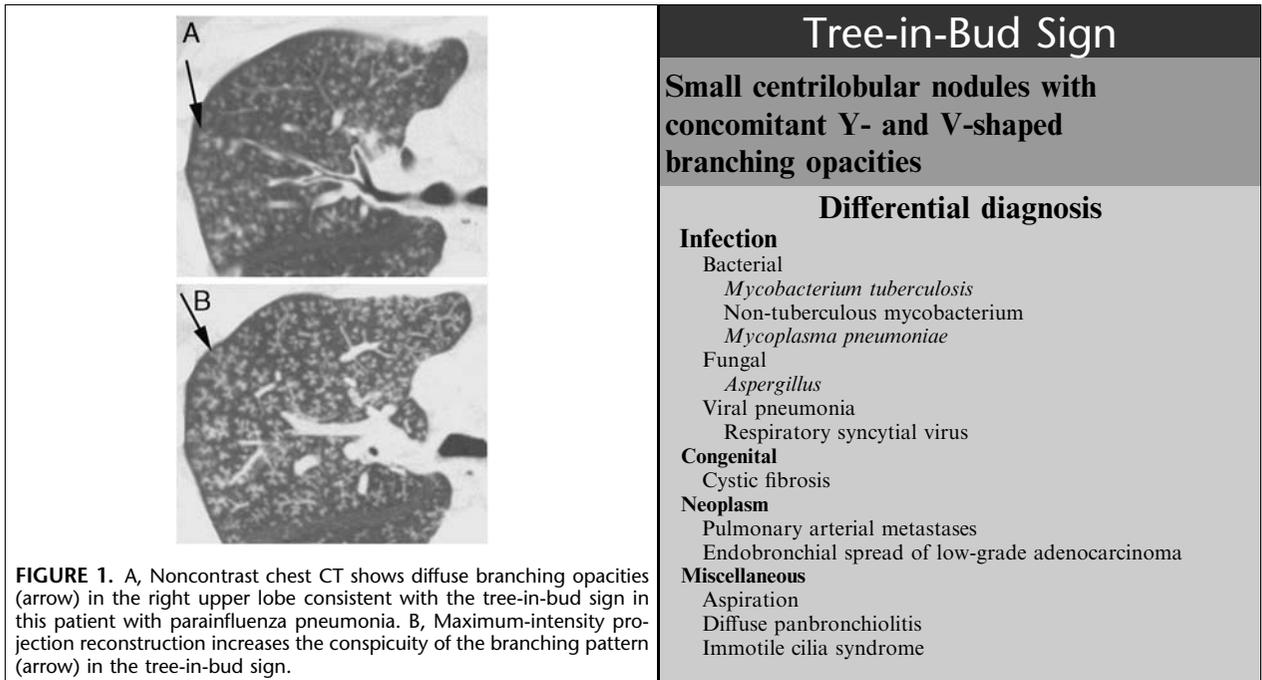


“Tree-in-Bud Sign”

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Appearance: The tree-in-bud sign is the constellation of small centrilobular nodules and concomitant branching opacities, which mimics the branching pattern of a budding tree. The nodules and connecting branches are peripheral but spare the subpleural lung.

Explanation: The smallest component of the lung surrounded by septa is the secondary pulmonary lobule; this portion of the lung is supplied by a lobular bronchiole and arteriole, which are usually not seen on CT.¹ However, the diseased small airway often becomes visible as fluid replaces gas in the small airway and inflammation thickens the bronchiolar walls.^{1,2} This results in a V- or Y-shaped branching pattern, which together with centrilobular nodularity forms the tree-in-bud sign (Fig. 1). Infiltration of the small pulmonary arteries may also rarely result in the tree-in-bud sign given that the pulmonary arteries and small airways travel together and, therefore, share the same branching morphology.

Discussion: Although the tree-in-bud sign was initially assumed to be pathognomonic for *Mycobacterium tuberculosis*, it is now recognized as a common pattern that can be seen in many pulmonary diseases and disorders including infection (most common), aspiration, and rarely neoplastic conditions (such as low-grade adenocarcinoma). In *Mycobacterium tuberculosis*, the tree-in-bud sign results from impaction of caseous material in the bronchioles of the secondary pulmonary lobule.^{1,3} Identification of the tree-in-bud sign along with other imaging findings such as bronchial wall thickening or narrowing, bronchiectasis, consolidation, cavitation, and/or necrotic lymphadenopathy, as well as an appropriate exposure history, supports the diagnosis. This is in contradistinction to non-tuberculous mycobacterial pneumonia in which centrilobular or tree-in-bud nodularity and bronchiectasis with volume loss (usually most severe in the right middle lobe and lingula) predominate. Non-tuberculous mycobacterial pneumonia usually occurs in middle-aged to elderly women who often have low body mass index and kyphoscoliosis. The tree-in-bud sign may also be present in other types of pneumonia (such as *Staphylococcus aureus* and *Haemophilus influenzae*) as pus or inflammatory secretions impact the distal small airways.³ Post-processing techniques such as maximum-intensity projections (MIP) may facilitate the recognition of the tree-in-bud pattern (Fig. 1).^{4,5} In patients with aspiration, a gravitational and lower lung predominance of the tree-in-bud pattern is often observed. In patients with cystic fibrosis, a combination of upper lung predominant bronchiectasis, bronchial wall thickening, mucous plugging, and air trapping or mosaic attenuation is commonly encountered. A rare but under-recognized cause of the tree-in-bud sign is distant metastatic disease (e.g. from breast, hepatic, ovarian, prostatic, and renal primaries). The appearance is due to carcinomatous endarteritis—inflammatory intimal hyperplasia of the small pulmonary arteries secondary to filling with tumor cells.⁴⁻⁶

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