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Original Article

A study of the perforating arteries of the leg derived from the anterior tibial, posterior tibial and peroneal arteries

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ABSTRACT

Introduction: The present study deals with dissection of anterior tibial artery (ATA), posterior tibial artery (PTA) and peroneal artery (PA) angiosomes or their vascular territories in both legs of 10 freshly donated cadavers prior to embalming. The study shows the distribution of perforating arteries in their respective angiosomes.
Methods: Perforating arteries arising from ATA, PTA and PA and passing through the fascial planes between muscles to the skin and subcutaneous tissues were dissected. The numbers of perforating arteries and their distance from easily recognizable anatomical landmarks was measured. The resultant data was tabulated and the average numbers of perforators in each of these three angiosomes was calculated.
Results: PTA angiosome had the largest number of perforating arteries followed by PA angiosome, the least number of perforators being found in the ATA angiosome. The middle and lower thirds of the leg generally had a greater number of perforators in all three territories. Presence of sural artery perforators arising from peroneal/popliteal artery was an additional supply in the PA angiosome.
Discussion: The knowledge of angiosomes and perforating arteries of the leg is essential for flap repairs and reconstruction for injuries of the leg. Such injuries may occur in accidents, burns and non-healing tissue defects due to ischemic ulcers, varicose veins, leprosy, diabetes and nerve injuries.

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1. Introduction

Angiosomes are three dimensional anatomical territories supplied by source arteries and accompanying veins and are composed of skin, underlying fascia, muscles and bones. They may be further classified into arteriosomes and venosomes. Each angiosome has an extensive anastomotic network (by choke vessels) with adjacent territories.[1] Each of these source arteries has a number of perforating branches supplying discrete territories of skin and subcutaneous tissue. The present study deals with the dissection of these perforators in the anterior tibial artery (ATA), posterior tibial artery (PTA) and peroneal (fibular) artery (PA) territories. These perforating arteries are used for raising viable pedicle flaps for successful tissue reconstruction in lacerated wounds in road traffic accidents/bomb blast injuries, diabetic neuropathy causing skin ulcers and rupture of tendo Achilles, non-healing venous ulcers in thalassemia/varicose veins, 3rd degree burn injuries etc. The anatomical knowledge of these angiosomes and their contained perforating arteries act as guidelines to determine the approximate size and orientation of fasciocutaneous and musculocutaneous flaps for tissue reconstruction in lesions of the legs.[2]

2. Materials and methods

Dissections were carried out on 10 freshly donated cadavers prior to embalming, over a period of 1 year at the Institute of Post Graduate Medical Education and Research, Kolkata, in the Department of Anatomy, with the help of the Department of Plastic Surgery. Dissections were carried out in both legs between the knee and ankle. The legs were dissected along anterior and posterior borders of the tibia and the back of the

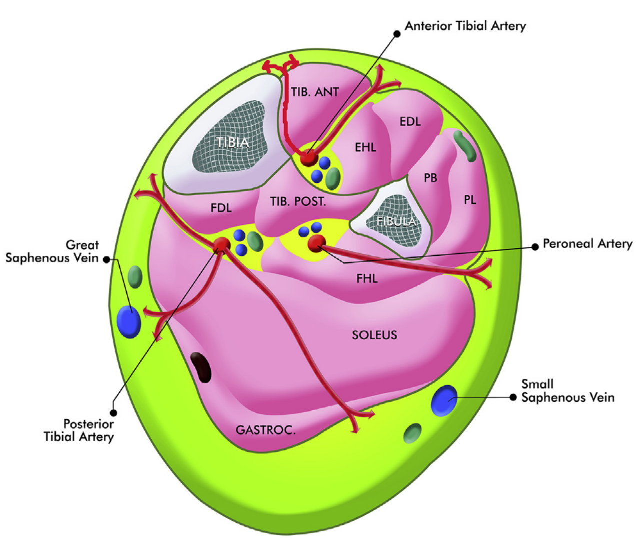

Fig. 1 – Points of emergence of perforating arteries in the leg [EDL – Extensor Digitorum Longus, EHL – Extensor Hallucis Longus, FDL – Flexor Digitorum Longus, FHL – Flexor Hallucis Longus, PL – Peroneus Longus, PB – Peroneus Brevis, Gastroc –Gastrocnemius].

Table 1 – Numbers of perforating arteries of ATA, PTA & PA territories.

Cadaver no.	Number of perforating arteries dissected					
	Ant. tibial artery territory		Post. tibial artery territory		Peroneal artery territory	
	Right	Left	Right	Left	Right	Left
1	4	4	3	4	4	4
2	3	3	4	4	3	3
3	4	4	7	7	5	5
4	4	4	5	5	4	4
5	3	3	6	6	5	5
6	4	4	5	5	5	5
7	3	3	6	6	4	4
8	4	4	5	5	5	5
9	4	4	5	5	5	5
10	3	3	5	5	4	4
Total	36	36	51	55	44	44

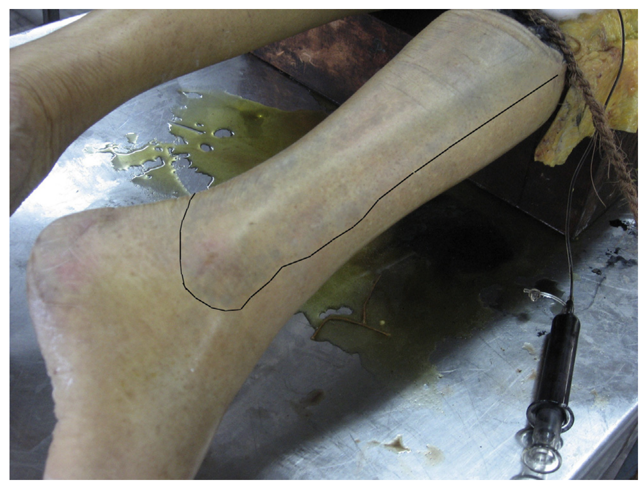

Fig. 2 – Posterior tibial artery angiosome area shown by bluish discoloration due to dye injection.

Fig. 3 – A posterior tibial artery perforator injected with dye.

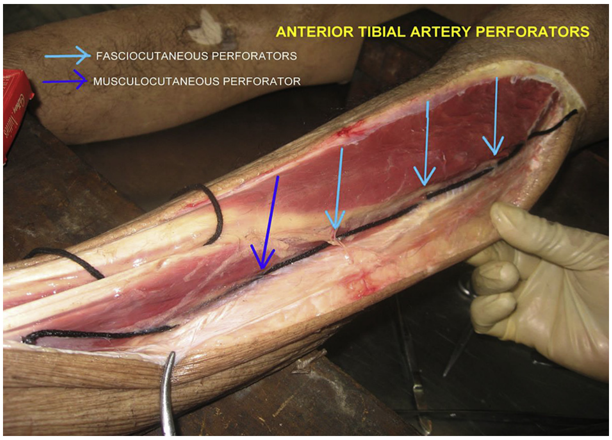

Fig. 4 – Anterior tibial artery perforators in the dissected area.

leg. The tissue planes were followed to the main feeding arteries (ATA, PTA & PA) and the perforating arteries emerging and passing along the fascial planes were dissected (Fig. 1). The number and position of perforating arteries were noted in the Anterior Tibial, Posterior Tibial and Peroneal (Fibular) Artery territories. Position of the perforators was measured as the distance from the medial malleolus.

3. Results

Dissections of ATA, PTA and PA were done in 20 legs of 10 freshly donated cadavers revealed a total of 263 perforators (ATA – 72, PTA – 106, PA – 88) as shown in Table 1. Dye injection into the main feeding arteries and individual perforating arteries may give us an approximate idea of its area of blood supply (Figs. 2 and 3). Fig. 4 shows ATA perforators, both fasciocutaneous and musculocutaneous. Fig. 5 shows multiple perforating arteries of the PTA territory coming out through the fasciocutaneous plane. PA perforators in their vascular territories emerging out of fasciocutaneous planes are shown in Fig. 6. As an additional feature, a sural artery

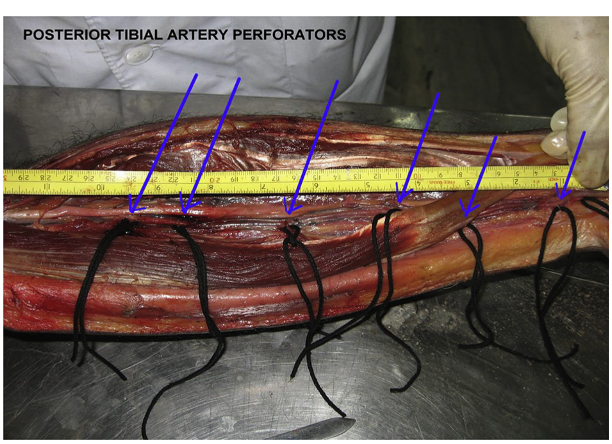

Fig. 5 – Posterior tibial artery perforators in the dissected area.

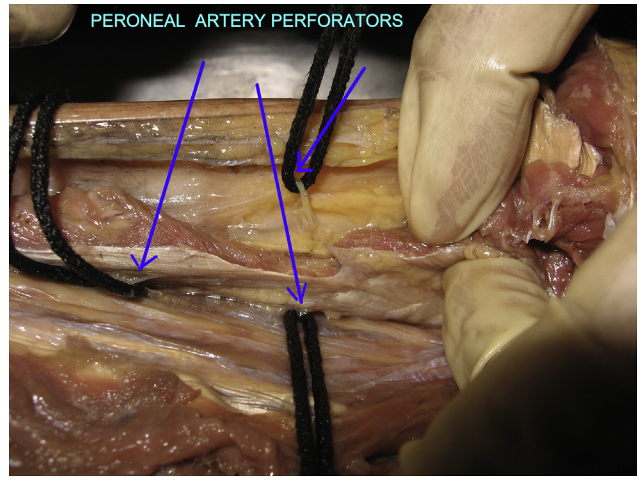

Fig. 6 – Peroneal artery perforators in the dissected area.

perforator as a cutaneous branch of popliteal artery was found in two cases (Fig. 7).

Distances of individual perforators were measured from the medial malleolus. The distance varied from 5 cm to 30 cm. The average distance of the perforators from the medial malleolus is shown in Table 2. Table 3 shows a comparative analysis of angiosomes of ATA, PTA and PA. Dye injection studies showed by a rough estimate that the supply area of PTA angiosome was maximum followed by PA and ATA angiosomes. Lateral part of the leg received better supply from peroneal artery in PA angiosome than by PTA.

4. Discussion

Dissection of cutaneous perforators of ATA, PTA, PA showed largest angiosome areas of PTA followed by PA and ATA. The points of origin of perforating arteries were measured from the level of medial malleolus in the present study.[3] The

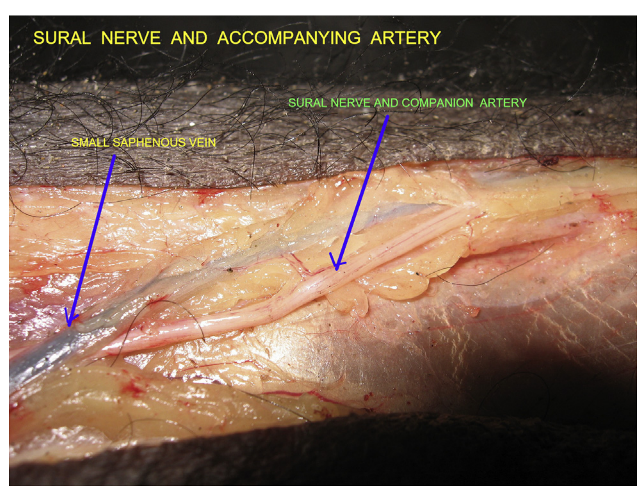

Fig. 7 – Sural artery perforator in the peroneal artery angiosome which is a branch of popliteal/peroneal artery accompanying sural nerve.

Table 2 – Positions of perforating arteries of ATA, PTA & PA territories.

Cadaver no.	Average distance from the origin of the perforating arteries to the medial malleolus (cm)					
	Ant. tibial artery territory		Post. tibial artery territory		Peroneal artery territory	
	Right	Left	Right	Left	Right	Left
1	20.3	20.4	20.5	17.5	14.9	15.1
2	15.8	15.7	15.2	15.2	27.5	27.6
3	20.8	20.9	15.9	15.9	20.1	20
4	21.7	21.7	18.2	18.2	19.8	19.8
5	18.2	18.1	17.1	17.2	16	16
6	18.1	18.2	18.5	18.5	16	16.2
7	16.9	16.9	19.1	19.2	16.7	16.7
8	14.7	14.8	18.6	18.6	19	19.1
9	22.8	22.7	17.9	18	16.3	16.4
10	17.8	17.9	19.8	19.7	19.2	19.2

commonly used dissection method to expose ATA was a transverse line joining tibial tuberosity and fibular neck, a lower transverse line joining the two malleoli and a longitudinal incision joining them. But in some cases a longitudinal incision over the skin of the lateral part of the tibia was used as most of ATA perforators were found to emerge from medial and lateral side of extremities in front of leg.[4]

India ink injection into ATA from below after proximal ligation before its point of perforation through interosseous membrane regularly stained an area of skin over the proximal anterolateral compartment of leg. The anterior border of the stained area was the crest of tibia and posterior border extended to fibula.[5] Major perforating arteries were found to aim at a gap of 3 fingers/5 cm in the present study.[6] The present study shows distribution of ATA perforators more numerous in upper and middle 1/3 of leg and sparse in lower 1/3. Most of them arise when ATA perforates the interosseous membrane into the anterior compartment. The majority of them descend and become superficial in the fascio-septal space between peroneal and extensor muscles; longer branches supply peroneus longus and extensor digitorum longus. Some perforators supply only extensor muscles and a large proximal perforator accompanies superficial peroneal nerve on the tibial side for a variable extent.[7]

The skin of the posteromedial aspect of the leg was supplied by fasciocutaneous perforators of PTA and usually some of the angiosome territory received an additional blood supply from saphenous artery and this could be of added advantage during wound healing.[8] The study also shows a limited supply from cutaneous perforators accompanying the sural artery emerging through gastrocnemius. The average number of perforators in each leg was 5.3.[9] Majority of perforators rose in the middle 1/3 of leg (4.7 was the average perforator count).[10]

The peroneal artery angiosome territory dissected out in the present study measured 31.2 × 13.4 to 8.2 cm which compares favorably with other studies, where angiosomes measured 32 × 15 cm.[11] A fasciocutaneous flap reconstruction based on this angiosome would contain small saphenous vein and sural nerve. The peroneal artery perforators were maximally concentrated all along posterior intermuscular septum. Presence of sural artery was also found in this angiosome which was a fasciocutaneous branch arising from popliteal or peroneal artery.[12]

The average perforator count in PA angiosome was 4.4 per leg in the present study, which is similar to the results obtained by other authors.[13,14]

Although perforator site locations were randomly distributed within any vascular territory, the separate cutaneous regions that make up a fasciocutaneous perforator territory have reasonably constant dimensions. Random dye injections into selected perforators revealed the supply areas to have length:breadth ratios of 2:1 to 3:1. This is similar to the clinically observed 2.5:1 to 3:1 length to width ratios for fasciocutaneous flap viability.[15] In surgical practice, a vascular equilibrium or watershed exists as the boundary between these anatomical territories and when one vessel is occluded other vessels extend their anastomotic network. Hence these dynamic territories correlate with the margins of a clinically viable flap.[16]

Most of the perforating arteries dissected in this project were fasciocutaneous perforators, passing to the skin and subcutaneous tissues from the main feeding arteries along fascial planes. However some of these were musculocutaneous arteries which reached the skin after supplying the underlying muscles. In practice the fasciocutaneous arteries are usually larger and more useful for creation of vascular flaps.

5. Conclusion

The present study highlights the vascular territories of ATA, PTA, PA of which the PTA angiosome was found to be the most extensive, making it best suited for reconstructing fasciocutaneous flaps in plastic surgery. The knowledge of these angiosomes is based on a perforator vessels ramifying in the fasciocutaneous plane, anastomosing with adjacent vessels. Creation of extensive perforating artery maps of all vascular territories in the limbs trunk and face will be of great help to

Table 3 – Comparative analysis of angiosome territories of ATA, PTA & PA.

Angiosome	Total perforator artery count [20 legs]	Average perforator artery count [APAC] [each leg]	APAC[a] Upper 1/3 [each leg]	APAC[a] Middle 1/3 [each leg]	APAC[a] Lower 1/3 [each leg]
ATA	72	3.6	1.8	3.4	2.0
PTA	106	5.3	2.6	4.7	3.0
PA	88	4.4	2.5	3.5	2.8

[a] APAC – Average perforator artery count.

anatomists and surgeons to study soft tissue vascular patterns and in the creations of viable flaps for soft tissue repairs in trauma surgery.

Conflicts of interest

All authors have none to declare.

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