating from the posterior radial collateral artery or from the profunda brachii artery, which communicates with the vascular network that supplies the lateral flap in the arm.[2-4]

This intramuscular dissection strategy derives from a vessel individualization technique that became popular after the advent of flaps based on the perforating arteries. Vessels that were ignored in the past are now carefully dissected and studied. It was observed that a small vessel would be able to supply a flap of up to 30 cm by 11 cm.[7]

Although the existence of perforating vessels has been known by medicine since the 19th century,[11] it was the work of Taylor that disseminated the concept of the angiossome, a tissue unit supplied by a perforating vessel, and often endowed with peripheral vessels capable of contributing toward the nutrition of other units, making the limits of the flaps "virtual".[12,13] The perforating arteries were described as branches of deep arteries, generally septal, which cross the fascia and muscles to supply the skin. The discovery of the effectiveness of these vessels in skin supply paved the way for the development of more versatile, ample flaps of good quality, like the flaps based on the anterior-lateral thigh, thoracodorsal perforating and deep epigastric arteries.[6]

Martin applied the anatomical knowledge of the anastomotic network of the elbow with the intramuscular dissection technique derived from flaps based on the perforating arteries to the "Y-V" elongation of the vascular pedicle, guaranteeing sufficient length to cover the distal forearm and the wrist.

The flap is irrigated in a retrograde manner by the posterior radial collateral artery, a branch of the profunda brachii artery, as in the lateral arm flap.[5] The posterior radial collateral artery, dissected according to Martin's technique, receives the reverse flow of the middle collateral artery, which can be a branch of the posterior radial collateral artery or of the profunda brachii artery. An island-shaped flap is obtained with a long pedicle that is capable of covering areas up to the wrist.[2-4]

The elongation of the flap pedicle depends on the presence of the middle collateral artery. In penetrating the lateral head of the triceps, the artery communicates with the olecranon anastomotic network, which in turn, communicates with the ulnar recurrent artery, allowing the supply by retrograde flow.[1]

The actual nomenclature is under discussion, and the name middle collateral artery is the free translation of Casoli's work.[1] The vessel does not usually receive a name, but is known only as one of the muscle branches of the posterior radial collateral artery or of the profunda brachii artery.

This survey served as a contribution to the anatomical study prior to the clinical application of the lateral arm flap extended with retrograde flow from extended pedicle for the coverage of distal forearm lesions.

One arm was dissected on each cadaver at random. Due to the need for careful dissection, it was not possible to dissect both sides.

The average length of the humerus presented a minor variation in the specimens studied. The technique used for the measurement proved a practical method of clinical examination of the arm to be dissected.

The middle collateral artery was observed in all the specimens. It is a small-caliber vessel, averaging 1.27 mm in diameter. This caliber, however, is compatible with the nutrient arteries of other flaps based on the perforating arteries, capable of supplying large areas of skin.[11,13,14]

Two emergence patterns of the middle collateral artery were observed: proximal and distal. In the first group, the arteries originate more than 17 cm from the lateral epicondyle, penetrating just around 5.7 cm after this in the belly of the lateral head of the triceps. In the second group, the arteries originate between 9 cm and 15 cm from the lateral epicondyle, and cover a distance of around 4.5 cm until they also penetrate in the muscular mass. The patterns proved mutually excluding, as no cadaver with more than one middle collateral artery was observed.

The intramuscular dissection of the middle collateral artery up to the anastomotic network of the elbow was performed successfully on the thirteen cadavers, proving more arduous in those with proximal origin. The ligature of the posterior collateral artery was performed immediately proximal to the emergence point of the medial collateral artery and the pedicle could be elongated successfully, simulating the coverage of a distal lesion.

An inconvenience of proximal pedicle dissection is the need for medial incision for the localization of the origin of the middle collateral artery and the performance of its ligature. The presence of a venous plexus close to the origin of the middle collateral artery makes the dissection laborious and technically difficult.

CONCLUSION

The middle collateral artery is constant, and originates in most cases from the posterior radial collateral artery, making clinical evaluation of the lateral flap in extended arm with retrograde blood flow with pedicle elongated in "Y-V" viable.

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