Ultrasonography in the Assessment of Lymph Node Disease

Hans-Peter Weskott, MD[a,*], Sanshan Yin, MD[b]

KEYWORDS

• Reactive lymph nodes • Metastatic lymph nodes • Lymphoma • Ultrasonography • Color Doppler • B-Flow • Contrast agent

KEY POINTS

- The lymphatic system consists of a network of interconnected lymphatic channels collecting lymph fluid from the interstitium. The lymph may contain antigens entering a lymph node (LN) while LNs take up and filter the lymph on its way through the lymph node meshwork.
- Ultrasonography has become the first imaging modality in patients with inflammatory or malignant diseases to evaluate both peripheral and abdominal LN status. Several sonographic imaging modes including B-mode, elastography, color and pulsed-wave Doppler techniques, B-flow, and contrast-enhanced ultrasonography (CEUS) can be applied to characterize LNs.
- The sensitivity for detecting regional LN metastases on B-mode depends on the primary tumor, size, and echogenicity, but is limited by the minuscule size of tumor infiltrations. Besides gray-scale patterns, evaluating the vascularity and perfusion add great value in characterizing LNs and distinguishing normal from suspicious LNs.
- A typical reactive LN has an oval shape with an even thickness of its preserved cortex and regular vessel architecture.
- LN metastases are mostly round shaped and hypoechoic to cystic; an echogenic hilum is missed and its vessel architecture is chaotic.
- The presence of a dominantly peripheral vascularity in LNs is highly suspicious of malignancy.
- At present, no single gray-scale or color Doppler criterion exists that can reliably differentiate between reactive LN enlargement and involvement of a non-Hodgkin lymphoma.
- There are considerable overlaps of sonographic features, especially between inflammatory and non-Hodgkin lymphomas.
- Ultrasound-guided biopsies are in most cases successful in defining the characteristics of LNs.
- The use of contrast agents is most advantageous in the detection of tissue perfusion, thus confirming the effect of chemotherapy or radiation therapy.

Videos of color Doppler and B-flow examinations accompany this article at http://www.ultrasound.theclinics.com/

THE LYMPHATIC SYSTEM

The lymphatic system consists of a network of interconnected lymphatic channels collecting lymph fluid from the interstitium by blind-ending lymphatic capillaries to carry it to the next regional lymph nodes (LNs). It is estimated that about 2 L of lymph fluid is produced within 24 hours. The

The authors have nothing to disclose.

[a] Central Ultrasound Department, Klinikum Siloah, KRH, Hannover, Germany; [b] Department of Ultrasound, Key Laboratory of Carcinogenesis and Translational Research, Peking University Cancer Hospital & Institute, Beijing 100142, People's Republic of China
* Corresponding author.
E-mail address: weskotthp@t-online.de

Ultrasound Clin 9 (2014) 351–371
http://dx.doi.org/10.1016/j.cult.2014.03.008
1556-858X/14/$ – see front matter

size of these tiny tubes allows only small molecules and particles (including antigens) to pass this network. The lymphatic vessels have a valve system that allows the lymph to flow only in one direction, preventing intraluminal fluid to flow backward.

Depending on the size of an LN, the lymph enters an LN by 1 or several afferent lymph vessels and runs through a reticular meshwork to be filtered and analyzed on its way through the LN. The cleared lymph is drained by the efferent lymphatic vessels and enters the systemic circulation via the thoracic duct into the left and right subclavian vein. The efferent lymph vessels may also function as an afferent lymphatic vessel when it again enters the next LN for clearance. Some lymphatic vessels may bypass the first (sentinel LN) or secondary LN and enter the next, or one of the next, LNs (**Fig. 1**).[1]

Lymph nodes have a capsule of dense connective tissue. Each LN is composed of 3 parts. The subcapsular cortex consists of the primary and secondary follicles, which are surrounded and separated by the interfollicular cortex. The secondary follicles develop when they encounter antigens. The lymph may contain antigens entering an LN via the afferent lymphatic vessels, whereas most lymphocytes enter the LN via blood vessels. B lymphocytes home to follicles in the superficial cortex where they interact with follicular dendritic cells. The paracortex consists of the deep cortical units where T lymphocytes home to the deep cortical unit (DCU) and interact with dendritic cells (**Fig. 2**). When coming in contact with antigens via specialized venules, namely high endothelial venules (HEV), the palisades of the HEV open to allow lymphocytes to migrate to the interstitium to encounter specific antigens. HEVs are specialized postcapillary venous swellings characterized by plump endothelial cells as opposed to the usual thinner endothelial cells found in regular venules. HEVs enable naïve lymphocytes to move in and out of the LNs from the circulatory system. In contrast to the endothelial cells from other vessels, the endothelial cells of HEV have a plump appearance different from the flat morphology of endothelial cells that line other vessels, and are therefore called high endothelial cells by reference to their thickness. Lymphocytes that are not involved in this process leave the LN via the efferent lymphatic vessels. The medulla with the medullary cords is located in the center of the LN. The LNs take up and filter the lymph on its way through the LN meshwork. This meshwork provides lymphocytes, antigen-presenting cells, and macrophages to interact with immunocompetent cells.[2] The feeding and draining blood vessels enter the LN from the hilum and branch arbitrarily up to the follicles (**Fig. 3**). Some LNs are supplied by accessory arteries and veins entering the LN extrahilarly.

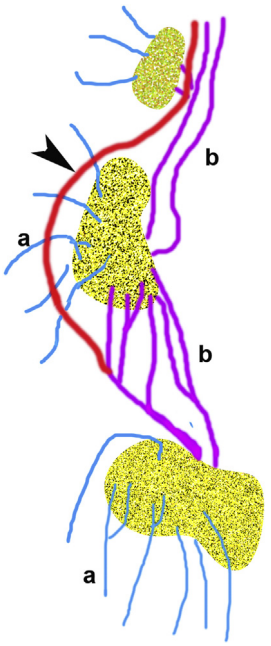

Fig. 1. Scheme of lymph node (LN) chains (a, afferent vessels; b, efferent vessels). *Arrowhead* indicates a bypassing efferent lymphatic vessel draining fluid into a secondary LN.

In contrast to LNs, lymphatic nodules have no capsule; they are also known as mucosa-associated lymphatic tissue (MALT) and can be found most often in the upper gastrointestinal (GI) tract. Part of the MALT is made up of Peyer plaques of the terminal ileum. The GI tract is the most frequent extranodal site of non-Hodgkin lymphomas (NHLs), but accounts for only about 5% of all NHLs.

ULTRASONOGRAPHY EXAMINATION MODES

Sonographic assessment of LNs includes number and size of LN, shape, echotexture (including microcalcifications and cystic changes), B-mode architecture, margin, stiffness, vascular patterns, and evaluating the tenderness of enlarged LNs. To evaluate these different morphologic and perfusion features, several sonographic imaging modes are available. Besides B-mode, stain and shear-wave based elastography, color and pulsed-wave (PW) Doppler techniques, B-flow, contrast-enhanced ultrasonography (CEUS), and ultrasound-guided biopsies have become valuable tools in the diagnostic workup of LN. B-Mode is the basic