Diagnostic Lymphangiography

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Khairuddin Memon, Riad Salem, and Ron C. Gaba

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Introduction

The lymphatic system is complex; its imaging remains challenging because it links different structures together that can be involved in a wide variety of congenital, neoplastic, and infectious diseases [1]. Lymphangiography is the radiographic demonstration of the lymphatic system by injection of contrast material [2]. The earliest attempts at indirect lymphangiography were made by injection of radiopaque material into subcutaneous tissue with uptake in the adjacent nodes [3]. Direct injection into large palpable nodes, or lymphadenography, was also demonstrated [4]. In 1955, the technique of lymphangiography was developed to study lymphedema of lower extremities [5]. Given to the important role of lymphangiography in lymphatic interventions, such as thoracic duct embolization [6], as well as development of new contrast agents and imaging techniques such as magnetic resonance (MR) lymphangiography, contrast-enhanced ultrasound, and positron emission tomography, the field of lymphatic imaging is growing [1]. The purpose of this chapter is to review the procedural elements of traditional bipedal lymphangiography with stepwise illustration of the interventional radiologic technique.

K. Memon, MD • R. Salem, MD, MBA
Department of Radiology,
Section of Interventional Radiology,
Northwestern University,
251 East Huron Street,
Chicago, IL 60611, USA

R.C. Gaba, MD (✉)
Department of Radiology,
Interventional Radiology Section,
University of Illinois at Chicago Medical Center,
1740 West Taylor Street, MC 931,
Chicago, IL 60612, USA

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Case

A 73-year-old woman with a history of chronic lymphocytic leukemia underwent chest radiograph for diagnostic evaluation of dyspnea. The radiograph revealed a left-sided pleural effusion (Fig. 98.1), and ultrasound-guided thoracentesis yielded milky white fluid (Fig. 98.2). Fluid analysis showed a triglyceride level of 909 mg per dL, indicating a lymphatic source. Lymphatic invasion by tumor with secondary chylothorax was suspected, and the patient was initially managed with dietary fat restriction for 3 weeks. However, radiographic evaluation demonstrated no resolution of the chylothorax, indicating failure of conservative therapy. The patient remained symptomatic and was therefore referred to interventional radiology (IR) for lymphangiography and possible thoracic duct embolization.

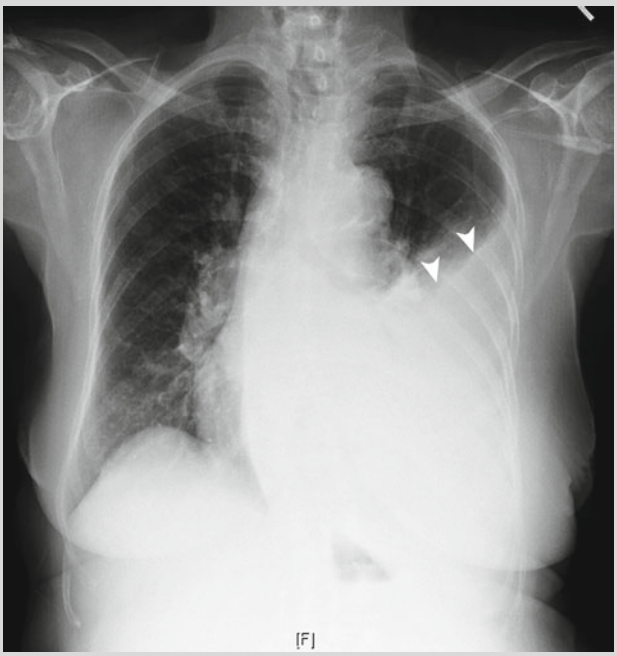

Fig. 98.1 Frontal chest radiograph demonstrates moderate-sized left pleural effusion (*arrowheads*)

Fig. 98.2 Photograph of evacuated pleural fluid reveals milky white color compatible with diagnosis of chylothorax

Diagnostic Lymphangiography: Annotated Step-by-Step Interventional Approach

Injection of contrast material for lymphatic imaging can be accomplished by following methods [1]: direct endolymphatic injection where contrast is injected directly into distally located lymph vessels, indirect interstitial contrast injection where it is taken up by the surrounding lymph vessels, and indirect intravascular injection where contrast accumulates in organs belonging to reticuloendothelial system and consequently passes through the lymphatic system. Herein, we describe direct endolymphatic injection, which may be performed on an outpatient basis [7].

1. *Blue dye injection*: A mixture of 3 mL of 2 % lidocaine and 2 mL of methylene blue dye (2.5 % patent blue V dye; Guerbet Laboratories, Aulnay-sous-Bois France) is injected into the subdermal tissues on the dorsal aspect of the foot between the toes using a 25- or 27-gauge needle. Approximately 0.1–0.2 mL is injected per web space.
2. *Lymphatic channel identification*: The lymphatic channel is visually identified along the dorsum of the foot after it fills with dye (Fig. 98.3). This typically occurs 10 min after blue dye injection.

Fig. 98.3 Photograph taken 10 min after subdermal methylene blue dye injection between web spaces of toes shows blue colored lymphatic channels (*arrowheads*) visible on dorsum of foot

Fig. 98.4 Photograph demonstrates dissection and exposure of blue lymphatic channel (*arrowhead*)

3. *Lymphatic channel dissection*: A lymphatic channel is selected, and a parallel incision is made. The duct is exposed using blunt dissection (Fig. 98.4), and fat and loose areolar tissue are stripped from the lymphatic channel. The duct is prepared for cannulation by securing it with suture and adhesive strips (Fig. 98.5).
4. *Lymphatic channel cannulation*: The vessel is cannulated using a 30-gauge needle (Rabinov Sialography Catheter; Cook Medical, Bloomington IN) (Fig. 98.6). The catheter and needle are secured with adhesive strips. If the first cannulation attempt is unsuccessful, a more central duct up near the ankle may be chosen and the process repeated.
5. *Contrast injection*: The standard material used for lymphangiography is ethiodized oil (Lipiodol; Guerbet Laboratories, Villepinte, France). This oil may remain in lymph nodes for months and sometimes years, allowing one to evaluate the effects of treatment or progression of the disease. After lymphatic duct cannulation, slow intra-lymphatic injection of the contrast agent is performed using a mechanical injector (PHD Ultra syringe pump; Harvard Apparatus, Holliston MA). The normal dose is 6–7 mL of contrast medium injected

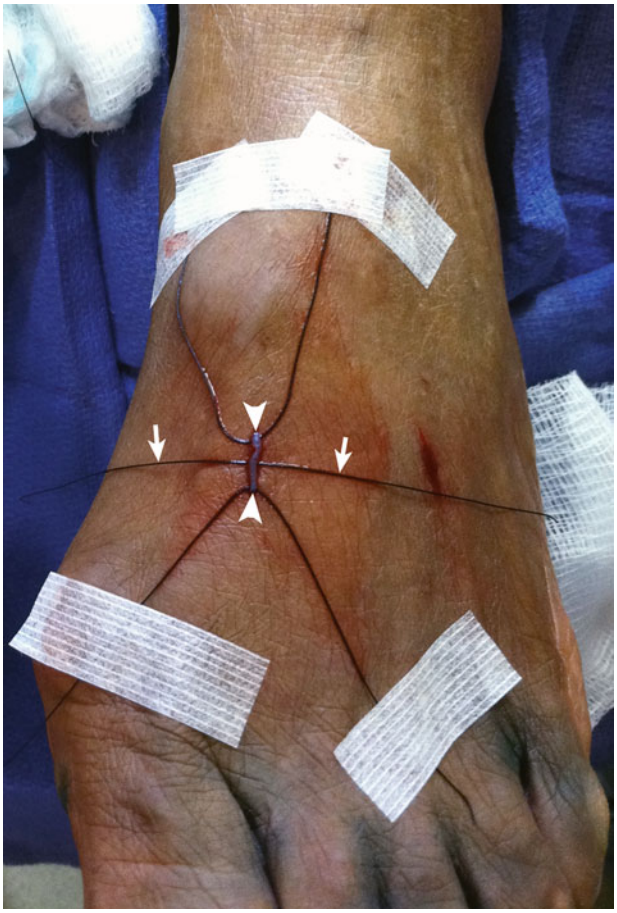

Fig. 98.5 Photograph illustrates preparation of lymphatic channel (*arrowhead*) for cannulation. Lymphatic channel secured using silk sutures and adhesive strips. Central suture (*arrows*) tied around lymphatic channel after cannulation to secure needle within duct

into the lymphatics of each extremity. The rate of injection is 4–10 mL per h, depending on the size of the lymphatic channel. An injection that is too rapid may rupture the lymphatic channel.

Fig. 98.6 Photograph shows 30-gauge cannula within lymphatic duct prior to contrast injection

6. *Diagnostic imaging*: Multiple fluoroscopic (Fig. 98.7) or radiographic images of the lower extremities, pelvis, and abdomen are then obtained for diagnostic purposes.
7. *Wound closure*: After the study is complete, the lymphatic cannula is removed, and the wound is thoroughly cleansed, sutured, and covered with adhesive bandages. The sutures are removed after 10–12 days [7].

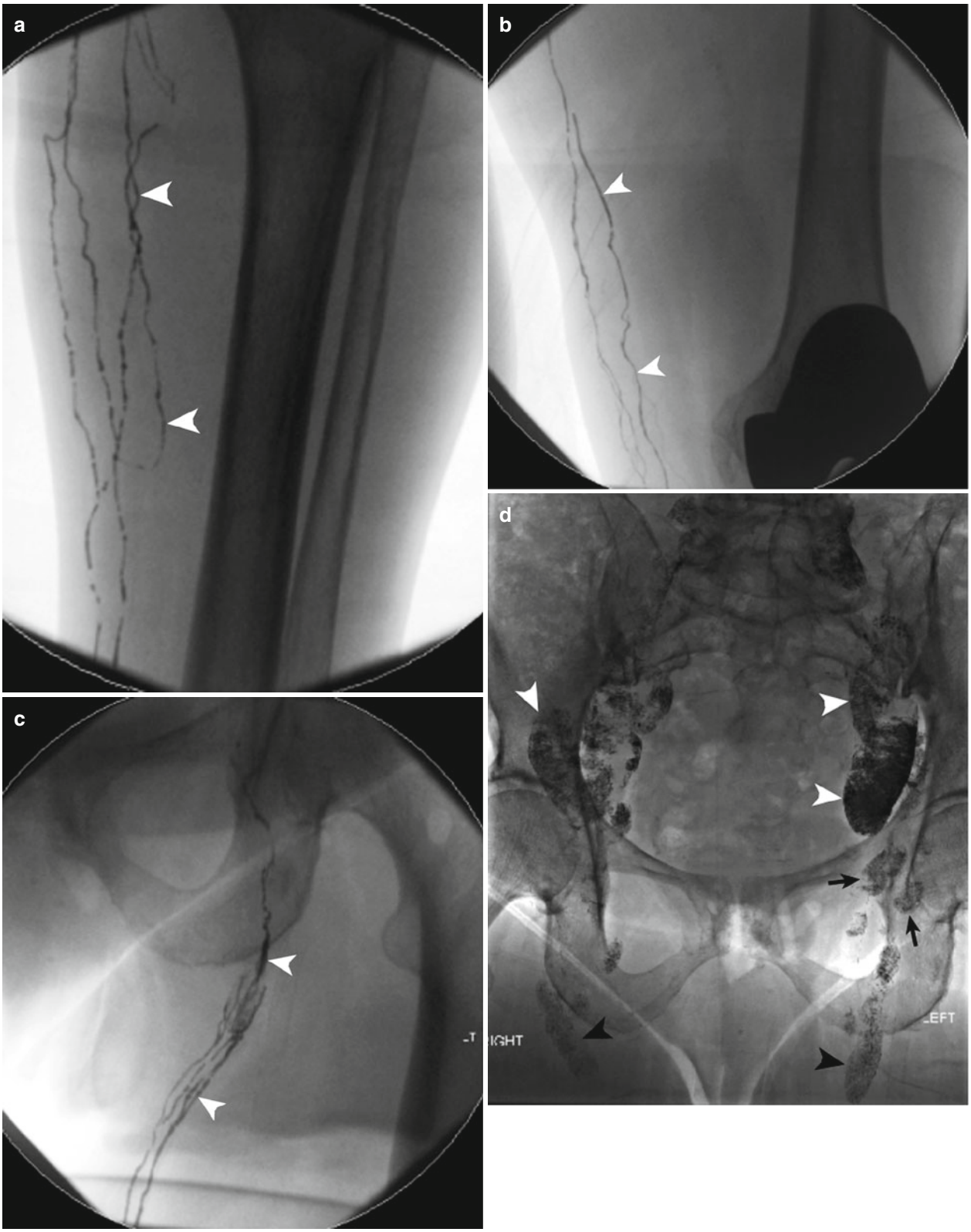

Fig. 98.7 Fluoroscopic spot images from lymphangiogram show ethiodized oil opacification of normal lymphatic ducts (*arrowheads*) in the lower leg (**a**), thigh (**b**), and pelvis (**c**). Fluoroscopic spot image of the pelvis (**d**) demonstrates ethiodized oil accumulation within enlarged femoral (*black arrowheads*), inguinal (*black arrows*), and iliac (*white arrowheads*) lymph nodes bilaterally

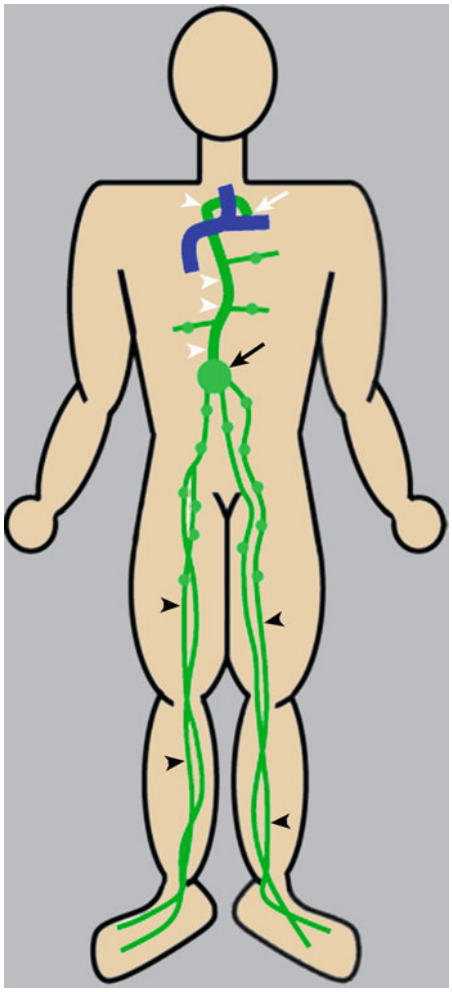

Fig. 98.8 Anatomic figure delineating lymphatic system anatomy. Lymphatic ducts travel along medial aspects of both lower extremities (*black arrowheads*). At level of upper thigh and pelvis, intervening femoral, inguinal, and iliac lymph nodes present. Lymphatic ducts traverse pelvis and lower abdomen and coalesce into cisterna chyli (*black arrow*), a dilated lymphatic sac. Thoracic duct (*white arrowheads*) begins at level of second lumbar vertebra, runs along thoracic spine, and receives intercostal lymphatic channels. Thoracic duct empties into central venous system near confluence of jugular and subclavian veins (*white arrow*)

Discussion

The lymphatic system drains interstitial fluid from small capillaries to lymphatic vessels through lymph nodes and finally to the venous system via a common jugular anastomosis (Fig. 98.8). Above the diaphragm, lymph vessels represented by the thoracic ducts usually merge and drain into the venous angle between the internal left jugular vein and the left subclavian vein (Fig. 98.8). Lymphatic capillaries allow the drainage of approximately 10 % of all interstitial fluid, while the remaining 90 % is taken up by the venous system. The interstitial fluid continuously circulates along the lymphatic vessels passing through a series of holding points (lymphatic valves and lymph nodes). When lymphatic circulation is impaired, interstitial fluid accumulates in the extremities. The composition of lymph differs from that of plasma with a higher percentage of lipids (chylomicrons), particularly in the thoracic duct and a lower percentage of proteins. As a result, obstruction of the thoracic duct, whether because of trauma or mediastinal invasion, results in chylous lymph accumulation in the thorax better known as chylothorax [1].

Lymphangiography may be used for imaging of various disorders of the lymphatic system, including chylous ascites, chylothorax, chyluria, external genital lymphedema, lympholymphatic and lymphovenous anastomoses, perineural and perivascular spaces, lymphocele, and lymphatic fistula. Lymphangiography also plays a major role in the imaging and staging of various neoplasms such as Hodgkin's lymphoma, non-Hodgkin's lymphoma, testicular tumors, cervical carcinoma, and sentinel lymph node imaging in breast carcinoma. The detailed imaging findings of these pathologies have been described elsewhere [7]. Lymphangiography has also been employed in thoracic duct embolization to treat massive chylothorax after iatrogenic injury to thoracic duct [6].

Lymphangiography is a well-tolerated procedure. However, precaution should be taken when performing this procedure in patients with significant cardiac or pulmonary disease or right-to-left cardiac shunt. The major complications of lymphangiography are caused by the dye and contrast materials rather than the technique [7]. Among all complications, pulmonary oil embolization is the most frequent. It usually does not produce clinical symptoms unless there is an underlying cardiopulmonary disorder, excess amounts (greater than 20 mL) of contrast material are given, there are patent lymphovenous communications, or the patient is hypersensitive to the oil [7]. Pulmonary infarction is most probably due to mechanical obstruction of the lung capillaries by oil droplets [7]. Other complications have also been described, such as hypersensitivity to methylene blue dye and ethiodized oil [8], intra-alveolar hemorrhage with complete reversibility [9], hypothyroidism [10], and systemic arterial embolization to the brain or kidney, which is a rare complication in patients with right-to-left cardiac shunts [11, 12].

Various novel imaging techniques have been developed to enhance the assessment of pathologies of lymphatic system. These included positron emission tomography, ultrasonography of lymph nodes, ultra-small superparamagnetic iron oxide-enhanced MR lymphography, indirect interstitial computed tomography and MR lymphography, unenhanced cross-sectional imaging of the lymphatic system, indirect lymphangioscintigraphy, and sentinel node imaging. These techniques are described in detail elsewhere [1].

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