Lymphedema (LE) develops from an imbalance between the generation and removal of interstitial fluid and proteins. Swelling results when the lymphatic system fails to remove interstitial fluid at the rate it is accumulating. Although lymphedema is primarily a clinical diagnosis\(^1\), \(^2\), modern imaging can identify features of the disorder that cannot be easily discerned by clinical examination. They permit interrogation of the anatomic and pathophysiologic processes underlying the disorder.

**Diagnostic Imaging in Lymphedema:**

Dramatic advances in medical imaging have occurred over the last 20 years. All the common imaging modalities have been applied to the evaluation of patients with lymphedema. Oil Contrast Lymphography was the original imaging technique for evaluating the lymphatic system and it continues to be utilized occasionally for identification and demonstration of lymphatic channels, such as in preoperative planning.

**Ultrasound:**

Ultrasound is useful for the evaluation of deep venous thrombosis, determination of tissue consistency, and measurement of epifascial depth as a quantitative index of edema (arrows in Figure 1). In unexplained edema of the legs, duplex ultrasound examination of the venous system is mandatory for patient management. Duplex ultrasound with high frequency probe (10-20MHz) is a reliable and objective way to image the complex lymphedema areas (e.g. of breast, axilla, or back) and various anatomical abnormalities in addition to venous and arterial hemodynamics. The efficacy of lymphedema treatment may be assessed with duplex ultrasound evaluation measuring the epifascial hypoechogenic space. (Figure 1; Reduction of lymphedema volume).

**Computerized Tomography (CT):**

The utility of CT images in lymphedema derives from the exquisite anatomic detail as well as information about fluid content of tissues that they provide. If iodinated contrast is injected, they also provide information about tissue permeability to water soluble molecules. In lymphedema, CT can reveal structural or mechanical causes of lymphatic obstruction such as tumors, synovial cysts (Figure 2), or other mass lesions. This can be particularly useful within the chest, abdomen, or pelvis. Even without intravenous contrast, they often display subtle differences in tissue density resulting from edema\(^3\). (Figure 3)

**Magnetic Resonance Imaging (MRI):**

MRI images demonstrate fluid as well as anatomic detail in addition to subcutaneous edema, reticular lymphangiectasis (pathological dilatation of lymph vessels), lymph cysts and lakes, and dilated lymph channels. MRI can visualize peripheral lymph trunks, lymph nodes, and soft tissue. However, lymphoscintigraphy is more helpful in addressing the functional status of lymphatic obstruction. Using these two imaging modalities together is helpful for anatomical diagnosis and delineating the disarranged pattern of lymphedema.

Swollen subcutaneous tissue reveals low signal intensity on T1-weighted image (water/fat is dark) and high signal intensity on T2-weighted images (water/fluid is white). Short-TI-IR (STIR) images are useful for evaluation of trabecular structures and fluid collections in the subcutaneous tissue with high signal contrast as well as for evaluation of lymphedema\(^4\). Among

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**Figure 1.** Left Upper quadrant Ultrasound before (left) and after (right) manual lymphatic drainage.

**Figure 2.** Large synovial cyst (white arrow) arising from the left hip resulted in LE of the left leg, as depicted in lymphoscintigram in right pane of figure.

**Figure 3.** Left pelvic sarcoma demonstrated in PET scan in right pane resulted in lymphedema of left leg (arrow in right pane). CT image in left pane demonstrates subcutaneous epifascial swelling and subtle difference in fat density in left thigh (asterisk) compared to right.
its many uses in patients with edema include: localization of lymphedema to subfascial or epifascial compartments (Figure 4) (white area indicated with asterisk), demonstration of enlarged lymph vessels, and identification of structural causes of edema as with CT[5].

Lymphoscintigraphy (LS): Although widely employed for sentinel node localization, LS is also very useful for evaluating (LE) and other lymphatic disorders. Examples include differentiation of primary, secondary and venous lymphedema, and other lymphatic etiologies. LS is indicated in evaluation of edema of unclear etiology for clarification of therapy guidance. Undiagnosed or untreated LE is associated with progressive disease, recurrent infections, and resistance to therapy. Congenital lymphedema is variable in time of onset and severity, and increases surgical risk[6, 7]. Therefore, early and accurate diagnosis of the condition is important.

Cutaneous (skin) or subcutaneous (layer under skin) injection is followed by mild exercise of the limbs and/or ambulation. Images are usually acquired in whole body format at ~15-20 minutes, at ~2-3 hours, and sometimes the next day. The radiation dose to the patient is low from the small doses of Tc99m that are employed.

Normal lymphoscintigraphy demonstrates prompt flow to regional nodes by 15–20 min. in discrete, nontortuous lymphatics. Images at 2-3 hr. depict fairly intense nodal uptake, with some uptake in liver and spleen (Left panel, Figure 5). Abnormal findings include slow or no flow (Figures 5 and 6), tortuous or deviated channels, collateral or crossover flow, localized or diffuse dermal retention. Areas of inflammation or infection usually reveal increased retention of radiotracer, as a reflection of macrophage (scavenge cells) activation, increased numbers of phagocytic cells (ingest microorganisms and foreign particles), and regional stasis and edema with delayed clearance of interstitial fluid (Figures 5 and 6).

Summary and Conclusions: Lymphedema, in most cases, is established by history and detailed physical examination. It can also be evaluated with ultrasound of the epifascial compartment and demonstrated with MRI and CT.

The severity of lymphatic functional deficits and mapping of lymph drainage can be evaluated with lymphoscintigraphy®. Lymphatic imaging plays a pivotal role in defining the etiology and therapy of lymphedema. Lymphedema is a treatable disorder, and early recognition and treatment should be promulgated.

REFERENCES:

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