# Chapter 22
# Oil Contrast Lymphangiography

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Ever since the lymphatic vessels were discovered incidentally in 1622 by Gasparo Asselius, Professor of Anatomy at Pavia University in Italy,[1] the anatomy and physiological functions of these tiny structures have posed a challenge to the investigators because of their small size and the difficulties involved in visualization. Contrary to what happens in the arterial and venous systems, where visualization is relatively easy, visualization of the lymphatic system has been technically challenging. After Asselius's description, the lymphatics were the focus of attention of many investigators who used injections of mercury into cadavers to gain as much knowledge as possible about these intriguing little vessels. At the Medical–Surgical Military Academy of Austria, founded in 1785 by Joseph II, 1,192 beautiful anatomical wax models, crafted in Florence at the end of the eighteenth century, are on public display. Here, unique models of whole-body dissections of the lymphatic system created by the Italian artists can be admired.

The complex network of small lymphatic capillaries that absorb fluid from the interstitial space was described by Casley-Smith, who called them "initial lymphatics."[2] They are formed by a single layer of 10 to 60 μm endothelial cells. These lymphatic capillaries drain into larger valved channels of the dermis and subcutaneous tissues that run along the veins above the muscular fascia. Visualization of the initial lymphatics was the subject of the 1984 International Symposium in Zurich, Switzerland, and a publication edited by A. Bollinger, J. Partsch, and J.H.N. Wolfe[3] in which demonstration and functional evaluation of superficial lymphatics was explored using fluorescence microlymphography[4] and Iotasul (indirect lymphography).[5] Of course, all of these efforts came after the pioneering work of Professor John B. Kinmonth of Saint Thomas Hospital in London, of whose life the lymphatic system, its visualization by lymphography, its classification, and its function became

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the focus. In the introduction to the first edition of his book in 1972, it is compelling to read the following citation:

> The chief author had the good fortune to work in the years after the war with Professor Sir James Patterson Ross at St Bartholomew's Hospital. At that time there was no satisfactory clinical method of investigating lymphatic function. Pure speculation reigned. One eminent authority on vascular diseases even stated that "he doubted if the lymphatics existed, and if they did they were of no importance." Another said that such research was valueless: "you won't find anything out and if you do, no-one will believe you." But Sir James was encouraging. When on a ward round at Bart's he saw a picture of one of the first successful deep lymphangiograms and he said, "don't lose that slide it is going to be very important." Much of our early studies were on patients with lymphedema with aplasia or hypoplasia of the lymphatics. We did not know it but we had chosen the most difficult subjects for lymphography. Often we felt like the poet W.B. Yeats, "the fascination of what is difficult has dried the sap out of my veins."[6]

After the groundbreaking investigations of Hudack and McMaster, who injected patent blue dye intradermally and demonstrated small lymphatics in the skin,[7] Servelle in 1944,[8] and Kinmonth in 1952[9] explored the use of patent blue in the experimental and clinical visualization of the lymphatic vessels. This pioneering work culminated with the description of the technique of lymphography as a preliminary step to the visualization of the dermal and subcutaneous lymphatics. Cannulation of these vessels and injection of contrast materials produced some of the first radiological imaging of the lymphatic vessels. Kinmonth devoted the following 25 years of his life to the study of the lymphatic system and the development of techniques of lymphatic visualization that produced the first lymphangiographic and clinical classification of lymphedemas. By the time he published his book, he had performed more than 2,000 direct lymphographies. This author had the privilege to have met Professor Kinmonth and to have worked with him in 1957 during a visit to his close friend, and my mentor, Professor Richard Warren of the Peter Bent Brigham Hospital in Boston. Professor Kinmonth gave me a small bag containing several grams of patent blue violet powder (also known as Patent Blue V, Alphazurine 2G ) with detailed instructions on how to prepare an 11% sterile aqueous solution of the vital dye whose capacity to diffuse into the tissues and be absorbed by the lymphatics was higher than that of other vital dyes. Professor Kinmonth's visit sparked my life-long interest in the lymphatic system and my efforts to study the lymphatic system in different edema-producing conditions. An apparatus of my own design to measure the intra-lymphatic pressure (lymphomanometer) and perform direct visual and radiological lymphography was constructed and used in different types of lymphedema (Fig. 22.1). The results of my investigations on lymphatic pressure are beyond the scope of this chapter.

## Visual Lymphography and Radiological Lymphography

Visual lymphography is performed by injecting 0.1–0.3 mL of patent blue dye through a fine needle (27-gauge) into two to three interdigital spaces of the foot or hand. Gentle massage and active movements of the foot/hand are recommended to

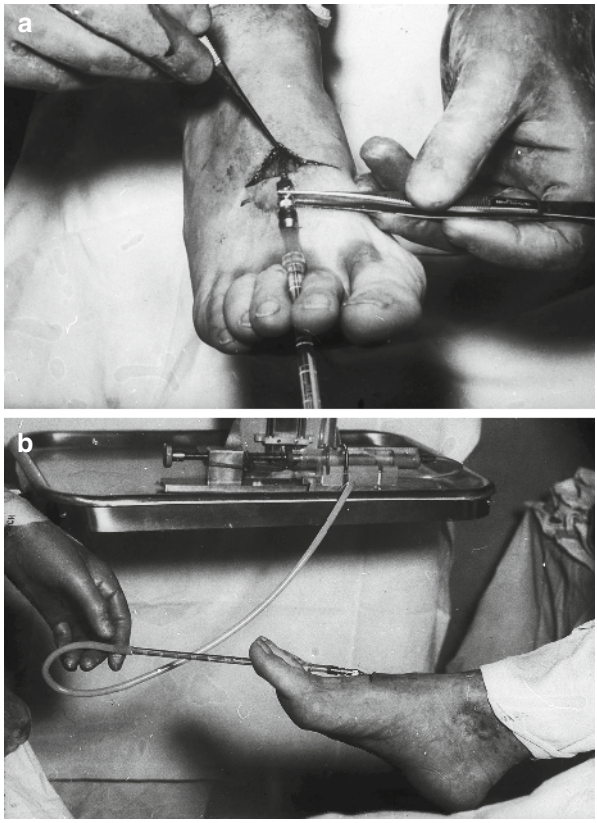


**Fig. 22.1** (**a**) Direct lymphography after lymphomanometry. This photograph shows a lymphatic vessel cannulation on the dorsum of the foot after injection of 0.2 mL of aqueous solution of patent blue violet into each of three interdigital spaces of the foot. (**b**) A 1-mm ID diameter micro-pipette attached by one end to a plastic tube connected to a syringe and a U water manometer and by the other to a 30-gauge needle. After the lymphatic pressure determination, a slow injection of ultrafluid lipiodol was performed by gradual turning of the metal piston on the syringe plunger

facilitate dye absorption and proximal progression. In patients with lymphatic truncal or nodal obstruction, a fine reticular cutaneous pattern (dermal backflow) may appear 5–15 cm proximal to the site of injection (Fig. 22.2). In addition to the detection of dermal backflow, visual lymphography is widely used intra operatively to facilitate the surgical identification of the lymphatic trunks travelling next to the greater saphenous vein or the superficial veins of the upper extremity in patients subjected to lymphovenous anastomosis or other lymphatic/node reconstruction procedures. The injection of patent blue can be performed in other areas of the body, such as the neck, testes (lymphocele, hydrocele), axilla, pelvis, etc., to visualize nodes or lymph trunks.

## *Radiological Lymphography*

After the dye injection has been absorbed by the lymphatics, one often may detect the blue lymph channels through the skin. A small transverse incision on the dorsum of the foot or hand is carefully performed using gentle strokes of the scalpel.

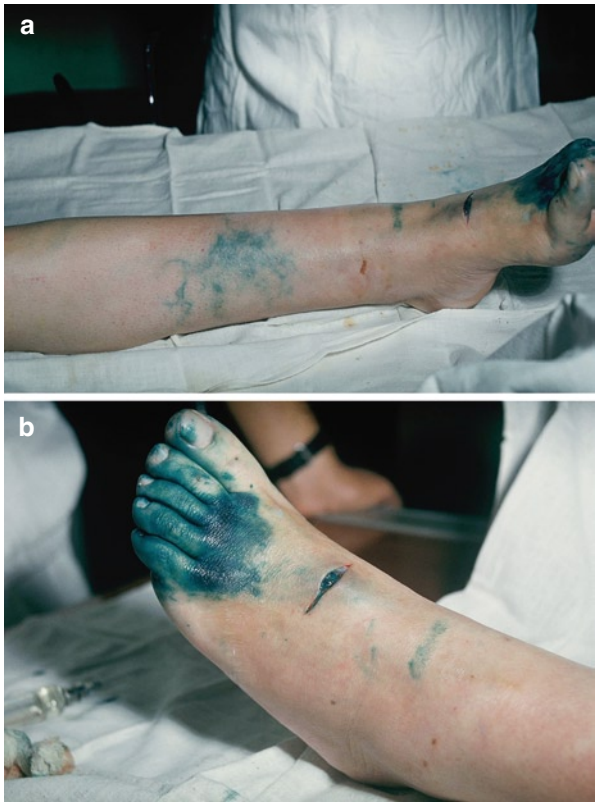


**Fig. 22.2** (**a**) Reflux of the dye to the skin is called "dermal backflow" and is strongly suggestive of lymphatic obstruction. (**b**) Visual lymphography. The interdigital injection of 0.2 mL of an 11% aqueous solution of patent blue violet into three to four web spaces produced this image

Magnification using 4+ surgical loupes or a 6+ surgical microscope is of great value in identifying the lymphatic trunks and distinguishing them from the neighboring veins. The lymphatic trunks appear stained in beautiful blue against the yellowish contrast of the fatty tissue. Dissection of the lymphatic is done carefully, freeing its anterior and lateral aspects and leaving the posterior segment intact to serve as a support for the cannulation. We used a # 30-gauge hypodermic needle with four small side holes in its distal 5 mm. The lateral holes drilled by a watchmaker decrease the resistance to the injection of the contrast material.

## Oil Contrast Lymphography

Oil soluble contrast materials such as ultrafluid lipiodol were used extensively in direct lymphography. Lipiodol contains 38% of iodine and is more viscous than its aqueous counterpart, "Conray" 280 or 420. The injection must be performed very slowly, using automatic injectors (1 mL every 6–7 min). A total of no more that 10 mL of lipiodol should be injected. The progress of the dye is monitored by serial

radiographs. The calf and thigh are massaged to assist the oil in its centripetal flow and further radiographs are taken at intervals of several hours. The contrast material has the disadvantage of producing inflammation of the vessels and, often, obstruction of the lymphatics. The latter complication is responsible for possible obstruction and lack of visualization of surgical lymphovenous anastomosis and thus, difficulty in assessing the patency and benefits of the procedure. Oil lymphography may also produce allergies and, on occasion, oil embolization, manifested by dyspnea, pyrexia, and slight hemoptysis. In spite of its risks, the procedure was extensively used throughout the world and was instrumental in the development of a lymphedema classification. The Kinmonth classification was based on clinical, lymphangiographic and histopathological studies. He described:

(a) The normal lymphatic system
(b) Hypoplasia of the lymphatic trunks
(c) Aplasia of the trunks and lymph nodes
(d) Hyperplasia or varicose dilatations of the lymph trunks

Primary lymphedemas have aplasia or hypoplasia of trunks with or without node aplasia. Secondary lymphedemas have abnormal patterns of lymph transport secondary to damage to the lymph trunks or to the nodes, such as in lymphadenectomy for malignancy and/or radiation.

Lymphography, as described, provided useful information on anatomy and morphology of the lymphatics. However, the procedure was tedious and time-consuming and requires exquisite patience and skill. It did not provide dynamic information and its use has been practically abandoned. Like many advances in science, lymphography has been a stepping-stone in the progress toward better technological procedures. Lymphoscintigraphy was the next step in the effort to obtain visualization and better information on flow dynamics and transport of fluids.[10-13] With the introduction of technetium-99m human serum albumin and advances in the digital gamma camera, improved resolution of the entire body lymphatic system was obtained.[14,15]

The lymphoscintigraphy technique as utilized in our department[15] requires the injection of 1 mc of Tc-$Sb_2$ $S_3$ mixed with 0.3–0.5 mL of normal saline, subcutaneously, into three interdigital web spaces of each foot. Before injecting the isotope, the patient exercises by walking for 5 min. Images are obtained in a gamma camera at 10 min intervals with a large field of view. Inguinal nodes are usually observed at or before 30 min. A normal lymphoscintigraphic pattern consists of symmetrical, bilateral transit of the tracer to the inguinal nodes within 1 h. Abnormal lymphoscintigraphic patterns include dermal backflow, complete obstruction, lymphoceles, reflux, and lateral channels. Because the tracer enters the lymphatics by diffusion rather than direct endolymphatic injection, lymphoscintigraphy accurately and reliably depicts the anatomy and function of the lymphatic system.[16]

Magnetic resonance imaging (MRI) has shown its value in congenital vascular anomalies. It has been used in the differential diagnosis of lipedema, venous edema, and lymphedema. Patients with lymphedema show a typical honeycomb pattern of the subcutaneous tissue. An advantage of the method is that it is possible to visualize

the lymphatic trunks or nodes proximal to lymphatic obstruction, something that lymphoscintigraphy cannot do.[17]

There is no doubt in my mind that the field of lymphatic imaging continues to evolve with the development of newer imaging methods such as positron emission tomography (PET), dynamic contrast-enhanced MRI (DCE-MRI), and color Doppler ultrasound (CDUS). These techniques provide structural and functional information using minimally invasive interstitial imaging techniques with new contrast agents. As occurs in the field of congenital vascular malformations, multi-modal techniques might be more appropriate for diagnosing and studying lymphatic diseases.[18]

The poor resolution of the conventional diagnostic method of radionuclide-based imaging has served as the incentive to investigate MRI and new contrast agents in the anatomical and functional evaluation of the lymphatics and lymph nodes in the diagnosis of lymphatic circulatory disorders, particularly in primary lymphedema. In a recent study, contrast-enhanced lymphangiography was performed with a 3.0-T MR unit after intracutaneous injection of gadobenate dimeglumine into the interdigital webs of the foot. This study demonstrated the possibility of visualizing the precise anatomy of lymphatic vessels and lymphatic nodes in patients with lymphedema, as well as functional data regarding lymph flow transport in the lymphatic vessels and nodes.[19]

From the direct lymphography of Kinmonth to the current wave of novel radiological techniques and newer contrast materials, many years of clinical and experimental investigations have elapsed, always in search of better methods and techniques to discover the true significance of the challenging and elusive lymphatics.

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