Recognizing the signs of bronchiolitis on HRCT

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Abstract: High-resolution CT (HRCT) can play an important role in the assessment of bronchiolitis. Direct signs of bronchiolitis include centrilobular nodules, bronchial wall thickening, and bronchiolectasis. Indirect signs include mosaic perfusion, hyperlucency, mosaic or diffuse airtrapping, vascular attenuation, and increased lung volumes. Expiratory HRCT scans are considered an essential part of the workup, because airtrapping may be evident only on these scans. In infectious cellular bronchiolitis, the centrilobular nodules typically have a branching, or "tree-in-bud," appearance, whereas in hypersensitivity pneumonitis, these nodules have a round or nonbranching pattern. The HRCT signs of constrictive bronchiolitis include mosaic perfusion, mosaic airtrapping, vascular attenuation, bronchiolectasis, and bronchiectasis; centrilobular nodules are usually absent. (J Respir Dis. 2005; 26(5):222-228)

Bronchiolitis is defined as inflammation of bronchioles that are less than 3 mm in diameter. This inflammation primarily involves the terminal bronchioles, the more distal respiratory bronchioles and, in some cases, the adjacent alveolar ducts and spaces.¹

Bronchiolitis can be categorized as inflammatory or fibrotic. Inflammatory forms include cellular bronchiolitis, respiratory bronchiolitis, diffuse panbronchiolitis, and follicular bronchiolitis. Constrictive bronchiolitis and primary neuroendocrine cell hyperplasia are examples of fibrotic disorders. Bronchiolitis is a known complication of asthma and bronchitis and is now well documented in patients with emphysema.

In this article, we will describe the imaging techniques used to assess small-airway disease, with the main focus on the role of high-resolution CT (HRCT) in bronchiolitis. Our review will not cover bronchiolitis that is secondary to asthma, bronchitis, or emphysema. It also will not address proliferative bronchiolitis, or bronchiolitis obliterans with organizing pneumonia, because this entity produces a consolidative inflammatory response to many insults in the lungs and does not have a dominant imaging feature.¹

IMAGING TECHNIQUES
In clinical practice, the most common imaging techniques that are used in the assessment of airway disease include projection imaging (classic chest radiography) and multichannel CT with HRCT images of the lung parenchyma. Projection imaging is less accurate than HRCT in making the diagnosis of emphysema, bronchiectasis, and small-airway disease. In patients who have small-airway disease that is secondary to asthma or bronchiolitis, findings on projection imaging are often normal.

Multichannel CT scanning should be performed at total lung capacity (TLC) and at functional residual capacity (FRC) in patients with suspected airway disease. Contiguous 5-mm images and 1.25-mm images should be reconstructed at 10-mm intervals from both the inspiratory and expiratory multichannel CT acquisitions. Most multichannel CT scanners use "beam modulation" to obtain high-quality images at the lowest effective dose for the patient. Additional isotropic 0.625-mm-diameter cubic voxel 3-dimensional data sets can be reconstructed and viewed as 2-dimensional projection imaging or 3-dimensional volume-rendered sets of images viewed in any direction. The "post-processed" group of images is helpful in identifying subtle or confusing airway abnormalities and for surgical planning, if necessary.

HRCT FINDINGS
The HRCT signs of bronchiolitis can be either direct or indirect. Direct signs include centrilobular nodules, bronchial wall thickening, and bronchiolectasis. Indirect signs include mosaic perfusion and hyperlucency on images obtained at TLC; mosaic or diffuse airtrapping on images obtained at FRC; vascular attenuation; and increased lung volumes.

Normal small bronchioles are usually not seen on HRCT; however, when inflammation surrounds them, they appear as nodules in the center of the secondary pulmonary lobule.² Centrilobular nodules are the small (1 to 3 mm) nodules that develop in the central portion of the secondary pulmonary lobule; they are readily visible on HRCT scans in patients with some forms of bronchiolitis. Bronchiectasis refers to the lack of tapering and the dilatation of the bronchiole lumen in the small airways (diameter, less than 3 mm) in the periphery of the HRCT images.
Mosaic perfusion/hyperlucency refers to the variability in the attenuation of the lung secondary to airtrapping and/or decreases in perfusion. The term "mosaic" is used because the lung attenuation varies rapidly across a relatively linear interface and may produce a polygonal or quilt-like appearance. Hyperlucency is the result of decreased attenuation or density in the areas of mosaic perfusion. Mosaic perfusion and hyperlucency apply to HRCT images that are obtained at TLC. Mosaic or diffuse airtrapping refers to the appearance of the lungs on HRCT images that are obtained at FRC. The areas of decreased attenuation or density evident on the expiratory images correspond to obstructed small airways that produce hyperexpansion of the distal alveolar structures. Expiratory HRCT scans are considered an essential part of the workup in patients with bronchiolitis, because airtrapping may be evident only on these scans.

In patients with constrictive bronchiolitis or bronchiolitis obliterans, expiratory CT images have been shown to provide the best correlation with indices of physiologic impairment. These areas of decreased density may be diffuse, patchy, or mosaic in patients with bronchiolitis, but the mosaic pattern of airtrapping is specific for bronchiolitis.

**Cellular bronchiolitis**

The causes of cellular bronchiolitis can be categorized as infections or hypersensitivity reactions. Viral causes include respiratory syncytial virus (RSV), adenovirus, and parainfluenza virus. Bacterial pathogens include *Mycoplasma pneumoniae*, *Mycobacterium tuberculosis*, and *Mycobacterium avium* complex. Fungal pathogens may include *Aspergillus fumigatus* or *Cryptococcus neoformans*. Hypersensitivity reactions are seen in patients with hypersensitivity pneumonitis, such as farmer's lung or pigeon breeder's disease.

Typical direct observations on HRCT scans from patients with cellular bronchiolitis include centrilobular nodules, bronchial wall thickening, and bronchiolectasis. Indirect observations include mosaic airtrapping, mosaic perfusion, and vascular attenuation.

In infectious cellular bronchiolitis, the centrilobular nodules typically have a branching, or "tree-in-bud," appearance (Figure 1). Figure 2 shows infectious cellular bronchiolitis in a patient with Kartagener syndrome. In hypersensitivity pneumonitis, the centrilobular nodules have a round or nonbranching pattern (Figure 3). **Respiratory bronchiolitis**

This is one of a number of smoking-related lung diseases, including emphysema, bronchitis, lung cancer, Langerhans cell histiocytosis, and desquamative interstitial pneumonia. Respiratory bronchiolitis may be associated with interstitial lung disease, particularly when significant symptoms are present.

The typical HRCT findings in respiratory bronchiolitis include nonbranching centrilobular nodules, bronchiolar wall thickening, airtrapping, and patchy areas of ground-glass opacity (Figure 4). Ground-glass opacities represent areas of diffuse increased lung attenuation that may be the result of interstitial inflammation and/or airspace fluid or inflammation.

The vessels in the lung are not obscured by ground-glass opacities. There is no evidence of air-bronchogram formation, because considerable air remains in the alveoli. **Follicular bronchiolitis**

This condition is usually secondary to connective tissue disease and can also be seen in immunodeficient patients. Follicular bronchiolitis is part of the spectrum of lymphoproliferative diseases and may sometimes overlap with lymphoid interstitial pneumonia.

Most cases of connective tissue disease-induced follicular bronchiolitis are secondary to rheumatoid arthritis, Sjögren syndrome, or scleroderma. It has been reported that 17% of patients with rheumatoid arthritis, 46% of patients with scleroderma, and 20% to 31% of patients with Sjögren syndrome have follicular bronchiolitis.

Typical imaging observations include centrilobular nodules, airtrapping, cyst formation, and patchy ground-glass opacities (Figure 5). Larger, more unusual-appearing centrilobular ground-glass opacities or consolidative opacities may be present. **Diffuse panbronchiolitis**

This is a bronchiolitis of unknown origin, although it is thought to be secondary to infection, and it generally responds to antibiotic therapy. Diffuse panbronchiolitis, which usually occurs in Asian women, produces progressive constrictive bronchiolitis, bronchiolectasis, and bronchiectasis. The associated HRCT findings include bronchial wall thickening, centrilobular nodule formation with extensive branching, mosaic perfusion, mosaic airtrapping, vascular attenuation, bronchiolectasis, and bronchiectasis (Figure 6). **Constrictive bronchiolitis**

The causes of constrictive bronchiolitis include infection (especially RSV and *Mycoplasma* infections), collagen vascular disease, graft versus host disease, and toxic fume (particularly nitric oxide) inhalation. Constrictive bronchiolitis may also be cryptogenic or idiopathic. The projection image is frequently normal.

HRCT findings in patients who have constrictive bronchiolitis include mosaic perfusion, mosaic airtrapping, vascular attenuation, bronchiolectasis, and bronchiectasis (Figure 7). Centrilobular...
Primary diffuse neuroendocrine cell hyperplasia

This rare condition primarily affects women who are in their fifth and sixth decades. Usually, patients with primary diffuse neuroendocrine cell hyperplasia have never smoked and present with progressive airway obstruction.

Pathologically, there is evidence of diffuse hyperplasia and dysplasia of the neuroendocrine cells. Numerous neuroepithelial bodies, prominent carcinoid tumorlets, and carcinoid tumors involving the large and small airways may develop in some patients. The typical HRCT findings include mosaic perfusion, mosaic airtrapping and, occasionally, small (3 to 5 mm) nodules (Figure 8).

References:

REFERENCES


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