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High-Resolution Computed Tomography Evaluation of Interstitial Lung Disease for the Pulmonologist

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Abstract

Purpose of Review Interstitial lung disease encompasses variety of entities that have diverse clinical manifestations, prognosis, and treatment options. It is imperative to identify the specific disease early as delays in diagnosis can lead to irreversible damage. Studies demonstrate that treatment with certain medications and avoidance of exposures that potentiate injury can reduce disease progression.

Recent Findings The use of high-resolution computed tomography has become essential for the evaluation of interstitial lung disease. Being able to accurately identify the characteristic patterns of abnormalities can lead to expedited diagnosis and has obviated the need of other diagnostic studies such as lung biopsy.

Summary High-resolution computed tomography imaging of the chest has changed the approach to the diagnosis and treatment of interstitial lung diseases. Given the numerous entities that compose this group and options for individualized treatment plans, it is imperative for pulmonologists to recognize the defining imaging characteristics.

Keywords Interstitial lung disease · High-resolution computed tomography · Usual interstitial pneumonia · Nonspecific interstitial pneumonia · Chronic hypersensitivity pneumonia · Smoking-related interstitial lung disease

Introduction

Interstitial lung disease (ILD) encompasses a wide variety of disease entities with different clinical presentations, characteristic CT (computed tomography) findings, disease progression, and treatments. With the advancements in imaging, the emphasis on pathologic tissues diagnosis has waned. Instead, a thorough history including time course of symptoms, exposure history (occupational, environmental, and smoking for example), personal and family history of auto-immune and connective tissue disease, and findings on high-resolution computed tomography (HRCT) scans of the chest can lead to a definitive diagnosis obviating the need for biopsy. This in turn can allow for practitioners to discuss with patients the expectations of disease progression, specific treatment regimens aimed at the precise disease, and overall prognosis as each ILD has unique clinical courses.

As research in the field of ILD continues to grow, the pharmacologic treatment options also increase as both new medications are developed and previous disease-specific medications have expanded clinical indications. Many of these medications can alter the rate of progression, thereby making it imperative to make an early and accurate diagnosis. These include examples such as antifibrotic therapies for fibrotic lung disease and steroid-sparing agents such as mycophenolic acid for rheumatologic diseases. HRCT imaging of the chest, when used in the context of a history and physical, is a vital piece of information in this diagnostic process. This review will discuss the imaging characteristics of common interstitial lung diseases seen in practice.

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American Thoracic Society Classification

In 2002, an expert panel of clinicians, radiologists, and pathologists in adult pulmonary diseases standardized idiopathic interstitial pneumonia (IIP) classification. They classified them in 7 distinct clinicopathologic entities: idiopathic pulmonary fibrosis (IPF), nonspecific interstitial pneumonia (NSIP), cryptogenic organizing pneumonia (COP), acute interstitial pneumonia (AIP), respiratory bronchiolitis–associated interstitial lung disease (RB-ILD), desquamative interstitial pneumonia (DIP), and lymphoid interstitial pneumonia (LIP) [1]. In 2013, American Thoracic Society/European Respiratory Society (ATS/ERS) provided an update based on new publications. Major updates included regrouping major IIPs into chronic fibrosing, smoking-related, acute/subacute IIPs and AIP. Cryptogenic fibrosing alveolitis was removed from the classification. Rare entities were added to the classification system such as acute fibrinous and organizing pneumonia and interstitial pneumonias with a bronchiolocentric distribution. Based on newer research, NSIP was upgraded from a provisional diagnosis to a distinct clinicopathologic entity. A stronger emphasis was additionally placed on the molecular and genetic features where certain biomarkers such as elevated epithelial or macrophage-related proteins could indicate rapid deterioration and high risk of progression [2••].

The new classification system paved the way for directed therapeutic approaches. For example, treatment of IPF with nintenanib and pirfenidone has been shown to reduce disease progression rate [3–5]. The most recent ATS guidelines for IPF treatment now have conditional recommendation for antifibrotic therapy [6]. This has resulted in increased utilization with nearly one-fifth of the IPF patients have taken one of the two antifibrotic medications in the USA since 2014 [7]. This has partly been made possible by 2018 ATS guidelines for diagnosis of IPF which relies on imaging diagnosis of usual interstitial pneumonia (UIP) in combination with clinical work-up failing to reveal an alternate etiology. HRCT has high positive predictive value in establishing UIP pattern with characteristics imaging findings, but not all patients demonstrate all of the hallmark findings. This is reflected in the new guidelines by four patterns—definite "UIP pattern," "probable UIP pattern," "indeterminate for UIP pattern," and "alternative diagnosis" [8•].

Stepwise Approach to Interstitial Lung Disease

A stepwise approach can be utilized in imaging interpretation of IIPs. A diagnostic HRCT protocol for evaluation of IIPs involves obtaining non-contrast axial thin sections using collimation sections of 1–3 mm in supine position during inspiratory phase. These are reconstructed using high-spatial frequency algorithm which can be utilized for primary evaluation of lung parenchyma [8•, 9]. Scanning in prone position can aid in delineating dependent atelectasis from subtle reticular opacities. Imaging during expiratory phase can additionally identify air trapping which is commonly seen in hypersensitivity pneumonitis (HP) [8•, 9, 10]. A thorough evaluation of all these sequences can depict classic findings of fibrosing ILD—volume loss, bronchiectasis, and homecoming [11].

In order to standardize and increase precision in chest imaging, the Fleischner Society have compiled a glossary of thoracic imaging terms. The archetypal finding of honeycombing is defined pathologically as destroyed and fibrotic lung tissue which appears as a cluster of cystic airspaces with an average diameter of 3–10 mm. These cysts have well-defined walls and tend to be in subpleural location. Traction bronchiectasis is another common finding of fibrotic lung disease where fibrotic parenchyma causes irregular airway dilatation. When this airway dilatation involves the bronchioles, it is termed traction bronchiolectasis. A subtle fibrotic finding is subpleural reticulation which represents interlobular septal thickening. Mosaic attenuation presents as geographic or patchy areas of attenuation differences both increased and reduced, related to air trapping or chronic thromboembolic disease. Air trapping, retention of air secondary to obstruction, can be distinguished on HRCT using inspiratory and expiratory phase imaging. A hypoattenuating area on inspiratory phase imaging related to air trapping will become more hypoattenuated in relation to normally ventilated parenchyma on expiratory phase. Increased opacification is a result of partial air displacement which may occur from a variety of reasons such as partial alveoli collapse, partial fillings of airspace, and/or increased capillary blood volume. In contrast, consolidation results in homogenous opacification of parenchyma with obscuration of the bronchovascular margins [12].

HRCT is comprised of multiple sequences including reconstructions, all of which should be utilized by the interpreting physician in characterizing IIPs. One such approach involves first utilizing axial inspiratory scans to evaluate for features of fibrotic disease, specifically looking for four characteristic UIP findings which include honeycombing with traction bronchiectasis, subpleural reticulation, basilar distribution, and absence of atypical UIP features. Atypical UIP findings include mid and upper lung distribution, GGO and consolidations disproportionate to reticulations, cysts, mosaic attenuation on inspiratory imaging, and air trapping on expiratory imaging [8•, 13]. NSIP has subpleural sparing and symmetry on CT with additional imaging features dependent on subtypes—cellular and fibrotic. Cellular NSIP typically has predominately GGOs; however, reticulation and bronchiectasis may be present. The more common subtype fibrotic NSIP have irregular reticulations and traction bronchiectasis as the common finding [12–15]. Prone scans are an invaluable tool in

problem-solving subtle cases of UIP and NSIP. Subpleural atelectasis in dependent portions of the lungs during supine scans can be misinterpreted as reticulation but readily distinguished on prone images.

Expiratory scans are important in identifying air trapping with heterogenous mosaic attenuation of chronic HP. The characteristic "headcheese sign" in chronic HP presents with areas of low to high attenuating parenchyma. Air trapping, as discussed earlier, presents as areas of low attenuation on expiratory scans while reticulation and GGOs result in areas of high attenuation [16].

Sagittal and coronal reconstructions should be used to assess disease distribution. While UIP presents with a basilar predominant distribution (Image 1), other IIPs can have upper lobe distribution. One such disease process is chronic hypersensitivity pneumonitis that has upper lobe and bronchocentric

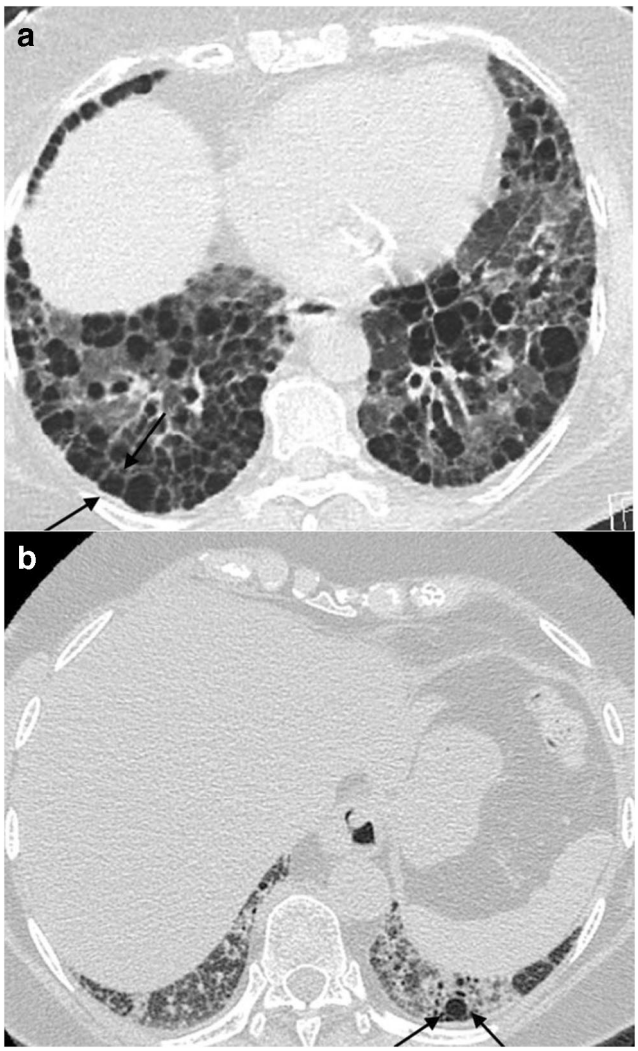


Image 1 Honeycombing. Non-contrast axial CT shows honeycombing-stacks of cystic air spaces in subpleural location (arrows), as seen in advanced disease in both lower lobes (**a**) and early fibrotic disease in left lower lobe (**b**)

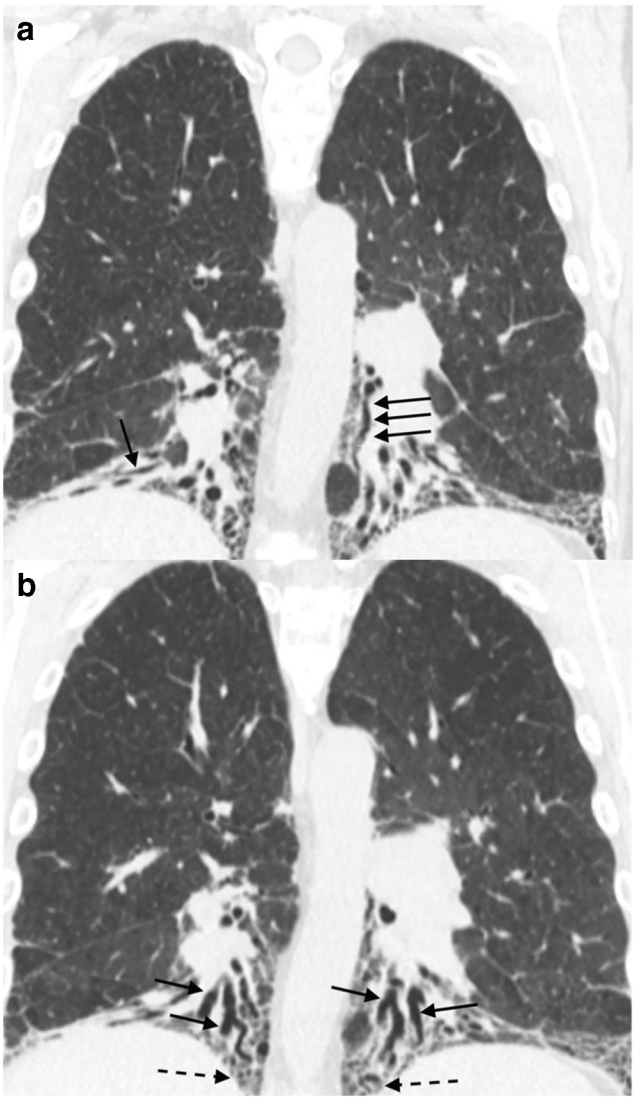


Image 2 Traction bronchiectasis. **a, b** Non-contrast coronal CT, in the same patient, shows dilated bronchi (solid arrows) with surrounding fibrosis (dashed arrows) in the basal lower lobes

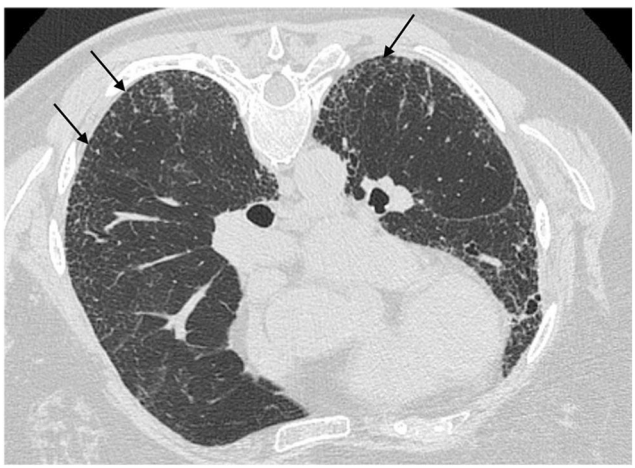


Image 3 Subpleural reticulation. Non-contrast axial prone CT chest image shows subpleural interlobular septal thickening or reticulation (solid arrows) in UIP

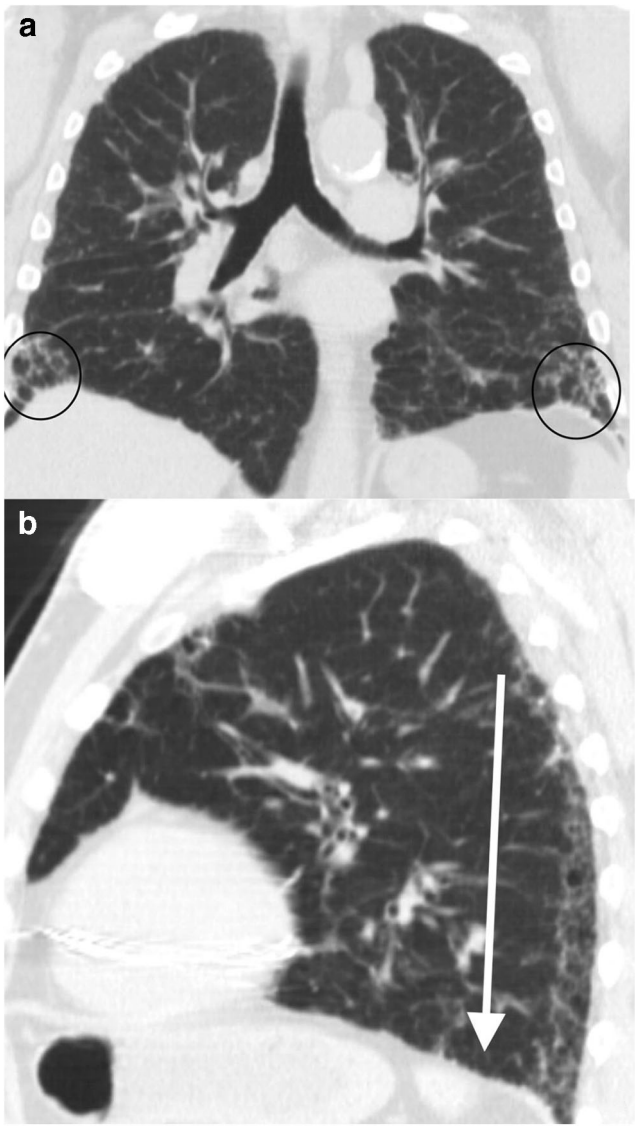


Image 4 Apicobasal gradient. Non-contrast **a** coronal and **b** sagittal CT images of chest showing basal and subpleural lower lobe predominant reticulation, bronchiectasis, and honeycombing (circles) in classic distribution for UIP

distribution. UIP pattern may coexist with upper lobe emphysema in combined pulmonary fibrosis and emphysema (CPFE) (Image 2) [17, 18].

Focused evaluation of non-parenchymal structures such as the pleura is important in diagnosis of pleuroparenchymal fibroelastosis (PPFE) which presents with pleural thickening and subpleural fibrosis in upper lung distribution [19, 20].

Usual Interstitial Pneumonia Categorization

Usual interstitial pneumonia (UIP) is a pattern seen on high-resolution CT scan of the chest that is associated with many different diseases, including idiopathic pulmonary fibrosis (the most common form of idiopathic interstitial pneumonia), chronic hypersensitivity pneumonitis, and certain connective tissue diseases such as rheumatoid arthritis [21]. As with many diseases where there are phenotypic variations in presentations, imaging abnormalities can also have different characteristics in the same disease or can change with time. Therefore, the diagnosis of UIP may not always be definitive at the time of the initial or subsequent imaging studies. The American Thoracic Society has therefore adopted four diagnostic categories based on the predominant features seen on imaging at that moment in time including "UIP pattern," "probable UIP pattern," "indeterminate for UIP pattern," and "alternative diagnosis" [8•]. This is important not just for classification and diagnosis but also for prognosis. It has been shown that patients with rheumatoid arthritis who additionally have a UIP pattern or probable UIP pattern have a lower survival rate compared with that same patient population with imaging findings consistent with non-specific interstitial pneumonia [22].

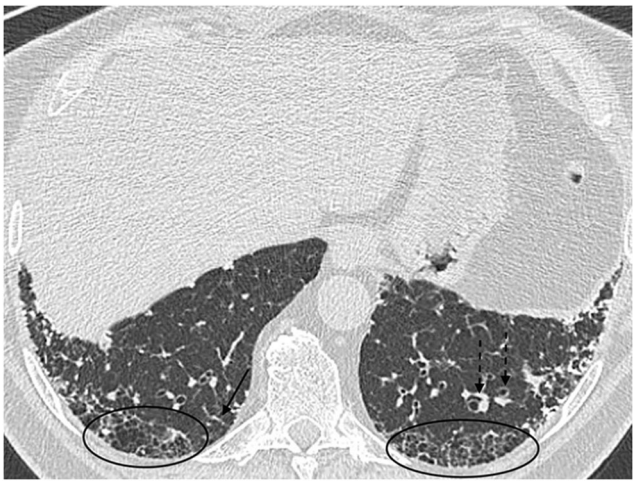


Image 5 Usual interstitial pneumonia. Non-contrast axial CT shows subpleural reticulation (solid arrow), traction bronchiectasis (dashed arrow), and honeycombing (circles) predominantly in lung bases consistent with UIP pattern

The classic UIP pattern is described as subpleural reticulation predominantly located in the subpleural and basal lung with a heterogenous distribution (Image 3). Other features include traction bronchiectasis and bronchiolectasis (Image 4). Honeycombing must be present to categorize a UIP pattern as definitive [8•]. Honeycombing is a finding of discrete thick-walled cystic airspaces that are clustered and stacked together (Image 5) [23]. The inherent difference between the definitive UIP and probable UIP categories is the absence of honeycombing. When considering the pretest probability of a patient having a UIP-related disease based on other supporting data (history, physical, labs, etc.), the imaging finding of probable UIP pattern can have a high positive predictive value, precluding the potential need for a histopathological UIP diagnosis (Image 6) [24, 25]. For example, if a patient has rheumatoid arthritis (a condition that is known

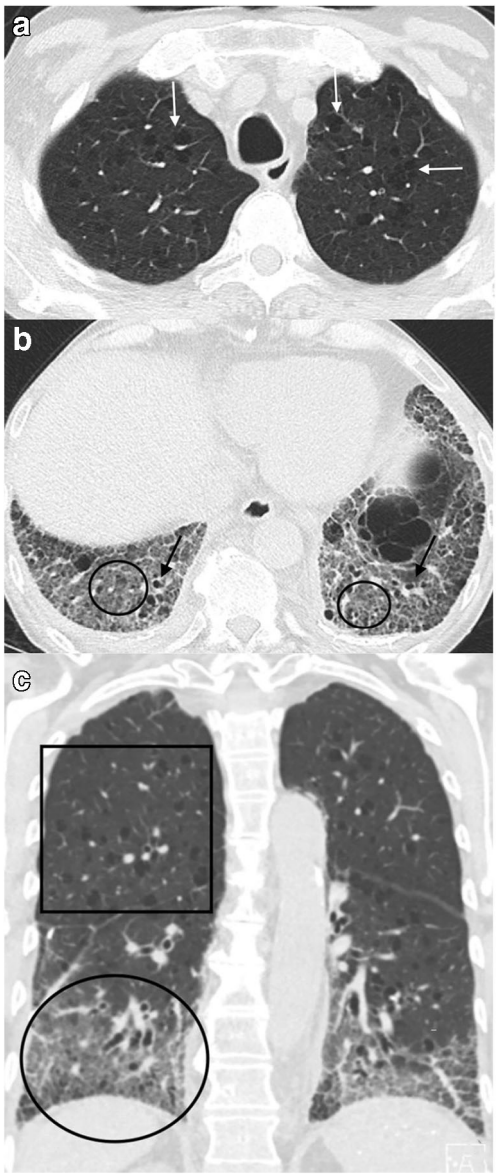


Image 6 Combined pulmonary fibrosis and emphysema (CPFE). **a** Non-contrast HRCT axial images through the upper lungs show centrilobular emphysematous changes (white arrows) and **b** lower lobe subpleural reticulation, traction bronchiectasis (black arrow) with ground-glass changes of fibrosis (circles). **c** Coronal image best demonstrates distribution of apical emphysema (square) and basilar fibrosis (circle)

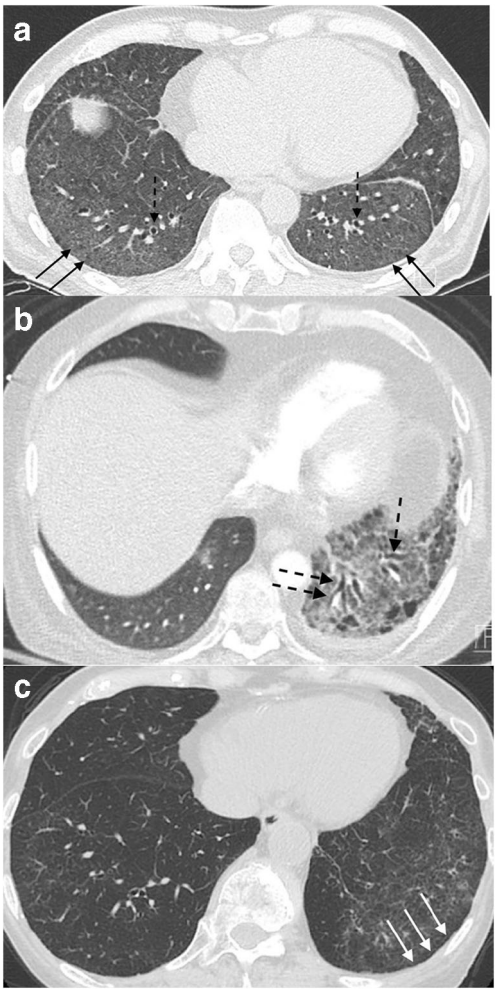


Image 7 Nonspecific interstitial pneumonitis (NSIP). **a** Non-contrast axial CT image shows bilateral lower lobe symmetric diffuse ground-glass opacities (solid black arrows) associated with traction bronchiectasis (dashed black arrow) characteristic of NSIP. **b** Contrast-enhanced axial CT images, status post right lung transplant, demonstrate persistent extensive ground-glass opacification with traction bronchiectasis (dashed black arrow) in the left lower lobe. **c** Axial CT images show classic subpleural sparing in left lower lobe (solid white arrow)

to cause a UIP pattern), a surgical biopsy is unnecessary and can cause unwarranted morbidity and mortality. Furthermore, if a patient has a definitive UIP pattern on HRCT, current guidelines stress that a lung biopsy is not required for diagnosis [8•]. It is the role of the clinician to determine the etiology of the pattern by identifying potential causes such as autoimmune disease, drug toxicity, or chronic irritant exposure. If there is no identifiable cause after the history, labs, and imaging are reviewed by a multidisciplinary team including radiologist, pulmonologists, and pathologists, the diagnosis can be presumed to be idiopathic pulmonary fibrosis.

The other two categories, "indeterminate for UIP pattern" and "alternative diagnosis," are classifications in which the imaging findings may gradually turn into a UIP pattern, but at that moment in time the findings are not consistent. These features may include fibrosis similar to that seen in UIP, but may also have elements not typical of UIP such as extensive ground-glass abnormalities, a predominance of abnormalities in the middle of upper lung, significant mosaic attenuation or air trapping and peribronchovascular predominance [21]. Given the atypical findings, in combination with the other clinical history, alternative diagnoses could be considered. In patients with pulmonary fibrosis, if a patient may also have subpleural curvilinear lines, the patient could be alternatively diagnosed with fibrosis secondary to asbestosis exposure

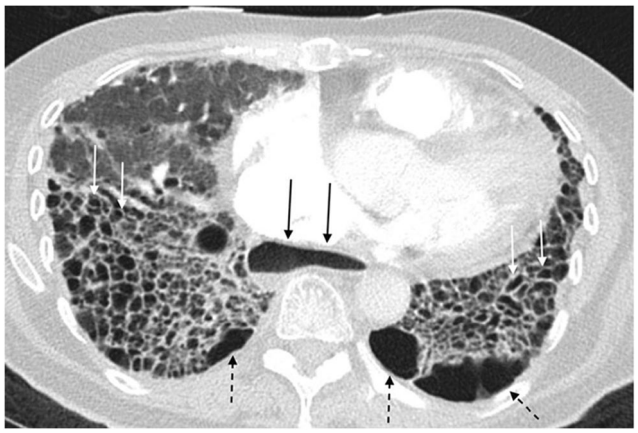
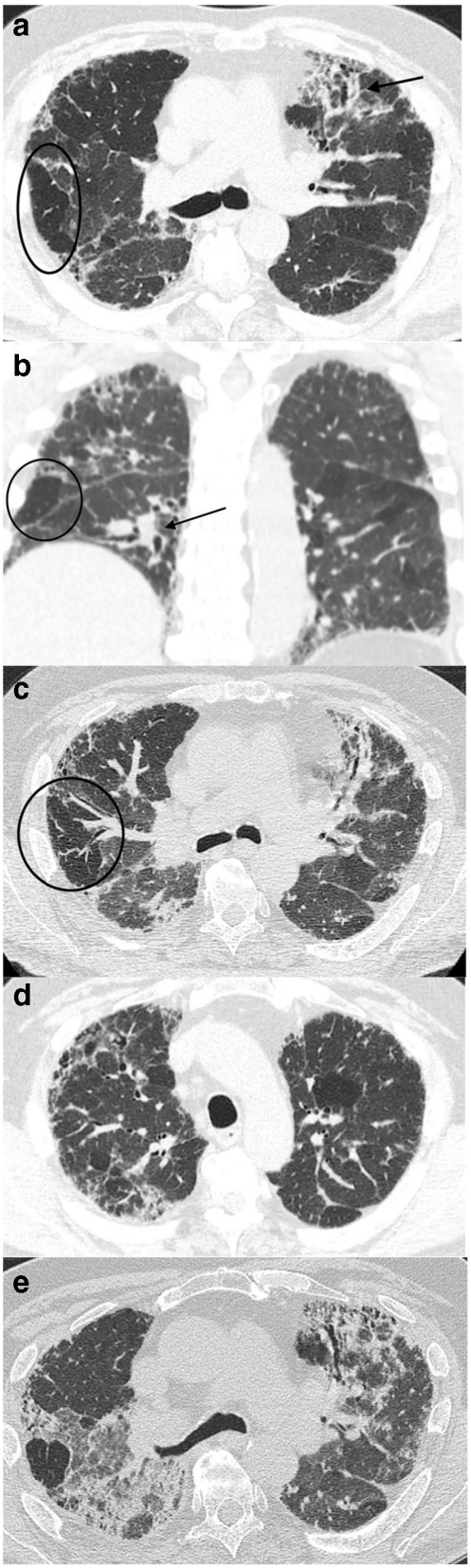


Image 8 Biopsy-proven fibrotic NSIP. Contrast-enhanced axial CT demonstrates extensive bronchiectasis and bronchiolectasis (solid white arrow) with cystic change (dashed black arrow). Note the severely dilated thoracic esophagus with air-fluid level (solid black arrow) in patient with scleroderma

especially in the presence of pleural plaques [26]. Monitoring the imaging studies over time, an alternative diagnosis of NSIP or organizing pneumonia could be established. Therefore, for this category, obtaining a thorough history and focused diagnostic work-up can be essential in making the correct diagnosis.

Nonspecific Interstitial Pneumonia

Most connective tissue diseases and collagen vascular diseases present with a nonspecific interstitial pneumonia (NSIP) pattern of ILD. An NSIP pattern on CT scan may be the initial manifestation of polymyositis, dermatomyositis, systemic sclerosis, Sjogren's syndrome, and mixed connective tissue disease, in addition to rheumatoid arthritis (though NSIP is less common than UIP in rheumatoid arthritis) [27]. The characteristic imaging findings in NSIP include symmetric ground-glass opacities with lower lung predominance and subpleural sparing associated with reticulation, traction bronchiectasis, and bronchiolectasis [2••]. In NSIP, there is an extremely sharp demarcation of reticulation between the lower lung field and remainder of the normal lung without extension to the lateral margins, described as the "straight-edge-sign," the absence of which has a high positive predictive value for UIP in patients with ILD [28]. Compared to UIP symmetry of distribution and homogeneity, predominant ground-glass and subpleural sparing are all hallmarks of NSIP, whereas heterogeneity of involved lung and subpleural involvement are hallmarks of UIP. Also seen in NSIP, there can be elements of minor honeycombing, consolidations (similar to an organizing pneumonia), and surrogate signs of connective tissue disease such as esophageal dilatation (seen in scleroderma) [29]. In contrast to organizing pneumonia where areas of



◀ **Image 9** Chronic hypersensitivity pneumonitis. High-resolution CT chest **a** axial and **b** coronal images showing bronchocentric and upper lobe fibrosis (arrows) with associated lucent areas of air trapping (circle). **c** Expiratory phase axial image shows exacerbation of the lucent areas in pulmonary parenchyma due to air trapping. Alternating areas of lucent and dense pulmonary parenchyma, as seen on axial image (**d**), is known as the "headcheese sign." **e** Axial image shows progression over a year due to continued exposure image

abnormalities can move in location with time, the areas that are affected in NSIP are fixed.

Another subtype analysis that should be emphasized in NSIP is the histologic division of cellular, fibrotic, and mixed pathology. The cellular subclass has the predominant imaging changes mentioned above including ground-glass opacities with reticulation (Image 7). Pathologically, a biopsy would reveal inflammatory cells with homogenous septal thickening, with some elements being reversible. Alternatively, the fibrotic subtype would reveal areas of fibrosis of the interstitium with minimal remaining inflammatory cells, with these findings being irreversible (Image 8) [30]. Radiographically, the areas of abnormality would have evidence of fibrosis, including the aforementioned traction bronchiectasis and bronchiolectasis. These subclassifications are important with respect to prognosis as cellular has an excellent prognosis compared to the fibrotic subtype [31]. Furthermore, within the fibrotic subtype, being associated with autoimmune features (physical examination findings or serologic testing) is a positive prognostic factor for disease severity [32]. Finally, it is important to note that as some of these ILDs progress, elements of fibrosis can become dominant and it can become more difficult to determine if the original findings were more consistent with NSIP or UIP.

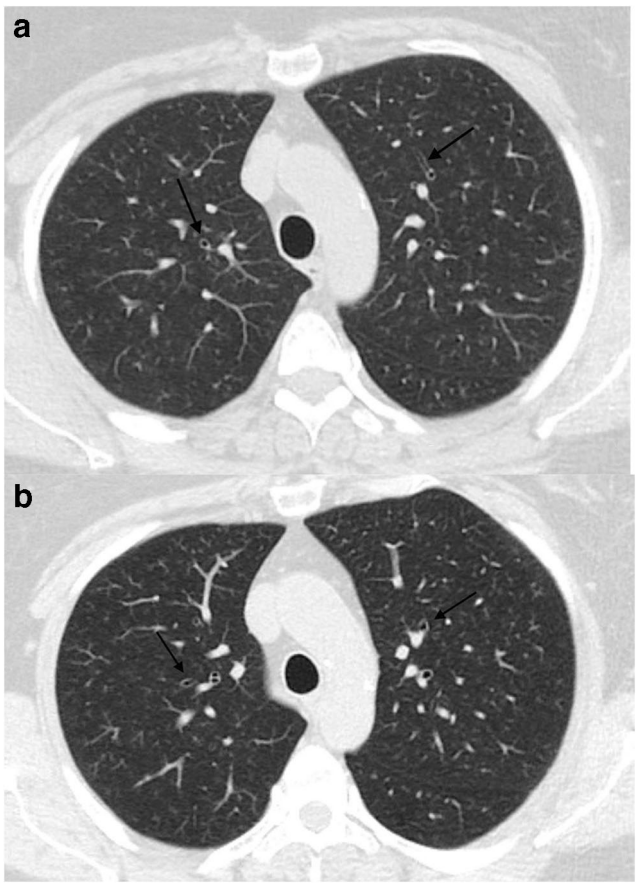


Image 10 Respiratory bronchiolitis–ILD. **a**, **b** Non-contrast axial CT images show upper lobe predominant diffuse centrilobular ground-glass nodules and bronchial wall thickening (black arrows)

Chronic Hypersensitivity Pneumonitis

Hypersensitivity pneumonitis (HP) is a form of ILD that is caused by exposure to an environmental antigen, chemical, or irritant that leads to a robust and persistent immune response with resultant pathologic damage of the lung. This allergic injury is typically localized to the alveoli, terminal bronchioles, and alveolar interstitium [33]. Traditionally, this condition has been defined by the correlation between the length of time with the exposure and appreciable CT changes. The diagnosis of HP can therefore be further classified as acute, subacute, or chronic [34]. The radiographic findings of each classification show the progressive spectrum of this disease process caused by continued exposure and the host response. In its most severe appearance, the chronic form of HP is almost indistinguishable from an UIP pattern, making it imperative to obtain a thorough clinical history including items such as home environment, work exposures, hobbies, travel, and pets to arrive at the correct diagnosis.

The distribution of this airway centric disease is a predominance in the middle and upper lung zones that can be patchy or diffuse. The acute form of HP may resemble pulmonary edema. The subacute pattern has centrilobular diffuse micronodular pattern, with ground-glass opacification and mosaic attenuation [34, 35]. While these previous findings can also be present in the chronic form of HP, the findings that characterize chronic HP are signs of irreversible damage which are fibrosis, reticulation, architectural distortion, and traction bronchiectasis [34, 36]. The presence of mosaic attenuation with areas of ground-glass and air trapping in chronic HP gives the classic heterogenous appearance of "headcheese pattern" (Image 9) [37]. In addition, the areas of air trapping are commonly seen within the lobules as opposed to that seen in small airway disease [37]. Other abnormalities that can be seen, but not as consistently, include honeycombing, areas of consolidation, and interlobular septal thickening [38]. As many of these findings can be seen in an UIP pattern and fibrotic NSIP, the key difference between these and chronic HP is the upper lung predominance, bronchocentric fibrosis (fibrosis localized to the medial part of the lung instead of the periphery), and presence of air trapping. Also similar to other ILDs, it is possible to have acute exacerbations in the background of chronic HP

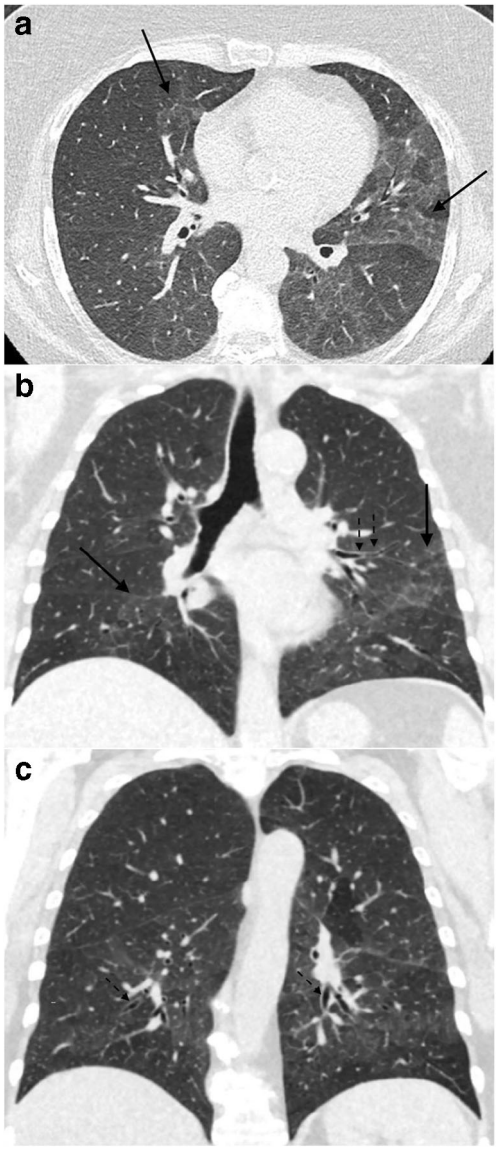


Image 11 Desquamative Interstitial pneumonitis (DIP). **a** Axial and **b**–**c** coronal HRCT images show diffuse ground-glass opacities (solid black arrow) and bronchial wall thickening (dashed black arrow) predominantly in mid-lower lung distribution in a chronic smoker

[38]. This highlights the premise that this disease process manifests on a spectrum as exposures can lead to the full gambit of radiographic phenotypes in the same individual.

Smoking-Related Interstitial Lung Disease

Smoking has high mortality causing nearly 1 in 5 deaths in the USA from various pathologies including cardiovascular disease and several lung diseases. Recently ATS/ERS regrouped the category of smoking-related interstitial lung diseases—respiratory bronchiolitis–interstitial lung disease (RB-ILD) and desquamative interstitial pneumonia (DIP) [2••].

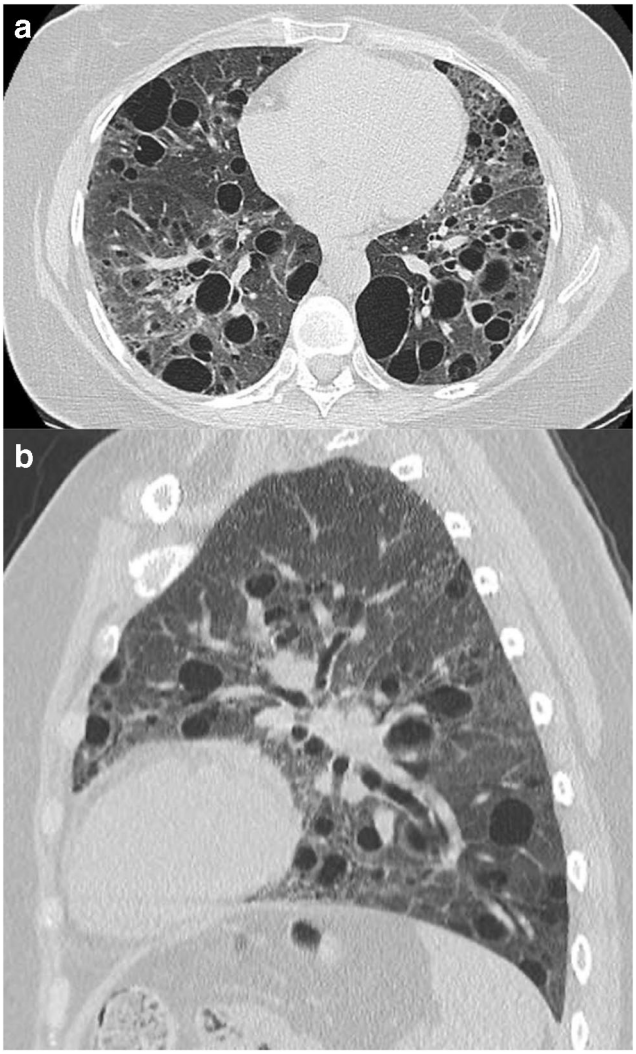


Image 12 Lymphocytic interstitial pneumonia (LIP). **a** Axial and **b** sagittal CT images demonstrate diffuse bilateral ground-glass opacification with multiple small and large pulmonary thin-walled cysts (black arrow)

Respiratory bronchiolitis (RB) is denoted by centrilobular nodules in an asymptomatic smoker. Patients with clinical systems lead to diagnosis of RB-ILD which is also known as "smoker's bronchiolitis." Scattered pigmented macrophages with inflammatory changes surrounding respiratory bronchioles and alveoli are the hallmark histological finding in RB-ILD [39–42]. The correlative radiological findings on CT are upper lobe predominate centrilobular nodules, GGOs, and bronchial wall thickening (Image 10) [39–42].

Clinically RB-ILD and DIP present insidiously with dyspnea and cough with markedly reduced diffusing capacity for carbon monoxide (DLco) in DIP [39]. There is also histological overlap with RB-ILD which is differentiated from DIP based on disease extent and distribution. There are diffuse pigmented macrophages within alveoli and associated variable mild interstitial inflammation [39, 41, 42]. On CT, DIP presents with subpleural and basilar predominant GGO with scattered areas of cysts and

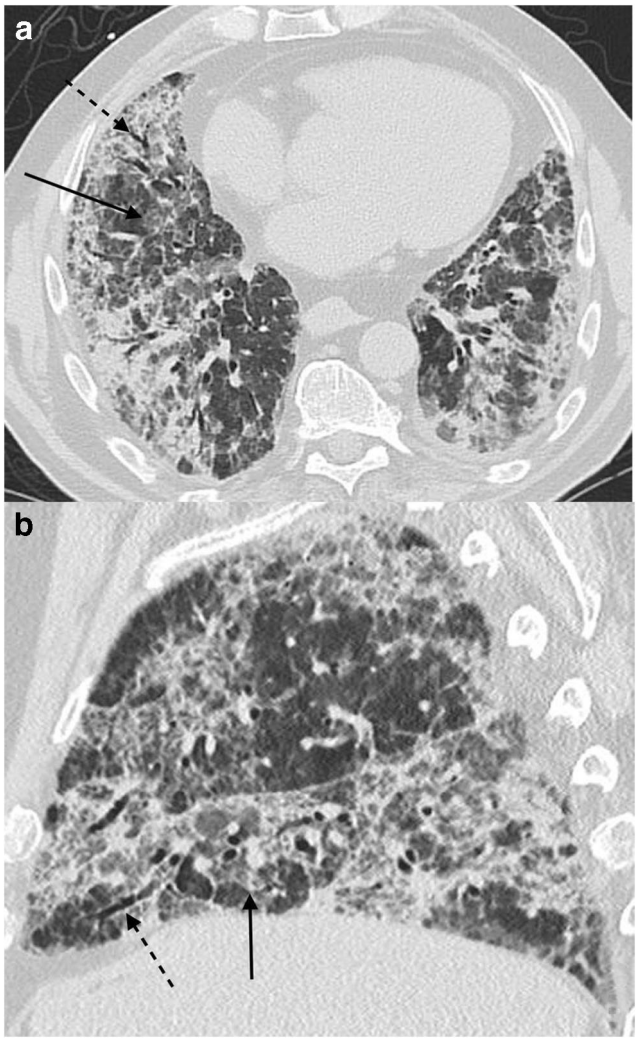


Image 13 Acute interstitial pneumonia (AIP). **a** Axial and **b** sagittal CT images show patchy diffuse bilateral ground-glass opacities (solid arrow) with mild traction bronchiectasis (dashed arrow) and peripheral predominant mid and lower lung zone reticular opacities. In acute setting, these findings were thought to be secondary to acute interstitial pneumonia

emphysema (Image 11). While NSIP, LIP, and HP may have similar appearance, presence of emphysema in combination with smoking history favors diagnosis of DIP [39–43]. It is also important to note that DIP has been associated with other exposures such as diesel fume, marijuana, asbestos, and textile processing chemicals [43].

Miscellaneous

Common Variable Immune Deficiency Interstitial Lung Disease

Common variable immunodeficiency (CVID) is a rare disease with prevalence of 1 in 25,000 to 50,000 [44]. It is a primary immune deficiency characterized by heterogenous pathologies ranging from defective B lymphocytes to antibody production. It has several pulmonary manifestations ranging from infectious to noninfectious processes such as airway disease and lymphoproliferative disease [44, 45].

Pathogenesis of CVID-related ILD disease is incompletely understood, but histopathological features overlap with LIP, OP, and granulomatous disease [44]. More recently, granulomatous lymphocytic interstitial lung disease (GLILD) has been described which is generally related to CVID-like disorders [44–47]. On imaging, there are diffuse micronodules with lower lung predominance and smooth interlobular septal thickening [48]. Pulmonary symptoms and findings can wax and wane. CVID patients with GLILD have poor prognosis and reduced survival [44]. Accurate diagnosis may require biopsy and to exclude underlying malignancy [45].

Lymphocytic Interstitial Pneumonia

Lymphocytic interstitial pneumonia (LIP) is a benign lymphoproliferative disorder characterized by interstitial infiltration of lymphoplasmacytic cells which presents as pulmonary cysts as a result of postobstructive alveolar dilatation and ischemia from vascular obstruction [49–51]. These are most commonly seen with collagen vascular disease, particularly Sjogren's syndrome and lupus, and with acquired immunodeficiency syndrome (AIDS). It clinically presents with cough and progressive dyspnea [50]. The LIP cysts are generally few in number and small in size with diameters < 3 cm. Concurrent GGO may be present in chronic cases (Image 12) [51]. Radiographically, it is part of diffuse cystic lung disease differential and often requires distinguishing from lymphangioleiomyomatosis (LAM) and pulmonary Langerhans cell histiocytosis (PLCH). In comparison to LIP, cysts in LAM tend to be numerous and 2–10 mm in size, often with concurrent pneumothorax or pleural effusion. PLCH presents with pulmonary nodules and bizarre shaped cysts sparing lung bases in setting of smoking history [50, 51].

Acute Interstitial Pneumonia

Acute interstitial pneumonia (AIP), also known as Hamman-Rich syndrome, is a rapidly progressive disease resulting in diffuse alveolar damage (DAD) [52–54]. There is generally a prodromal illness similar to an upper respiratory infection with fulminant course. It is similar to acute respiratory distress syndrome (ARDS) with histopathological findings of acute and organizing DAD, hyaline membrane formation and septal edema with fibroblastic proliferation [52]. Imaging findings vary depending on 3 recognizable phases—acute exudate, subacute proliferative, and chronic fibrotic phases. In acute and subacute phases, there are GGO and consolidative opacities in mid- and lower lung fields.

Chronic phase may progress to traction bronchiectasis and irregular reticulation (Image 13) [52].

Other disease processes can overlap AIP imaging findings including multifocal pneumonia, hemorrhage, and even pulmonary edema. These can be differentiated based on detailed clinical evaluation with serological and microbiological data. Underlying infectious organisms should be excluded [53]. Bronchoalveolar lavage in AIP can help with differential diagnoses by demonstrating neutrophils with atypical type 2 pneumocytes and hyaline membrane fragments [55].

Pleuroparenchymal Fibroelastosis

There has been an increase in diagnosis of PPFE since it was recognized as a distinct clinicopathologic entity in 2013 ATS/ERS updates of IIP classification [56]. Exact pathogenesis of PPFE is not well-understood but has been suggested that it relates to lung injury with subsequent vigorous interstitial inflammation. Clinically, patients present with non-specific symptoms like cough and dyspnea at age of 40–70 years. However, pleuritic chest pain may be present when it is complicated by a pneumothorax. Definitive PPFE diagnosis on CT requires upper lobe predominant pleural fibrosis with adjacent subpleural fibrosis [19]. In chronic phases, patients undergo chest wall bulk reduction as a part of the disease with resultant platythorax deformity of the chest characterized by decreased anteroposterior diameter of the chest in relation to the lateral diameter [57].

Conclusions

The information provided by high-resolution computed tomography imaging of the chest has changed the approach to the diagnosis and treatment of interstitial lung diseases. Being able to describe and discern the different radiographic patterns offers providers invaluable information that, when combined with other patient data (subjective history, physical examination, laboratory measurements, etc.), can yield a definitive diagnosis without invasive testing such as tissue biopsy or bronchoscopic evaluation. This, in turn, can change the course of a disease as many of the interstitial lung diseases have known modifiable risk factors and pharmacologic treatment options. It is therefore imperative for clinicians to be acquainted with accurately identifying these radiographic patterns on CT imaging.

Compliance with Ethical Standards

Conflict of Interest Alan Nyquist, Raza Mushtaq, Faryal Gill, and Kavitha Yaddanapudi declare no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- •• Of major importance

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