Imaging–Bronchoscopic Correlations for Interventional Pulmonology

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KEYWORDS

- Interventional pulmonology • CT • Virtual bronchoscopy
- Endobronchial ultrasound (EBUS)
- Transbronchial needle aspiration (TBNA)

The development and rapid advancement of both bronchoscopic, CT and ultrasound imaging technology has had considerable impact on the management of a wide variety of pulmonary diseases. The synergy between these newer imaging modalities and advanced interventional endoscopic procedures has led to a revolution in diagnostic and therapeutic options in patients with both central and peripheral airway disease. Given the broad clinical implications of these technological advances, only the most important areas of interventional pulmonology in which imaging has had a major impact will be selectively reviewed to highlight fundamental principles.

Whereas interventional pulmonology is often conceptually organized around different technologies and instruments such as stents, lasers, and electrocautery, among others, it is important to emphasize applications of the same technology may vary widely in terms of their methods, risks, and benefits depending on the nature of the indication. For example, while the method in which a stent is placed may not alter, indications and complications are significantly different between patients with benign and malignant disease.[1] As a consequence, particular emphasis will be placed first on evaluation of CT-bronchoscopic correlations in the evaluation and treatment of central airway disease, followed by CT- bronchoscopic correlations in the evaluation of peripheral lung disease, in particular, pulmonary nodules. Following this, the rapidly evolving topic of interventional bronchoscopic approaches to the treatment of emphysema will be reviewed.

Although attention will be primarily be placed on CT bronchoscopic correlations (including CT-fluoroscopy and virtual bronchoscopy), emphasis will also be placed on newer imaging technologies including endobronchial ultrasound (EBUS), electromagnetic navigation and guidance, and Doppler ultrasound site selection for bronchoscopic treatment of emphysema.

BRONCHCOSCOPIC IMAGING CORRELATIONS IN THE EVALUATION OF CENTRAL AIRWAY DISEASE

CT Imaging Technique

Key to the recent ability of imaging to serve as a guide for interventional bronchoscopic procedures has been the introduction and now widespread availability of multidetector CT scanners capable of acquiring contiguous and/or overlapping high-resolution images throughout the entire

This article originally appeared in *Radiologic Clinics of North America*, Volume 47, Issue 2, March 2009.
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Thorac Surg Clin 20 (2010) 103–119
doi:10.1016/j.thorsurg.2009.12.008
1547-4127/10/$ – see front matter

thorax in a single breathhold. This has led to a near revolution in the variety of methods by which the airways and lung can be visualized and evaluated, including the use of quantitative CT techniques.[2,3] Although a truly detailed discussion of this topic is beyond the scope of the present review, the following general points regarding CT technique for evaluating the airways are emphasized.

Optimal evaluation of both the central and peripheral airways requires at a minimum contiguous high-resolution images throughout the entire chest (**Fig. 1**). While contiguous 1- to 1.5-mm sections are sufficient for evaluating both the central and peripheral airways, in our experience, optimal visualization of the peripheral airways is best obtained with use of submillimeter overlapping sections whenever possible (typically 0.75 mm every 0.5 mm) especially in those cases for which three-dimensional (3D) segmentation or virtual bronchoscopic evaluation of the peripheral (sixth to ninth order) airways is deemed clinically important.[4] Although the use of low-dose technique (50 to 80 mAs) is more than sufficient to evaluate the central airways and in most cases the peripheral airways as well, in those cases for which 3D and/or virtual endoscopic views are intended, best results necessitate the use of routine standard CT exposure factors. Additional considerations include acquisition of select expiratory high-resolution images in cases in which tracheal and bronchial dynamics are of concern, or to confirm the presence of obstructive small airway disease.

Axial CT images are sufficient for evaluating most airway abnormalities;[3,5] however, there are inherent limitations of these for assessing the central airways, including (1) limited ability to detect subtle airway stenosis; (2) underestimation of the craniocaudad extent of disease; (3) difficulty displaying the complex 3D relationships of the airway to adjacent mediastinal structures; (4) inadequate representation of airways oriented obliquely to the axial plane; and (5) difficulty assessing the interfaces and surfaces of airways that lie parallel to the axial plane. Another relative limitation of axial CT scanning is the generation of a large number of images for review, especially with multidetector scanners, which may generate data sets containing hundreds of images. As a consequence, use of retrospectively reconstructed 2D and 3D images should be considered routine for bronchoscopic correlation to overcome these limitations.

Virtual bronchoscopy (VB) in particular may facilitate central airway evaluation by allowing the user to ''bypass'' an obstructing lesion, accurately measure its length and cross-sectional area, and to look backward from distal to proximal, ''retroflexing'' the virtual bronchoscope, which is not possible with the conventional bronchoscope.[6] Virtual bronchoscopy is especially complementary to bronchoscopy in the assessment of patients with high-grade airway stenoses, particularly for assessing the patency of the airways beyond the site of a stenosis. In one study[7] comparing virtual and conventional bronchoscopy in 20 patients with malignant airway stenoses, while high-grade stenoses were viewed equally well with both techniques, virtual bronchoscopy offered the advantage of viewing the airway beyond the site of

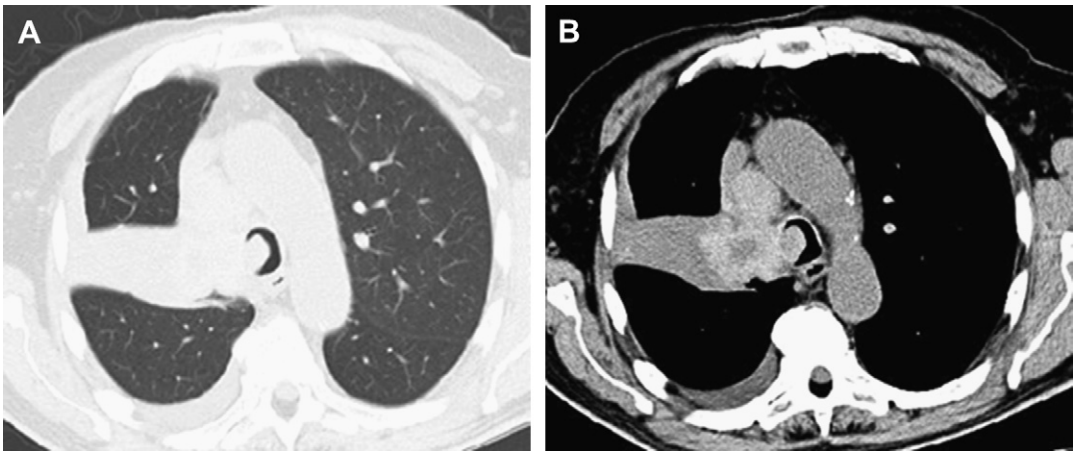

Fig. 1. Central airway lesions. (*A*) Section through the lower trachea imaged with lung windows shows a well-defined obstructing lesion. (*B*) Identical image as in *A* imaged with mediastinal window clearly demonstrates the true extent of tumor which appears denser then adjacent peripheral atelectasis. The ability to demonstrate the extent of tumor is critical to deciding the optimal method for interventional bronchoscopic therapy.