Dual-Energy Computed Tomography Applications for the Evaluation of Cervical Lymphadenopathy

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KEYWORDS

• Dual-energy CT • Head and neck imaging • Cervical lymphadenopathy • Cervical lymph nodes

KEY POINTS

- The head and neck region is rich in lymph nodes, and cervical lymphadenopathy owing to various causes is very common.
- Imaging is frequently requested to confirm the presence of lymphadenopathy, differentiate lymph nodes from other neck masses or cysts, and characterize the nodes as benign or malignant.
- Imaging evaluation of cervical lymph nodes in patients with head and neck squamous cell carcinoma is crucial.

INTRODUCTION

The head and neck region is rich in lymph nodes, and cervical lymphadenopathy owing to various causes is very common. Imaging is frequently requested to confirm the presence of lymphadenopathy, differentiate lymph nodes from other neck masses or cysts, characterize the nodes as benign or malignant, and aid in identification of the cause. Furthermore, imaging evaluation of cervical lymph nodes in patients with head and neck squamous cell carcinoma (HNSCC) is crucial for several reasons. First, lymph node status strongly influences prognosis; the 5-year survival of patients with HNSCC and no nodal involvement is roughly twice that of patients with lymph node metastases.[1,2] Second, the patient's lymph node status is a key factor in planning of surgical selective neck dissection, and in defining the radiation field extent in patients treated with radiotherapy.[1] Third, nonsurgical treatment options require monitoring of response and posttreatment restaging of the primary tumor and regional lymph nodes. Finally, after successful treatment resulting in disease remission, imaging surveillance is performed for early detection of tumor or nodal recurrence.

Several imaging modalities have been used for evaluation of cervical lymph nodes, especially in patients with HNSCC. Computed tomography (CT), MR imaging, ultrasound imaging, and PET-CT are currently used for this purpose.[3] The sensitivity and specificity of different imaging modalities for diagnosis of cervical lymph node metastases vary between studies, with PET-CT performing slightly better than CT or MR imaging in a number of studies.[4,5] It should be noted, however, that the diagnostic performance of all imaging modalities is nearly the same for clinically negative nodes.[6] Dual-energy (DE) CT scanning is an advanced form of CT scanning in which image acquisition

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is performed at 2 different energies, enabling generation of additional reconstructions and quantitative analysis not possible with single energy CT. In this article, DE CT applications for the evaluation of cervical lymphadenopathy are reviewed.

CONVENTIONAL COMPUTED TOMOGRAPHY IMAGING OF CERVICAL LYMPH NODES

CT scanning is a cornerstone of head and neck imaging and the most widely used imaging modality for evaluation of cervical lymphadenopathy. Typically, a lymph node is considered pathologic based on its size, although different size limits have been proposed.[1] A frequently used size limit defines pathologic nodes as larger than 10 mm in short axis diameter, except for retropharyngeal nodes (>5 mm), and level I and II nodes (>11 mm).[3] However, nodal size alone is neither sensitive nor specific enough; a large percentage of malignant nodes are as small as 5 mm, and many large nodes are reactive.[3] Other than size, additional criteria for the diagnosis of metastases include a rounded shape and grouping of 3 or more nodes in a drainage site for the primary tumor. Unfortunately, these criteria minimally improve the diagnostic performance of CT scanning.[1]

The presence of central necrosis is the most accurate CT sign of metastatic nodes form HNSCC,[1] and is caused by infiltration of the medulla of the node by malignant cells leading to necrosis. The center of the node is, thus, of lower attenuation than the cortex of the node, and the appearance is more conspicuous after contrast. Despite the very high specificity of this sign, the frequency of necrosis decreases in smaller nodes and so does the sensitivity of CT for its detection.[1,3]

DUAL-ENERGY COMPUTED TOMOGRAPHY SCANNING OF CERVICAL LYMPH NODES

Approaches to DE scanning include dual-source scanners with dual x-ray source-detector combinations acquiring images simultaneously at high and low energy, and single source scanners with either rapid kVp switching, split filters in the tube collimator housing, or dual layer detectors.[7] A detailed discussion of the different DE CT systems is beyond the scope of this article, but can be found in the article in this issue. Whether a dual or a single source system is used for scanning, DE postprocessing applications have been developed as a supplement to conventional CT, providing the radiologist with multiple additional sets of images, each having its own unique characteristics and potential benefits.[8,9]

Virtual Noncontrast Images

With DE CT, it is possible to identify and subtract iodine from contrast enhanced images to obtain a virtual noncontrast (VNC) image series (**Fig. 1**). An additional unenhanced scan is, thus, not needed and the radiation dose can be reduced in studies where both an unenhanced and enhanced acquisition are performed.[9] The subjective quality of VNC images in the evaluation of cervical lymphadenopathy has been reported as comparable with true unenhanced images.[10,11] Objectively, Fu and colleagues[11] analyzed the CT attenuation values of lymph nodes in 41 patients with 98 cervical lymph nodes and found no differences between VNC and true unenhanced images. In another study by Yang and colleagues,[10] lymph node attenuation values were slightly overestimated on VNC images, but

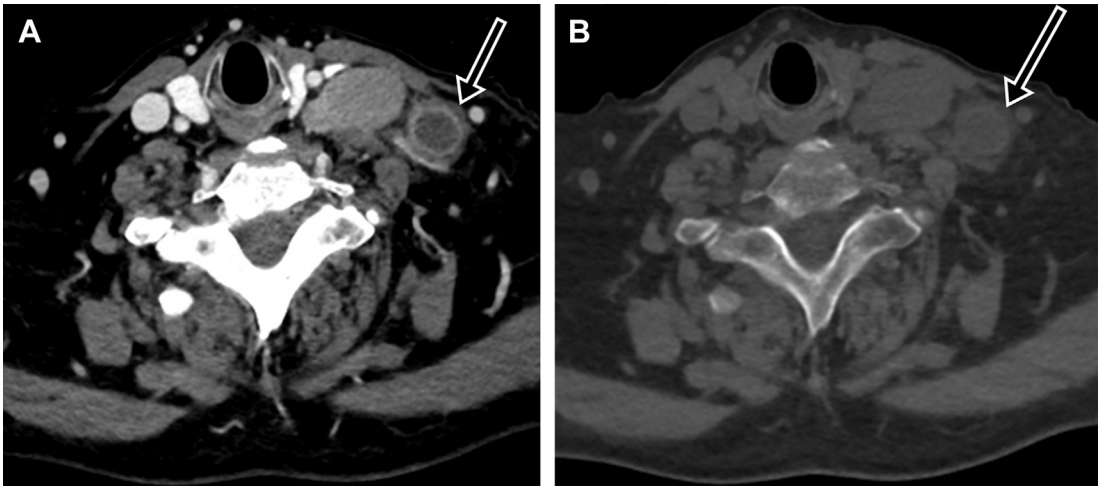

Fig. 1. Virtual noncontrast image. (*A*) Axial contrast-enhanced dual-energy computed tomography image of the neck showing a necrotic left supraclavicular metastatic lymph node (*arrow*). (*B*) Virtual noncontrast reconstruction showing subtraction of the enhancement in the cervical vessels and soft tissue. Notice the subtraction of the rim enhancement of the necrotic lymph node (*arrow*).