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The Tree-in-Bud Sign¹

APPEARANCE

The tree-in-bud sign is a finding seen on thin-section computed tomographic (CT) images of the lung (1–3). Peripheral (within approximately 3–5 mm of the pleural surface), small (2–4 mm in diameter), centrilobular, and well-defined nodules of soft-tissue attenuation are connected to linear, branching opacities that have more than one contiguous branching site, thus resembling a tree in bud (1–4) (Figs 1, 2).

EXPLANATION

The tree-in-bud pattern represents bronchiolar luminal impaction with mucus, pus, or fluid, which demarcates the normally invisible branching course of the peripheral airways (1–3,5,6). In addition, dilated and thickened walls of the peripheral airways and peribronchiolar inflammation can contribute to the visibility of affected bronchioles (1,5,6). In histopathologic studies, the tree-in-bud appearance correlates well with the presence of plugging of the small airways with mucus, pus, or fluid; dilated bronchioles; bronchiolar wall thickening; and peribronchiolar inflammation (1,6,7).

DISCUSSION

The tree-in-bud sign has become a popular descriptive term for various diseases of the peripheral airways in which mucous plugging, bronchial dilatation, and wall thickening are present (2,5). In addition, indirect signs of bronchiolar disease, such as air trapping or subsegmental consolidation, may be present.

Index terms:

Bronchi, abnormalities, 671.265
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The tree-in-bud pattern is particularly well depicted by thin-section CT. It is not visible on chest radiographs.

The appearance of the tree-in-bud sign is closely linked to the anatomy of the secondary pulmonary lobule. Each secondary lobule is supplied by a lobular bronchiole and a lobular artery that are located in the center of the lobule. Under normal circumstances, the intralobular bronchiole is less than 1 mm in diameter and is not normally visible on CT scans (8). However, diseased bronchioles with mucous plugging, wall thickening, or dilatation can be visualized on thin-section CT scans, often displaying the tree-in-bud phenomenon.

The tree-in-bud sign has primarily been used as a descriptive term for abnormalities found on CT scans of the lung in patients with endobronchial spread of *Mycobacterium tuberculosis* (6). In the past several years, however, it has become clear that the finding of a tree-in-bud sign on a CT scan is not specific for a single pulmonary disease entity, but it can be found with a large number of conditions, primarily those of infectious origin, but also with immunologic disorders, congenital disorders, neoplasms, aspiration of irritant substances, and disease entities with idiopathic causes (2,5).

Pulmonary infectious disorders involving the small airways are the most common causes of the tree-in-bud sign (2). Any infectious organism, including bacterial, mycobacterial, viral, parasitic, and fungal agents, can involve the small airways and cause a tree-in-bud pattern. In pulmonary infectious disorders, the tree-in-bud sign has most commonly been described in patients with endobronchial spread of *M tuberculosis* (6,9). In patients with pulmonary tuberculosis, the tree-in-bud pattern is the most characteristic, but not pathognomonic, CT feature of active endobronchial spread and can be found in 72% of patients with active disease (6).

At histopathologic examination, the tree-in-bud opacities seen on CT scans were correlated with caseous material in the small airways (6). The terminal tufts of the tree-in-bud pattern may represent inflammation with caseous material in the respiratory bronchioles and alveolar ducts, whereas the stalks may represent caseous material within the terminal bronchiole (6). Similarly, bronchogenic dissemination of atypical mycobacterial organisms or pyogenic bacteria can result in tree-in-bud opacities (10–12) (Fig 2). Less frequently, the tree-in-bud sign is seen with viral and fungal infections (eg, invasive as-

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Figure 1. Photograph of a twig obtained from a budding tree in spring.

pergillosis of the airways) and *Pneumocystis carinii* pneumonia (2,5).

The tree-in-bud sign is also a common finding on thin-section CT scans in patients with diffuse panbronchiolitis (1,7). In histopathologic studies, the centrilobularly distributed nodular and branching linear opacities at CT correspond to thickened and dilated bronchiolar walls with intraluminal mucous plugs (1,7).

In addition, various congenital disorders can cause diseases of the small airways that demonstrate a tree-in-bud pattern. In patients with cystic fibrosis, thick-walled mucus- or pus-filled bronchioles are frequently seen as branching or nodular centrilobular opacities at CT, usually associated with central bronchiectasis (2). Similar findings can be seen in patients with chronic infections of the small airways due to dyskinetic cilia syndrome, yellow nail syndrome, or congenital immunodeficiency states (5,10). Primary pulmonary lymphoma has recently been reported as a rare but important differential diagnosis for the tree-in-bud pattern. Lymphomatous involvement of the lung can simulate the radiologic findings of bronchiolitis (13).

In summary, the tree-in-bud sign is a characteristic and easily detectable CT finding in patients with disease of the small airways. It is a useful sign, which, in the appropriate context of clinical findings and laboratory features, almost invariably points to inflammatory disease of the small airways.

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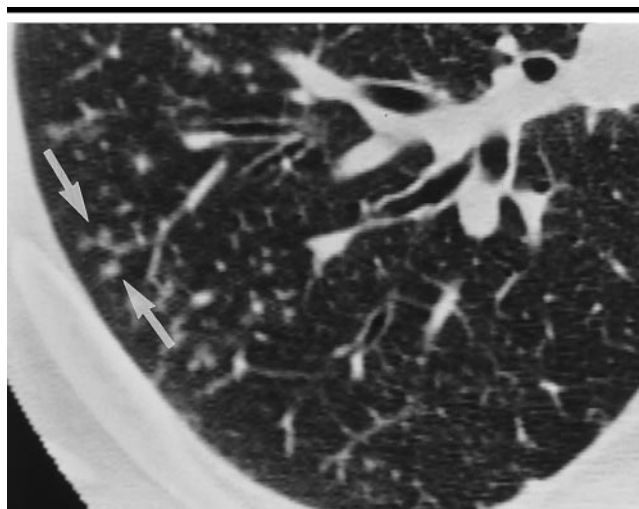


Figure 2. Thin-section CT scan obtained in a 29-year-old man with acute myeloid leukemia after bone marrow transplantation. The patient had a history of fever and cough. Image shows multiple, small, centrilobular nodules of soft-tissue attenuation connected to linear branching opacities (arrows). Note the morphologic similarities to the photograph of the tree in bud (Fig 1). At serologic examination, an infection with *Mycoplasma pneumoniae* was confirmed.

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