Role of Dual-Energy Computed Tomography in Thoracic Oncology

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KEYWORDS

• Dual-energy CT • Spectral imaging • Pulmonary blood volume • Pulmonary nodule • Lung cancer • Iodine map • Thoracic malignancy • Virtual noncontrast image

KEY POINTS

- Dual-energy CT (DECT) imaging has broadened the potential of thoracic oncologic imaging by offering multiple postprocessing datasets with a single acquisition.
- The most commonly used material-specific imaging techniques in thoracic oncologic imaging include virtual noncontrast (VNC) imaging, iodine-enhanced image (iodine map), automatic bone removal, and pulmonary blood volume (PBV).
- The characterization of the degree and pattern of contrast enhancement in solitary pulmonary nodules (SPNs) is considered valuable in differentiating benign and malignant nodules with a suggested cutoff value of 20 Hounsfield units of iodine uptake at DECT images acquired 3 minutes after intravenous contrast administration.
- 3-D iodine-related attenuation (IRA), also known as iodine volume, of primary lung cancers is significantly associated with tumor differentiation grade, where high-grade tumors tend to have lower iodine volumes than low-grade tumors. Future directions for the use of DECT include the potential correlation of iodine uptake with gene expression.
- DECT improves characterization of metastatic disease in patients with thoracic malignancies and has potential applications in assessment of tumor response to chemotherapy, radiation therapy planning, and prediction of tumor recurrence.

INTRODUCTION

Dual-energy CT (DECT) imaging has broadened the potential of thoracic oncologic imaging by offering multiple postprocessing datasets with a single acquisition. Although conventional single-energy CT imaging results in an anatomic depiction of the imaged area based on differences in physical density between adjacent structures, DECT imaging extends this capability because, in principle, structures of a similar density but with different elemental compositions may be distinguished based on differing photon absorption at different photon energies.[1] Hence, DECT imaging enhances the physical density anatomic display made possible with single-energy CT by moving toward imaging elemental composition within a given structure. This technique attempts to differentiate specific materials in the generated images, the so-called material specific imaging,

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for example, to selectively depict iodine distribution within an image.[1] Only substances with strong photoelectric effect, however, such as calcium, iodine, barium, and xenon, for example, can be easily differentiated from other body tissues that have weak photoelectric effect.[2]

Current DECT acquisition methods include dual-source scanner with 2 tube-detector systems with or without beam filtration, rapid voltage switching (spectral imaging), dual-layer detector, split filter technique, and sequential scanning. Besides the low and high peak kilovoltage image series, a weighted average image dataset (most similar to conventional 120 kVp images) and virtual monoenergetic or monochromatic image series (VMIs) are usually reconstructed for clinical interpretation. In addition, several material-specific imaging applications are currently available. The most commonly used material-specific imaging techniques in thoracic imaging include virtual noncontrast (VNC) imaging, iodine-enhanced image (iodine map), automatic bone removal, and pulmonary blood volume (PBV). The use of these techniques has shown established advantages and promising new directions for thoracic oncologic imaging, including evaluation of lung nodules and thoracic malignancies, staging of lung cancer, surgical planning, assessment of response to treatment, and characterization of complications, such as incidental pulmonary embolism (PE). The purpose of this article is to review the current status of clinical applications for DECT in thoracic oncology.

INDETERMINATE SOLITARY PULMONARY NODULE AND LUNG MASSES

DECT permits quantification of the degree of enhancement and identification of calcification of the lung nodules in a single postcontrast CT acquisition without the need of precontrast image acquisition, therefore lowering radiation dose.[3]

The characterization of the degree and pattern of contrast enhancement in SPNs is considered valuable in differentiating benign and malignant nodules. A study of Chae and colleagues[3] evaluated 49 patients with pulmonary nodules scanned before and 3 minutes after intravenous contrast administration. They compared CT numbers of SPN on true nonenhanced weighted average images and VNC images as well as the CT number of SPN on iodine-enhanced image (iodine map) and the actual degree of enhancement (CT number on enhanced weighted average image minus CT number on nonenhanced weighted average image), showing good correlation. The diagnostic accuracy for characterization of malignant nodules using a cutoff value of 20 Hounsfield units (HU) of iodine uptake on iodine-enhanced image was comparable to that of using the degree of enhancement (sensitivity, 92% and 72%; specificity, 70% and 70%; and accuracy, 82.2% and 71.1%), highlighting the potential of DECT to improve SPN characterization in a single postcontrast acquisition without additional radiation dose (**Fig. 1**).[3] On VNC images, 85.0% (17 of 20) of calcifications in the SPN and 97.8% (44 of 45) of

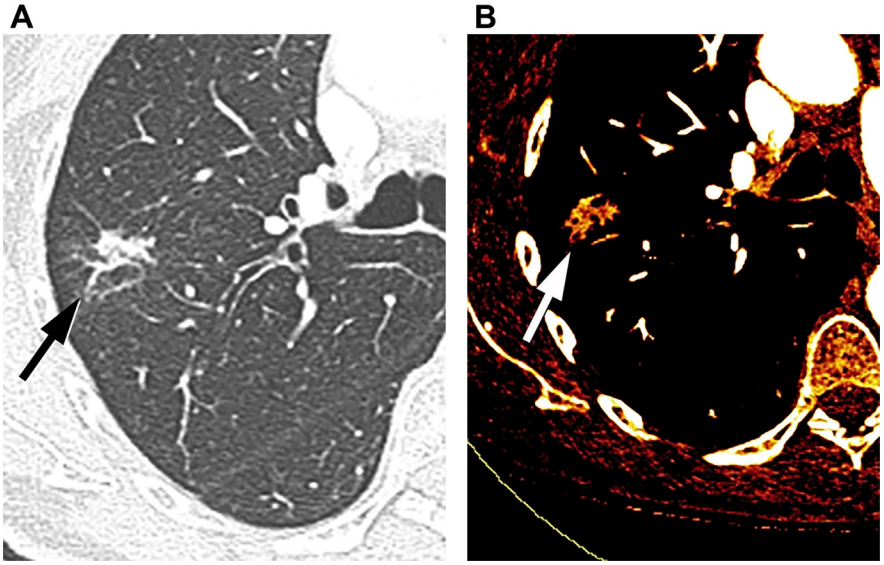

Fig. 1. SPN. (*A*) Lung window settings image shows an irregular right upper lobe nodule (*arrow*). (*B*) Color-coded Iodine map image shows contrast enhancement (35 HU of iodine uptake) (*arrow*). Biopsy reveled lung adenocarcinoma. A threshold of 20 HU of iodine uptake at DECT acquired 3 min after intravenous contrast administration has been proposed to differentiate benign from malignant lung nodules.