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THE LYMPHATICS OF THE SKIN FILLED BY A DERMAL BACKFLOW: AN OBSERVATION IN A SCARRED CADAVER LEG

H. Suami, W.-R. Pan, G.I. Taylor

The Jack Brockhoff Reconstructive Plastic Surgery Research Unit, Royal Melbourne Hospital, Department of Anatomy and Cell Biology, University of Melbourne, Australia

ABSTRACT

There have been few photographic studies done on lymphatics of human skin with previous images obtained by indirect dye injection into the dermis. We have developed a direct injection technique for investigating the lymphatic system in human adult cadavers and used this to investigate superficial lymphatics of the legs in a fresh human cadaver. We found an unusual observation in a skin graft scarred leg when the radio-opaque mixture injected into a lymph collecting vessel in the dorsal foot filled the skin lymphatics in the mid-lateral pretibial region. Further radiological investigation revealed that the dermal back flow was associated with a blockage of the lymph collecting vessel within the skin graft scar. We also found tracer transport through a circuitous pathway from the blocked collecting vessel to an adjacent intact collecting vessel. The transilluminated image of the skin demonstrated a three dimensional polygon of lymph capillaries and precollecting lymphatics in the dermis.

Keywords: Human cadaver, lymphatic collecting vessel, pre-collecting vessel, direct injection technique, dermal backflow

Previous anatomical studies have shown lymph structures of the skin using indirect dye injections into living and cadaveric specimens and recorded as schematic diagrams or as photographs (1-6). To date, there have been very few topographic images of the lymphatics depicting the entire thickness of the adult human skin.

The lymphatics are not present in the epidermis and originate as avalvular lymph capillaries (initial lymphatics) with blind ends in the dermal papillae just below the epidermis. They form an intricate three dimensional network in the superficial dermis and are gradually transformed into valvular pre-collecting vessels in the deep dermis where these vessels coalesce and merge into collecting vessels in the subcutaneous fat layer (1-3).

We have developed a direct injection technique for delineating the lymphatics in fresh human cadavers using photographs and X-ray films (7). In this case using a fresh cadaver leg, we report a rare observation of lead oxide filled skin lymphatics close to a skin graft scar. We investigated the region radiographically, photographically and histologically.

MATERIALS AND METHODS

The fresh cadaver was an 86 years old female without a history of vascular disease or lymphedema. The causes of death were recorded as aspiration pneumonia, cerebral stroke, renal failure, and obstructive airway.

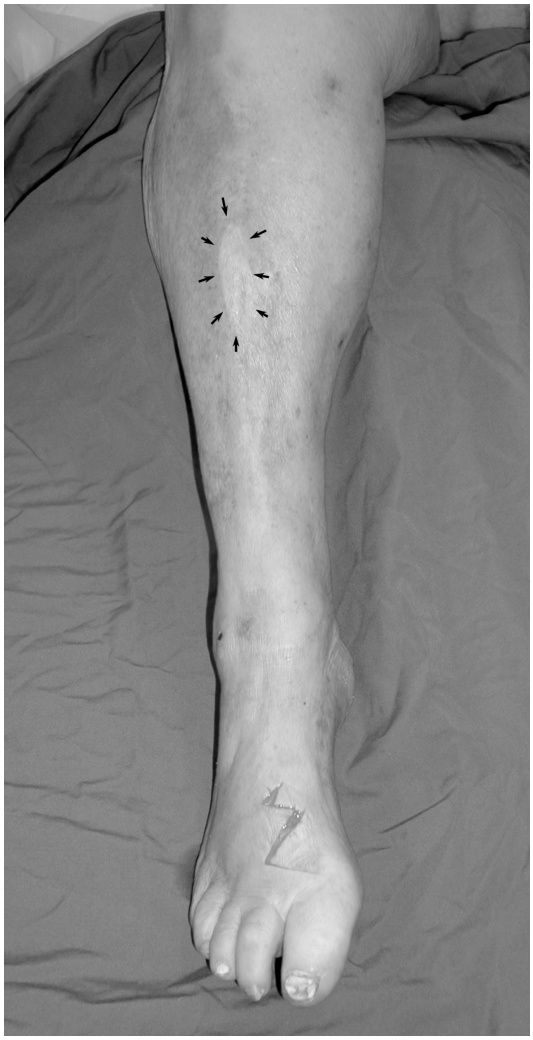

Fig. 1. Right cadaver lower limb. The limb had a 55 X 15mm skin graft scar (black arrows) in the pretibial region. The lymph injection commenced at the dorsum of the foot.

The right limb was disarticulated at the right hip, and we investigated the lymphatics of the right lower limb. The limb had a 55 X 15 mm sized elliptical skin graft scar at the upper part of pretibial region *(Fig. 1)*. Neither the history of the operation nor the donor site of the graft was recorded.

Lymphatic mapping commenced at the dorsal foot and then extended to the lateral and medial sides around the ankle joint. The method for delineating the lymphatics was based on our original radiographic injection technique (7). 6% hydrogen peroxide was injected into the dermis to identify and inflate the lymphatic vessels in the target area. A cannula of suitable size (24G cannula, 30G 1 inch needle or fine drawn glass tube) was selected as required. After the cannulation, the injection was begun gently by hand with a 1ml syringe commencing in the dorsum of the foot. Resistance in the syringe or leakage from the vessel at the injection point indicated the end of the injection. The injection mixture consisted of: 3gm lead oxide (orange Pb_3O_4: AJAX Chemicals, Australia), 0.5gm powder milk and 20ml hot water (40°C).

We injected lead oxide mixture into each lymph collecting vessel in the subcutaneous tissue. After we injected into a vessel on the lateral dorsum of the foot, an 80 x 50mm sized rhombic blush of orange lead oxide was seen in the lateral inferior skin around the skin graft. Following completion of the injections, the skin and soft tissue was incised along the axial mid lateral line and removed. The specimen including skin and deep fascia was flattened and radiographed with highly sensitive X-ray film (Ektascan, B/RA Film: Kodak Inc., Australia).

RESULTS

X-ray of the orange colored skin region showed that a lymph collecting vessel had been interrupted by the graft scar *(Fig. 2A)*. In addition, the lymphatics in the overlying skin above the blocked vessel filled with lead oxide presumably via dermal backflow. Transilluminated images of dissected skin depicted a dermal network of vessels *(Fig. 2B)*. The backflow pattern bridged the gaps between the blocked vessel and an adjacent intact collecting vessel (*Fig. 2A*, right arrow). Lymphatic connections (if any) between the graft and surrounding skin were indistinct.

At the microscopic level, the skin was densely filled with fine lymph vessels of various diameters (approx. 10 to 80 micro-

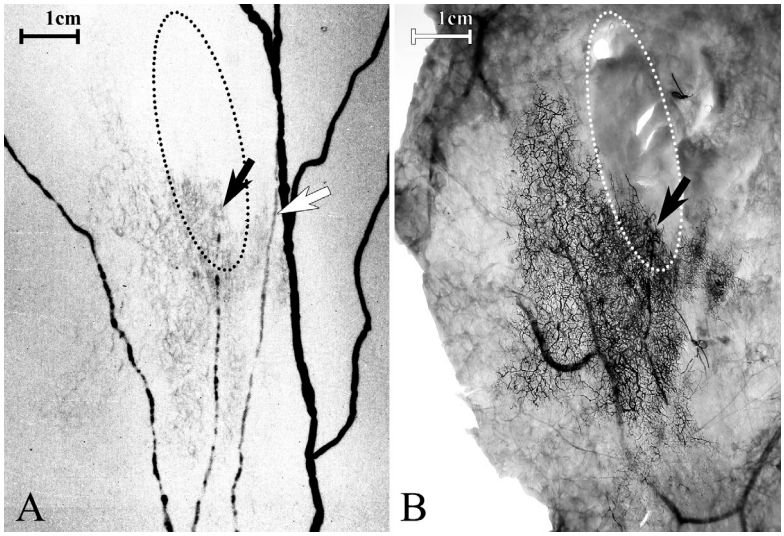

Fig. 2. (A) Radiographic image including skin, subcutaneous tissue and deep fascia of the orange colored skin region. Dotted line outlines the position of the skin graft. The dermal lymph vessels were seen emphasizing a blocked lymph collecting vessel (black arrow) and an adjacent vessel (white arrow). (B) Transilluminated image of the skin of the same region depicts a dermal lymphatic network filled with lead oxide mixture.

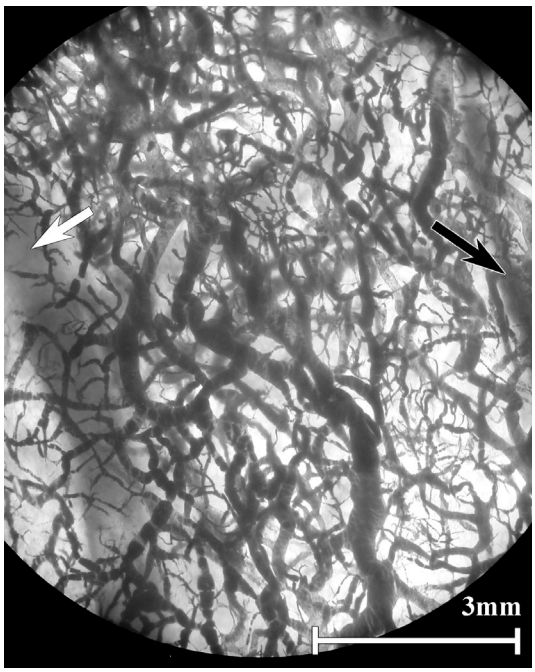

Fig. 3. The magnified 3 dimensional transilluminated image of the dermal lymphatics from the deep aspect. Fine mesh dermal lymph vessels are much smaller than the lymph collecting vessel (black arrow) in the subcutaneous fat layer. They have no connections with the cutaneous vein (white arrow).

meter) *(Fig. 3)*. They were much smaller than the caliber of the lymph collecting vessels (approx. 300 micrometer) and formed a three dimensional polygonal network through the whole thickness of the dermis. They had no connection with the blood vessels. The histological cross section also showed the capillaries and precollecting vessels distributed over the entire thickness of the dermis *(Fig. 4)*.

DISCUSSION

The lymphatics of human skin have been described by various researchers since Sappey's report in 1874 after injection of mercury into the skin of human cadavers (1). Following abandonment of mercury due to its toxicity, a dye injection (Gerota's method) became the replacement method for studying the lymphatics. Forbes applied this technique to cadaveric fetal studies (2) and described the lymph plexus in the different layers of the skin from the sole of the foot. In the early 20th century, most researchers used Gerota's method on the fetus or young child cadavers.

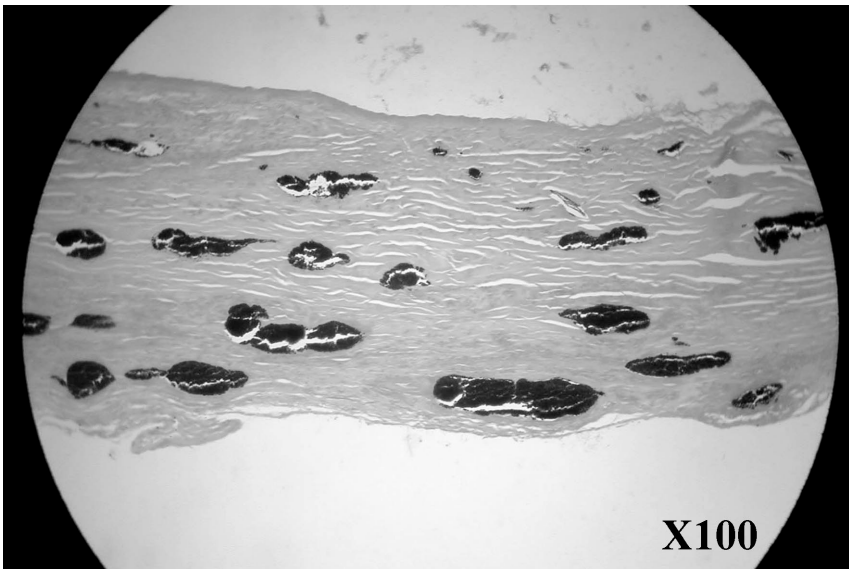

Fig. 4. Histological image of a cross section of the skin. Dermal lymph vessels filled with lead oxide particles are found in the entire thickness of the dermis.

Hudack and McMaster reported in vivo adult studies in 1933 (4). They injected dye into their own skin and investigated lymphatics in the normal and pathological conditions. Other agents such as fluorescent substances [fluorescent microlymphangiography (5)] and contrast medium [indirect lymphography (6)] have been used for delineating the lymphatics of the skin in vivo. Molecular markers of lymphatic endothelial cells [LYVE-1 (8,9), Podoplanin (10), Prox-1 (11)] have been used as a standard technique to distinguish lymphatics form the blood vessels in the last decade. However, these methods can only be used for histological studies. Our results with the exterior adult skin lymphatics are similar to those described in earlier studies. However, our transilluminated pictures show the lymphatics through the entire thickness of the skin *(Fig. 3)*.

There have been numerous clinical reports (12-17) describing lymphatic dermal backflow caused by blocked lymph collecting vessels and valvular incompetence between precollecting and collecting vessels. The phenomenon has been observed using both lymphangiography (12-15) and lymphoscintigraphy (16-17) of limbs affected following regional node dissection, and these are highly associated with of secondary lymphedema. We also observed and reported similar dermal backflow in the case of a non-edematous fresh cadaveric upper limb after axillary dissection (18). This phenomenon also seems to be relevant to in-transit recurrence of skin malignancies which often deposit in the dermis. Clodius reported that it is collateral lymph circulation between lymphatic watersheds in the presence of a lymph block that initiates lymphatic backflow towards the dermis (19), and our radiological findings from this case support his theory. An alternative hypothesis is that lymphangiogenesis has occurred due to the scar blockage and that these new vessels are transporting the injectant in an unsuccessful attempt to migrate around the scar. Although this may be possible, it may be more likely a minor component of the imaging we see since you might expect lymphangiogenesis not to develop toward the epidermis in the direction of the backflow seen here.

CONCLUSION

In this case, we have shown the dermal lymphatics filled by backflow due to a prior skin graft operation in the leg. Blockage of the lymph collecting vessel likely caused valvular incompetence as evidenced by the dense dermal lymphatics filled with orange lead oxide that would not normally be seen. Our images provide further insight and expand knowledge of the lymphatic network of the skin.

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Hiroo Suami, M.D., Ph.D.
The Jack Brockhoff Reconstructive Plastic Surgery Research Unit
E533, Medical Building
Department of Anatomy and Cell Biology
University of Melbourne, Grattan Street,
Parkville 3050, Victoria, Australia
Tel: (61) 3 9347 5939
Fax: (61) 3 9349 2535
E-mail: hsuami@unimelb.edu.au