Cross-sectional Study

The basic anatomy of the medial sural artery perforator flaps in Vietnamese adults

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ABSTRACT

Background: Both free medial sural artery perforator flaps and pedicled medial sural artery perforator flaps have been being effectively used in treatment of body defects especially in head and neck region by plastic surgeons worldwide. However, there is a lack of comprehensive studies on the anatomy of perforating artery branches in Vietnam. This study aims to describe anatomical vascular pedicles of medial sural artery perforator flap in Vietnamese adults.

Methods: A descriptive cross-sectional study, dissected 62 lower limbs of 41 Vietnamese adult cadavers preserved by formalin in Department of Anatomy, Hanoi Medical University and Ho Chi Minh Medicine and Pharmacy University.

Results: Origin of medial sural artery was branched constantly from popliteal artery. Common stem of artery was 8.39 ± 3.5 cm in mean length. The diameter of common stem, which was measured from origin, was 2.88 ± 0.98 mm averagely. The common stem of artery, which did not have any branch (15%), divided into 2 branches (15%), 3 branches (30%), 4 branches (40%) before entering muscle. Medial sural artery had 1 to 5 branches perforating to the skin. The distance from perforating branch to the knee joint (popliteal crease) was 10.12 ± 3.7 cm, the distance from perforator branch to middle posterior leg was 1.6 ± 0.96 cm.

Conclusions: The medial sural artery constantly originates from popliteal artery, supplies blood for medial gastrocnemius muscle. The skin area covering this muscle is nourished by one of five perforators of the medial sural artery. The perforating flaps can be created using medial sural artery perforating branches.

1. Introduction

In recent years, an increasing number of scholars have concerned about perforator flaps, the myocutaneous flaps known as pedicle flaps, pedicle free flaps or free flaps, which are nourished by musculocutaneous perforators or perforating arteries.

In 1989, the term “perforator flap” was first mentioned by Koshima and Soeda [1]. Until now, this term has been commonly used in academic documents worldwide. In order to establish a perforator flap, the name and position of the perforator that supplies blood to the flap has to be defined.

Normally, it is favorable to create perforator flaps from lower extremities. There are several types of perforator flaps, which have been widely studied and applied by plastic surgeons and anatomists, consist of descending genicular artery perforator flap, saphenous flap, medial sural artery perforator flap (MSAP flap) and lateral sural artery perforator flap (LSAP flap).

LSAP flap and MSAP flap are directly established from skin-gastrocnemius flap. Each head of gastrocnemius muscle is nourished by either an artery, which directly arises from one main vascular pedicle, or popliteal artery. Sural artery pierces deeply into the muscle through the muscular center and ends at the Achilles tendon. It gave off several sural artery-perforating branches to supply blood for the covering skin, including perforator flap.

In 2001, the anatomical characteristics of medial sural artery perforator flap was investigated for the first time in 10 cadavers by Cadavas and et al. [2]. In this year, Hallock et al. dissected 10 cadavers to explore medial skin-gastrocnemius perforators in the USA [3]. In 2004, a research which was conducted on 20 legs of 10 Caucasian cadavers to investigate musculocutaneous perforators by Thiome et al. was...
go on the public [4]. Following that, in 2007 there were several researches on perforating branches implemented including a research on 44 Asian cadavers of Okamoto (Japan) [5] and a research of Torres and Brazilian colleagues [6].

Kao and his colleagues in Taiwan evaluated the clinical application of free medial sural artery perforator flap on the treatment of defects of head and neck in 2010. This research expressed a positive result of this intervention. In 2011, Altarif in Saudi Arabia [7] implemented a research on 10 formalin cadavers using red latex and lead tetroxide pumped into the medial sural artery. In 2012, Wong and his colleagues [8] studied on the position of main artery perforator, which was reliable and stable enough for flap transposition in 10 fresh cadavers with red latex pumping. In this year, a study on 47 lower extremities of Asian formalin cadavers to investigate musculocutaneous perforating branches of medial sural artery was conducted by Otani and his colleagues in Japan [9].

These mentioned researches generally describes that sural artery constantly branches. The quantity of branches varies from 1 to 8 branches among which the medial sural artery gave off at least 2 branches on average. The length of the artery from popliteal crease to the position where it branches is between 5 and 19 cm. The length from gastrocnemius midline to branch starting point is from 0.3 to 7 cm. Additionally, most of the length of the pedicle of medial sural artery perforator flap is at least 7.7 cm.

Both free medial sural artery perforator flaps and pedicle medial sural artery perforator flaps have been being effectively used in treatment of body defects especially in head and neck region by plastic surgeons worldwide. However, there is a lack of comprehensive studies on the anatomy of artery perforating branches in Vietnam. Therefore, this research on anatomy of vascular pedicle of the medial sural artery perforator flap in Vietnamese adults was conducted.

2. Materials and methods

The study is fully compliant and in line with the STROCSS 2021 criteria [10].

2.1. Subjects

The study was implemented in 62 lower limbs of 41 Vietnamese adult cadavers preserved by formalin in the Department of Anatomy, Hanoi Medical University and Ho Chi Minh Medicine and Pharmacy University.

2.1.1. Inclusion

The study was carried out on Vietnamese adult cadavers who were over 18 years old without any damages lower leg area.

2.1.2. Exclusion

Cadavers who had any injuries of blood vessels, nerves and/or soft tissues before or during dissection or had been used for other purposes would be excluded from the study.

2.2. Research method

This was a cross-sectional study using cadaveric dissection.

2.2.1. Incisions

- Middle posterior leg incision (vertical line): starts from the peak of popliteal region, through the middle line of popliteal region, along the middle posterior calf line to the middle spot on the line linking between the medial and lateral malleolus.
- Horizontal incisions: popliteal crease and the line linking between medial and lateral malleolus

2.2.2. Dissection technique: medial and lateral sural artery skin perforators were dissected

- The popliteal fossa was dissected to expose popliteal vessels in order that medial sural artery was accessed. Several indexes of medial sural artery then were measured, including lengths and diameters of common trunk and branches. After that, a catheter was set into the artery and latex was pumped.
- At the next step, the myocutaneous was dissected from the midline of the gastrocnemius muscle to its two sides, limited by the line linking the medial end of popliteal crease with medial malleolus.
- All of the sural artery perforators were preserved and were dissected to the main trunk to define the number, location and distribution of the perforating branches related to several anatomical milestones namely posterior midline and popliteal fossa.
- Perforating veins, small saphenous vein, superficial nerves, and superficial medial sural nerve were also preserved.
- The length and diameter indexes of the perforators of which diameter were larger than 5 mm were calculated.

2.2.3. Anatomical milestones

- Knee joint (popliteal crease)
- Middle posterior leg line
- Apex of Medial and lateral malleolus
- Apex of head of fibula, medial condyle of tibia

All the results were documented and expressed through illustrative diagrams.

Research tools: dissection tool set, electricity meter, syringes, needle, catheter and latex.

The data was analyzed with statistical algorithm.

3. Results

The following observations are derived from investigation of 62 lower extremities in 41 Vietnamese adult cadavers:

- 55/62 specimens had 1 medial sural artery, accounting for 88.71%,
- 7/62 specimens had 2 supplying arteries, accounting for 11.29%.
Origins: Medial sural artery (Fig. 1) divided from the posterior side of popliteal artery. In 47/62 specimens, this artery was directly divided from popliteal artery, accounting for 75.8%. The number of cases in which medial sural artery divided from the same source vessel with lateral sural artery was 15/62 specimens, accounting for 24.2%.

Dimension: the artery runs downward, descends beneath the medial gastrocnemius sheath.

Measurements:

The length of main truck from the origin pedicle to the last muscle navel was around from 12.57 mm to 17.74 mm, mean ± SD was 14.75 mm ± 3.5 mm.

The diameter of main truck at the origin, where popliteal artery gave off the sural artery, was 1.74 mm for minima and 4.88 mm for maxima, mean ± SD was 3.4 ± 0.92 mm.

Branches of main truck of medial sural artery: 15% had no branches, 15% gave off 2 branches, 30% gave off 3 branches and 40% gave off 4 branches before piercing into the muscle.

Perforating branches of medial sural artery (Fig. 2, Fig. 3, Fig. 4): 100% gave off at least 1 branches and the number of the branches peaks at 5 perforators. Mean ± SD was 3.35 ± 0.91 perforators.

The distance from the perforators to posterior calf midline was fluctuated from 0.39 cm to 6.7 cm and mean ± SD was 1.6 ± 0.96 cm.

4. Discussion

Similar to other international and national researches, this study showed that medial sural artery perforator constantly exists in all of the dissecting specimens. In our study, 100% of medial sural artery was a branch of popliteal artery and the mean external diameter of medial sural artery at the point that popliteal branches was 2.88 ± 0.98 mm. In comparison with the research of Altaf [7], only 70% of medial sural artery was a branch of popliteal artery and 30% has a main truck with lateral sural artery; besides, the external diameter of medial sural artery in Altaf’s research, only 3.01 ± 0.02 mm, was smaller than it was in our study.

The main pedicle of medial sural artery, which was from its origin to the gastrocnemius muscle, was on average 8.39 mm ± 3.9 mm long. In 15% of cases, this pedicle gave off no branches, whereas, 15% of other pedicles gave off 2 branches, 30% of the pedicles gave off 3 branches and 40% left has 4 branches.

According to the study which was investigated on 20 lower limbs of 10 Caucasian cadavers by Thione and his colleagues [4], the main pedicle of medial sural artery gave off 2 branches namely lateral and medial branches which both run into the muscle and branches several perforators. The mean external diameter of medial sural artery was 2.2 mm (fluctuates between 2.3 mm and 3.0 mm), smaller than our study’s result (12 mm).

The following indexes in Table 1 are the results of several previous researches which are conducted to investigate the anatomy of medial sural artery and its perforating branches. In all of the cases, the medial sural artery gave from 1 to 5 perforating branches and median value was 2 branches per specimen. This was as the same as the results in Wong’s research [8] and Hallock’s research [3] which are 4.4 branches and 4 branches respectively.

The distance from perforator to popliteal crease also varies. The longest distance was 22.5 cm in Wong’s research [8] and the nearest was 5 cm in Otani’s research [9]. In our study, the perforators sit at the inner side of the gastrocnemius midline and reach 0.5–7 cm proximal to this midline, similar to other studies.

The study results showed the skin area where was blood supplied by the perforating branch of the internal abdominal gastrocnemius muscle artery. This suggested plastic surgeons to use a free flap or a rotated flap from those vascular peduncles to cover and heal the defects of soft
tissues in the lower extremities or other body areas.

The importance of artery perforators in general and medial sural artery perforators in particular has been proven and admitted through a large number of researches worldwide. It was acknowledged that these perforators play a crucial role in supplying blood to muscle and musculocutaneous tissue. Therefore, depending on this perforators, pedicle island musculocutaneous flap and myocutaneous flap should be used in the treatment of body defects especially in the region of head and neck.

While performing this study, we encountered several challenges: First, the dissection required high precision and meticulousness to remain intact perforating branches of the artery. Thus, it needed to be done carefully by experienced physicians. Besides, exposing the popliteal artery and internal abdominal gastrocnemius muscle artery of the lower leg was also difficult because these arteries located deep in the popliteal fossa, hindered color injection. This study was performed on fresh human cadavers, which is rare in Vietnam. Therefore, it took a long time to collect enough qualified fresh cadavers and lead to small sample size. This, as the limitations, partly affected the external validity of the study. Further large-scale studies may be planned to improve research validity and reliability.

5. Conclusion

The medial sural artery constantly originates from popliteal artery, supplies blood for medial gastrocnemius muscle. The skin area covering this muscle is nourished by one of five perforators of the medial sural artery. The perforating flaps can be created using medial sural artery perforating branches.

Table 1
Several previous researches investigated in the anatomy of medial sural artery and its perforating branches.

| Author       | Number of Specimen n | Preforators Mean ± SD (cm) | Origin from joint line (cm) | distance from perforator branch to posterior leg midline (cm) |
|--------------|----------------------|----------------------------|-----------------------------|-------------------------------------------------------------|
| Cavadas [3]  | 10                   | 1.4                        | 2.2                         | 8.5-19                                                      |
| Hallock [3]  | 10                   | 2.7                        | 4.6                         | 10.2-15.9                                                   |
| Thione [4]   | 20                   | 3.8/20                     | 1.9                         | 7.18                                                        |
| Shim [11]    | 40                   |                            |                             | Perforators lies along the line linking midspot of popliteal crease to medial malleolus 5.1-18.73 0.39-6.7 cm |
| Okamoto [5]  | 44                   | 1-5                        | 5.17-15                     | 1.5-4.5 cm                                                  |
| Torres [6]   | 12                   | 2.4                        | 2.9                         | 10.7-14                                                     |
| Kao [12]     | 26                   | 1-5                        | 2.7                         | 6-18                                                        |
| Altabf [7]   | 20                   | 1-5                        | 10.2-15.9                   | 0.5-7 cm                                                    |
| Wong [8]     | 10                   | 3-8                        | 4.4                         | 6-22.5                                                      |
| Otani [9]    | 47                   | 1-5                        | 2.4                         | 5-17.5                                                      |
| Ours         | 62                   | 1-5                        | 3.35                        | 5.1-18.73                                                  |

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Author contribution

KXN: creating study concept and design and writing the paper, HTV,: data collection, data analysis, DTHN: data interpretation, HTND: writing and proofreading the paper.

Trial register number

1 Name of the registry:
2 Unique Identifying number or registration ID:
3 Hyperlink to your specific registration (must be publicly accessible and will be checked):

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