Lymphology 30 (1997) 116-121

VASA VASORUM OF SUPERFICIAL COLLECTING LYMPHATICS OF HUMAN THIGH

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ABSTRACT

Collecting lymphatics were obtained from human thigh fat for light microscopy and tridimensional reconstruction at time of operation for varicose veins. No patient had lymphedema and routine sections showed no inflammation or notable pathologic alteration of the surrounding soft tissue. Abundant vasa vasorum was observed around the musculature of superficial collecting lymphatics of human thigh. Within intervalvular portions of the lymphatic collectors where the muscle coat was thicker and more compact, the vasa vasorum penetrated between smooth muscle cells and was in contact with the endothelium. In valvular portions of the collecting lymphatics where the muscle layer was thinner and more fragmented, there were fewer vasa vasorum. Tri-dimensional reconstructions of the collecting lymphatic wall showed two communicating plexi of vasa vasorum — one outside and the other inside the muscle layer. Arteries and veins of similar size did not have such an abundant vasa vasorum. The explanation for this difference may relate to the fact that a relatively low oxygen and nutrient content of lymph is insufficient to nourish the collecting lymphatic. Moreover, diffusion of nutrients from the external plexus is likely also impeded by the thickness and density of the muscle layer. The vasa vasorum deep in the muscular layer and in the subendothelial space probably sustain adequate nutrition and oxygenation to the collecting lymphatic.

Oxygen and nutrients supply the wall of blood vessels by direct diffusion from the blood and from the vasa vasorum and therefore depend on the thickness of the vascular wall and the blood oxygen content. Vasa vasorum are lacking in intracranial arteries (1), whereas in the aorta of small mammals (2) and in the rabbit carotid artery (3), vasa vasorum are confined to the adventitia. In the aorta of large animals (2,4) and also in its major abdominal branches (5), vasa vasorum are present not only in the adventitia but also in the outer layers of the media. According to Okuyama et al (6), vasa vasorum penetrate into the media of large human arteries when the thickness of the media is greater than 0.6 mm. In newborns, the critical thickness at which diffusion from the lumen of the aorta becomes insufficient has been estimated to be only 0.2 mm, probably because of the low partial pressure of oxygen of fetal circulation (30 mmHg) compared with 100 mmHg in the adult circulation.

The number and distribution of vasa vasorum is also age-related in veins. In newborns abundant capillaries penetrate as far as the intima, whereas in the adult, capillary density decreases and the vasa vasorum are farther from the inner layers of the venous wall (7), and concentrated primarily in the adventitia (8). Few capillaries penetrate into the deep layers of the vessel wall (~40 µm from the lumen.)

Because of relatively low partial pressure of oxygen in lymph, we postulated that the

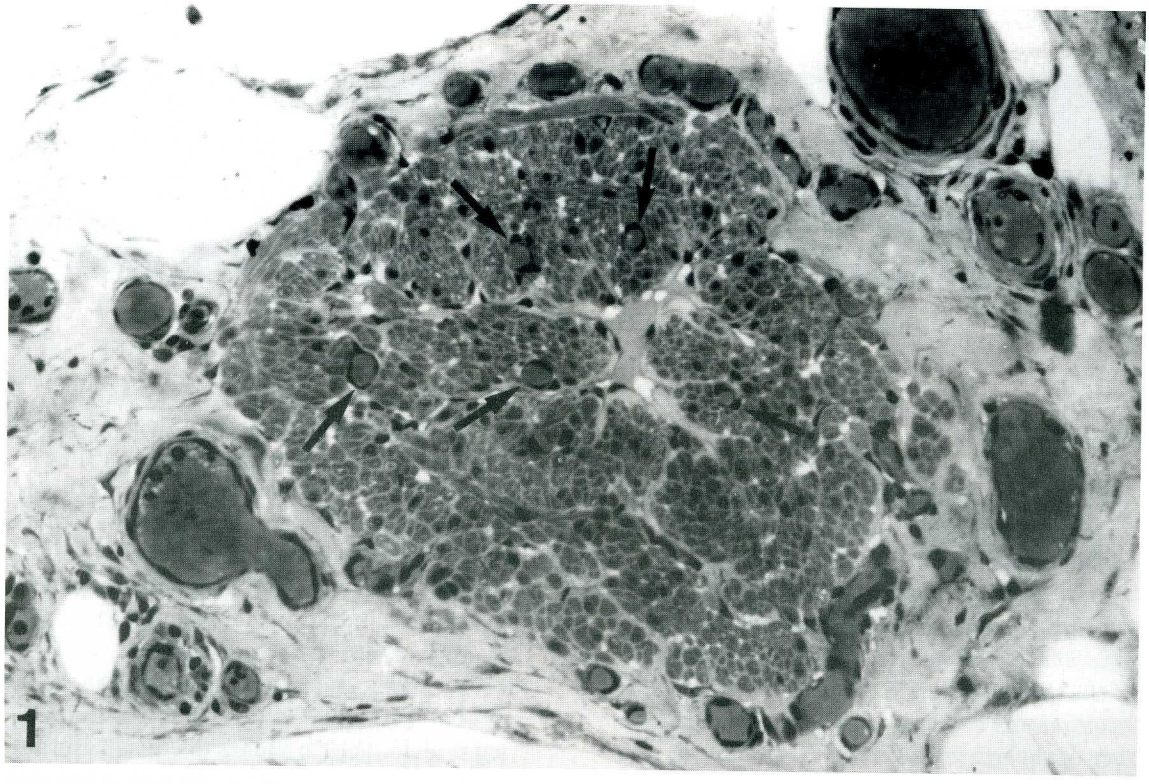

Fig. 1. Intervalvular portion of a human peripheral collecting lymphatic showing several vasa vasorum in the surrounding connective tissue and (arrows) in the muscle layer; x50.

oxygen supply of the lymphatic wall depends chiefly on the vasa vasorum. Vasa vasorum have been described in the muscle layer of bovine mesenteric collecting lymphatics (9) and externally in the muscle layer of human collecting lymphatics (10). We now describe the distribution of vasa vasorum in the wall of superficial collecting lymphatics of the human thigh.

MATERIALS AND METHODS

Segments of great saphenous vein with the adjacent fat that would have been discarded during operation for varicose veins were obtained in the region of the femoral triangle in 10 patients of both sexes (age 45-67 yrs). No patient had lymphedema. For light microscopic studies, the tissue samples were immersion-fixed in Karnovsky reagent and embedded in methacrylate. Serial sections, stained with 0.1% toluidine blue, were observed under a Zeiss Axioplan light microscope. The following parameters of the images, projected onto a ground glass screen, were traced on clear acetate paper: the outer profile of the vessel (identified as the abrupt end of the muscle coat in the surrounding connective tissue), the inner profile (identified as the edge of the endothelium) and the profile of blood microvessels located internally or externally were accomplished with a PC3D program (3D Reconstruction software) by Jandel Scientific using a Genius tablet GT1212.

RESULTS

The amount and distribution of vasa vasorum in the wall of these human collecting

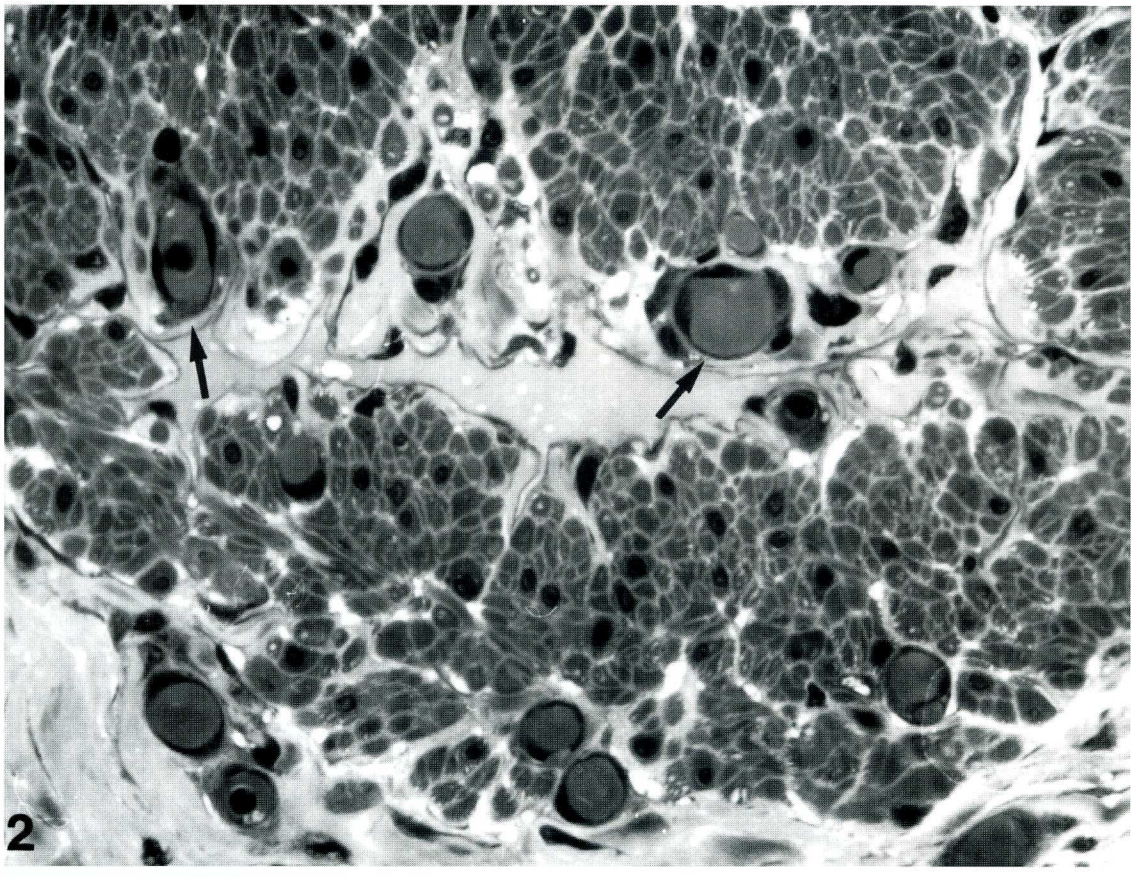

Fig. 2. Vasa vasorum in the subendothelial space, two (arrows) are in direct contact with the endothelium; x100.

lymphatics were closely related to the presence and distribution of smooth muscle cells. The surrounding connective tissue showed intact morphologic features. Specifically there was no inflammation or other noteworthy pathologic changes. Vasa vasorum were abundant in the intervalvular portions where the muscle was well developed and organized into two or three layers *(Fig. 1)*. The blood microvessels (arterioles, venules, and capillaries) were located external to the muscle layer, between smooth muscle cells, and extended to the subendothelial space *(Figs. 2,3)*. No arterioles were detected inside the muscular layer.

By contrast, in the valvular portions, where smooth muscle did not form a continuous layer, vasa vasorum were primarily interposed between groups of smooth muscle cells in the abundant connective tissue. Rarely where the valve buttress was implanted in a portion of the lymphatic wall where smooth muscle cells were unusually abundant, vasa vasorum were occasionally found in the valve leaflets *(Fig. 4)*.

Computerized reconstruction showed that the vasa vasorum were organized into two discrete networks—one external *(Fig. 5)* and the other internal to the muscle layer. The external plexus had more vasa vasorum; however, the two plexi commonly communicated *(Fig. 6)*.

DISCUSSION

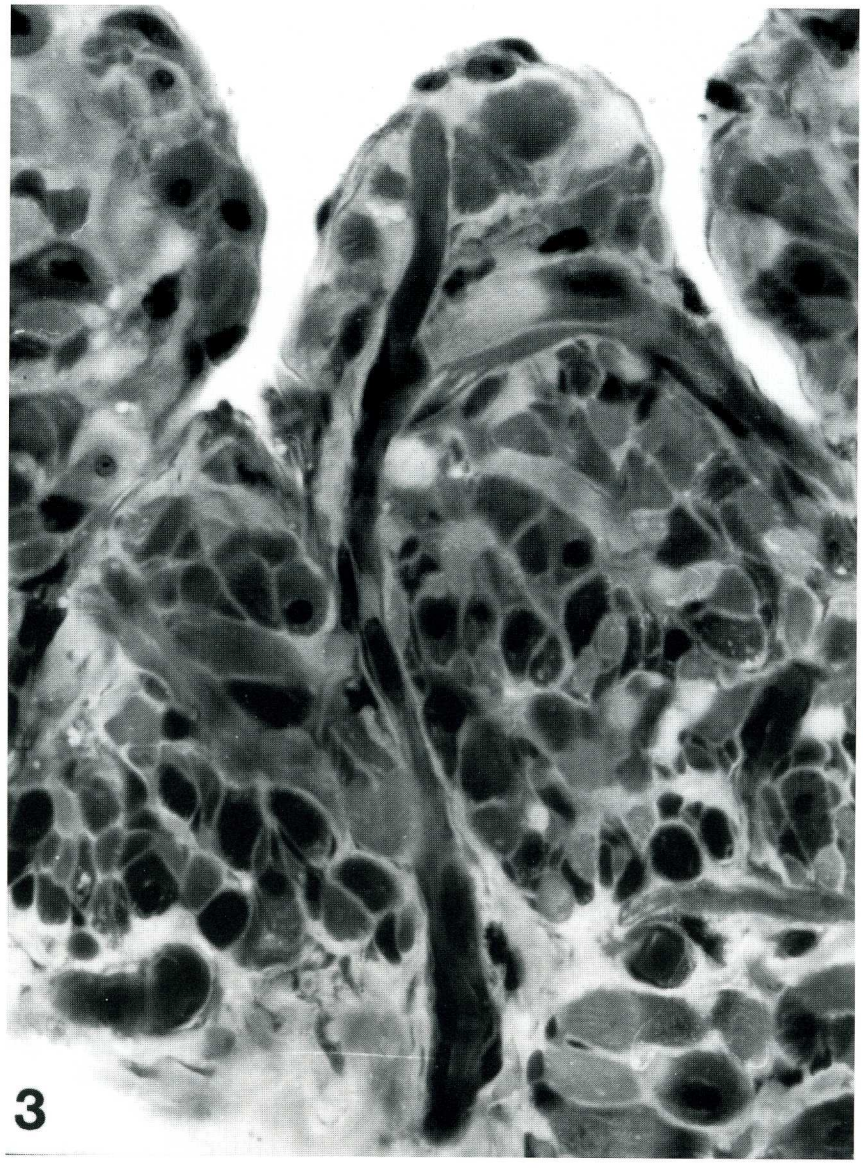

Fig. 3. A blood capillary in longitudinal section crossing the entire thickness of the collecting lymphatic wall; x160.

Our findings are consistent with Okuyama et al on the distribution of vasa vasorum in large arteries (6). In collecting lymphatics, as in arteries, the amount and distribution of vasa vasorum correlated with the thickness of the vessel wall and perhaps was also related to the oxygen content of luminal lymph.

The rich vasa vasorum network of human superficial collecting lymphatics is unlikely related to pathologic conditions because both the lymphatics and the surrounding tissues were normal and abundant vasa vasorum were not found in the walls of adjacent blood vessels of comparable size.

Propulsion of lymph in superficial lymphatic collectors depends primarily on active contraction of lymphangion smooth muscle cells. The walls of intervalvular portions of collecting lymphatics are thicker

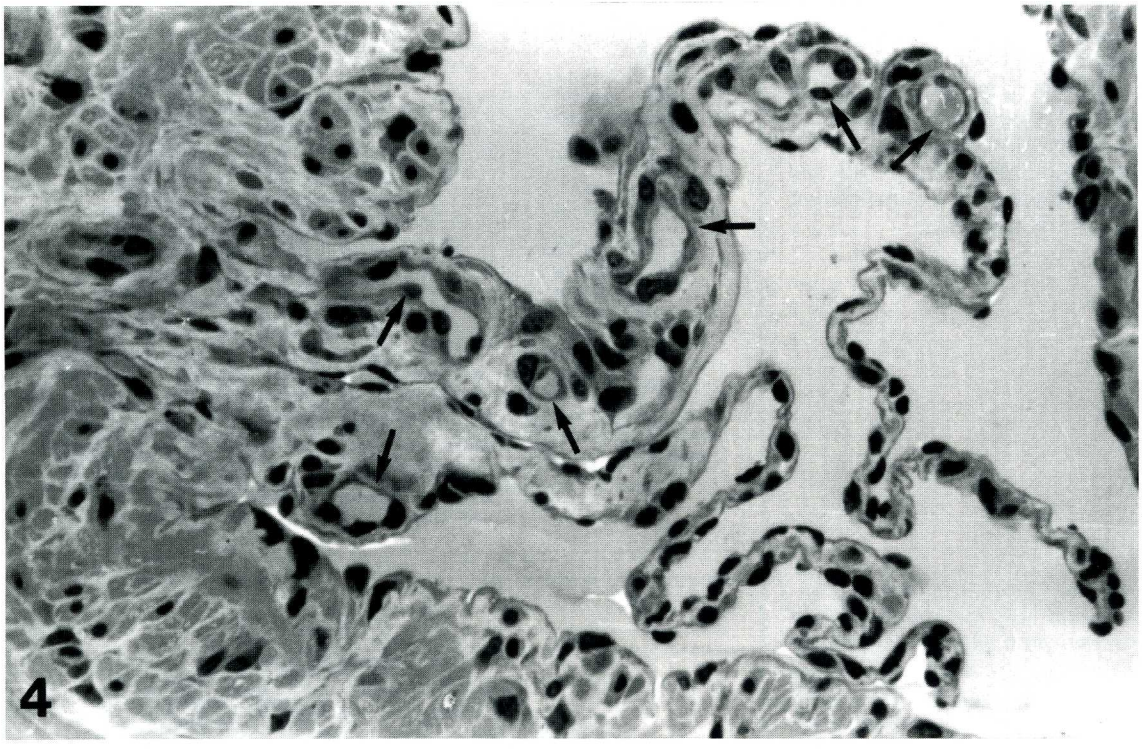

Fig. 4. A valvular portion of a collecting lymphatic showing several blood microvessels (arrows) in the valve cusps; x100.

than those of blood vessels of comparable size. It seems reasonable, therefore, that diffusion from the inside (i.e., intraluminal lymph) is unable to maintain nutritional requirements of the lymphatic itself with a relatively low partial pressure of oxygen and low nutrient content of lymph. Indeed, the close juxtaposition of the lymphatic smooth muscle cells and the thickness of the wall probably restrict diffusion from the outer plexus. Accordingly, the vasa vasorum probably penetrate deeply into the collecting lymphatic to maintain nutritional requirements of the internal layers.

ACKNOWLEDGMENTS

This work was supported by 40% and 60% funds from Ministero dell' Università e della Ricerca Scientifica e Tecnologica, Roma, Italy.

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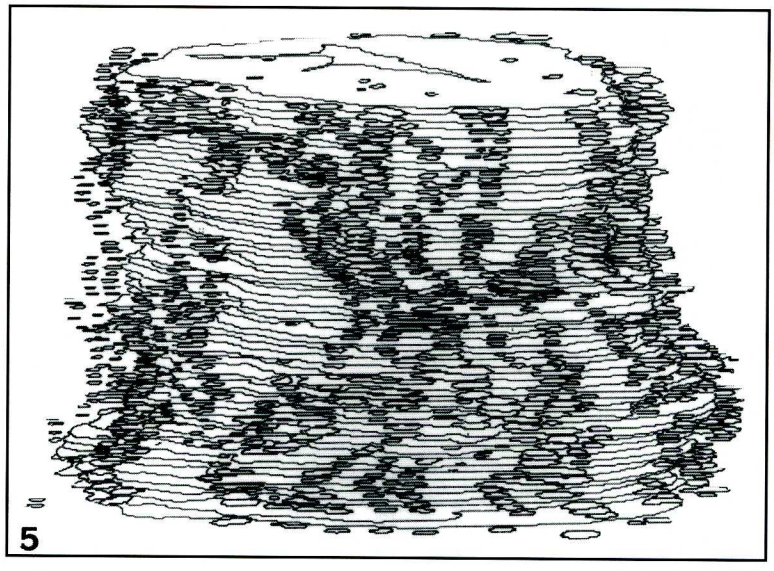

Fig. 5. Tridimensional reconstruction of the external plexus of vasa vasorum. The internal plexus is visible only in the topmost portion. 60 sections, total length of lymphatic vessel reconstructed 0.6 mm. Gray=endothelial profile and outer profile of the muscle layer, black=vasa vasorum.

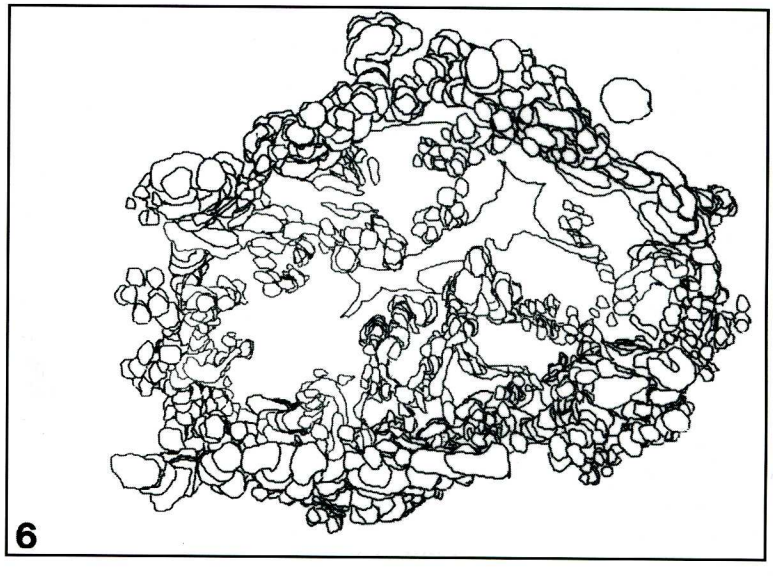

Fig. 6. Tridimensional reconstruction of the internal and external plexi of vasa vasorum of the same lymphatic collecting vessel as in Fig. 5 viewed from above. The two plexi are connected. Gray = endothelial profile and outer profile of the muscle layer, internal plexus of vasa vasorum, black = external plexus of vasa vasorum. 45 sections, total length of lymphatic vessel reconstructed 0.45 mm.

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