A Radiologist's Guide to Expert Interpretation

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Learning Objectives

1. The basics
   Assess quality of HRCT images and identify common interstitial abnormalities

2. Checklists & check areas
   Learn approaches for assessment and interpretation of complex HRCTs

3. Actionable recommendations
   Diagnose with specificity and add value in your HRCT report
HRCT Quality

Technicians/radiographers should be well trained in coaching patients. Patients are imaged in:

- Inspiration: To evaluate lung parenchyma
- Expiration: To assess for air trapping and
- Prone: To check if "dependant findings" persist

Scan parameters¹
- Volumetric acquisition
- Thin slices (0.65-1.25mm)
- High spatial frequency bone algorithm
- Lung window
- Non-contrast

Limitations of HRCT: As HRCT is non-contrast, it cannot evaluate for PE, pleural or nodal enhancement, and so on

Assess posterior tracheal membrane.

In full inspiration the trachea will appear as an "O" shape.

On expiration, the posterior membrane bows anteriorly to form a crescent-like shape

Quality: Evaluate for motion, respiratory artefact, metallic artefact etc

Case: Craig Hacking rID: 40797
### Legend

- **AIP**: Acute Interstitial Pneumonia
- **BHD**: Birt-Hogg-Dubé Syndrome
- **CF**: Cystic Fibrosis
- **COP**: Cryptogenic Organizing Pneumonia
- **CTD**: Connective Tissue Disease
- **DAD**: Diffuse Alveolar Damage
- **Ddx**: Differential Diagnosis
- **DIP**: Desquamative Interstitial Pneumonia
- **GGO**: Ground-Glass Opacity
- **HP**: Hypersensitivity Pneumonitis
- **HRCT**: High-Resolution CT
- **ILD**: Interstitial Lung Disease
- **IIP**: Idiopathic Interstitial Pneumonia
- **IPPFE**: Idiopathic PleuroParenchymal Fibroelastosis
- **LAM**: Lymphangioleiomyomatosis
- **LIP**: Lymphocytic Interstitial Pneumonia
- **NSIP**: Nonspecific Interstitial Pneumonia
- **OP**: Organizing Pneumonia
- **PLCH**: Pulmonary Langerhans Cell Histiocytosis
- **RA-ILD**: Rheumatoid Arthritis-Associated ILD
- **RB-ILD**: Respiratory Bronchiolitis-Associated ILD
- **SLE**: Systemic Lupus Erythematosus
- **SS-ILD**: Sjögren's Syndrome-Associated ILD
- **UIP**: Usual Interstitial Pneumonia

**Ddx**: differential diagnosis

**Pearl**: imaging pearl
Interstitial Lung Disease (ILD) is an umbrella term for a group of diseases affecting the lung's connective tissue. The interstitium, depicted as a light blue structure in this diagram, surrounds and supports the secondary pulmonary lobule. > 100s of conditions lead to ILD!

How are ILDs diagnosed? A Multidisciplinary approach, rather than a histologic diagnosis, is the gold standard for diagnosis as per The ATS/ERS. Consider: exposure history, specific clinical features, serology, and radiological pattern.

* American Thoracic Society/European Respiratory Society

Case: Frank Gaillard rID: 8760
## Classification of ILD by aetiology*

**Histological pattern in (brackets)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idiopathic interstitial pneumonia (IIP)</td>
<td>IPF (UIP), NSIP (NSIP), RB-ILD (RB), DIP (DIP), COP (OP), AIP (DAD), LIP (LIP), IPF</td>
</tr>
<tr>
<td>ILD of known association</td>
<td>CTD (NSIP, OP, LIP), Drugs (NSIP, HP, DAD), Occupational exposures (upper lobe process)</td>
</tr>
<tr>
<td>Granulomatous ILD</td>
<td>Sarcoidosis, PLCH</td>
</tr>
<tr>
<td>Miscellaneous ILD</td>
<td>LAM, PLCH</td>
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## Classification of ILD by HRCT pattern*

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Clinico-pathological diagnosis</th>
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<tbody>
<tr>
<td>UIP</td>
<td>IPF, RA-ILD, SS-ILD, Fibrotic HP, drugs, asbestosis</td>
</tr>
<tr>
<td>NSIP</td>
<td>Primary NSIP, CTD-ILD (scleroderma, sjogrens, polydermatomyositis), drugs</td>
</tr>
<tr>
<td>OP</td>
<td>COP, infection, drugs, CTD-ILD, RB-ILD, DIP</td>
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</table>

Certain clinicopathological diagnoses can result in a number of different HRCT patterns.

For example, a patient with scleroderma can present with the pattern of NSIP (most commonly), UIP (less commonly) and even OP!
Why Perform Expiratory Imaging?
Evaluates for air trapping, which in isolation, typically suggests small airways disease.

**Ddx:**
- In isolation: Asthma, chronic bronchitis, obliterative bronchiolitis
- With bronchiectasis: CF, idiopathic bronchiectasis, non-TB mycobacteria
- With ILD: sarcoidosis, HP (4)

Air trapping in a case of obliterative bronchiolitis.

**How to identify air trapping:** On a normal expiratory sequence, the attenuation of the lung should homogenously increase (i.e. become denser). Air trapping is identified as areas that remain abnormally lucent.
Why Perform Prone Imaging?

Prone imaging is useful for assessing if mild posterior abnormalities resolve; if not, early or mild ILD may be present. Prone imaging is unnecessary if there is no significant posterior abnormality or if it is highly pronounced (e.g. end-stage fibrosis).

Pearl

Assess where the CT table is to identify which is the prone image; Sometimes the image will be rotated for you, and sometimes not.

Case: Oliver Hennessy rID: 34673

Posterior reticulation in a case of UIP: Much of the posterior reticulation has reduced on the prone image, (likely superimposed dependant atelectasis), however some persists, indicating it is a true finding.
**Architectureal distortion** in a case of sarcoidosis. The normal anatomy in the upper zones is destroyed, with consolidation and severe traction bronchiectasis.

**Traction Bronchiectasis** in a case of UIP. This is the tethering of small airways, pulled apart by fibrosis of any cause. **Reticulations** are fine linear opacities, which are mesh-like or net-like.

**Honeycombing** in a case of UIP: small stacked subpleural cysts, typically 3–10 mm in diameter, typically seen in UIP, but also in basically any end-stage fibrotic process.
Two distribution patterns to be aware of: 1) Craniocaudal distribution and 2) Axial distribution.

**Craniocaudal distribution** refers to the location of the process within the lung, specifically whether it is more predominant in the upper or lower regions.

**Pearl**

Use coronal and sagittal to evaluate for CC distribution—using the hilum as a cut off.

- **Case: Bruno Di Muzio Babu rID: 78538**
  - Upper predominant findings in PLCH. Most of the cysts are above the hilar level.

- **Case: Varun Babu rID: 61877**
  - Lower predominant findings in UIP. Most of the disease is below the hilar level.
Where is the Abnormality?

Axial distribution refers to the location of the process within the lung on an axial image. It can be: central, peripheral, subpleural, peribronchovascular or diffuse.

Case: Ian Bickle rID: 26493
Predominantly peripheral process in a case of UIP

Case: Yi-Jin Kuok rID: 17192
Predominantly central/peribronchiolar process in a case of HP
**Where is the Abnormality?**

Axial distribution also refers to the location of the process within the lung on an axial image, in relation to the secondary pulmonary lobule, e.g. nodules.

**Case: Stefan Tigges rID: 95882**
Centrilobular nodules in excipient lung disease. Note how they spare the periphery, and affect the secondary pulmonary lobule.

**Case: Laughlin Dawes rID: 9145**
Perilymphatic nodules in sarcoidosis. Note how they are studded along the periphery and fissures.

**Case: Luu Hanh rID: 93896**
Random nodules in miliary TB, both centrilobular and along the periphery.
Pattern recognition plays a crucial role in the evaluation of ILDs because different patterns are associated with distinct underlying diseases and have varying prognoses and treatment approaches.

The identification of specific patterns helps guide further investigations, including histopathological analysis, and assists in formulating an appropriate differential diagnosis.

Following are some key ILD patterns that are commonly recognized.
UIP can be characterised\(^9\) as:

- **Typical**,  
  - Subpleural and basal distribution  
  - Honeycombing.  
  - Reticular pattern  
  - Traction bronchiectasis /bronchiolectasis
- **Probable**,  
  - the above, but absent honeycombing
- **Indeterminate for**,  
  - variable or diffuse distribution  
  - Evidence of fibrosis with some inconspicuous features suggestive of non-UIP pattern*  
- Consistent with alternative diagnosis

**UIP Pattern**

**Case: Bruno Di Muzio rID: 158775**

**Typical UIP pattern**

Subpleural and basal distribution, honeycombing, reticulation with traction bronchiectasis.

**Causes of UIP**

- Idiopathic + "Old CHARM\(^{10}\)
- Occupational (Asbestos, Silica)
- CTD (RA, Scleroderma)
- Hypersensitivity pneumonitis
- Aspiration
- Radiation-induced injury
- Meds (amiodarone, chemo, nitrofurantoin)
Lower predominant process, GGO, reticular abnormalities and traction bronchiectasis with subpleural sparing (relatively specific but not sensitive)

NSIP Pattern

Causes of NSIP

- Idiopathic + “CREAM”
- CTD (scleroderma, RA)
- Radiation-induced injury
- Environmental (bird antigens, silica, asbestos)
- Autoimmune (lupus, Sjogren)
- Medications (amiodarone, nitrofurantoin)

Case: Melbourne Uni Radiology Masters rID: 41181

NSIP pattern in a case of scleroderma: GGO, reticulation and traction bronchiectasis with direct subpleural sparing. Also note the dilated esophagus.

Case: Mohammadtaghi Niknejad rID: 22166

NSIP pattern with subpleural sparing. While some disease can touch the pleura, the maximal volume of disease is not at the pleura.
OP Pattern

OP can be primary (COP), or secondary to a variety of triggers. There is patchy or diffuse airspace **consolidation**, with a **peripheral** predominance. Atoll sign (reverse halo) is classic.

**Causes of OP**
- Idiopathic + "CRAO"
- CTD (RA)
- Radiation-induced injury
- Autoimmune (SLE)
- Other (infections)

**Case: Frank Gaillard**
- rID: 35045
  - Classic Atoll sign (reverse halo) in COP. Atoll = central GGO with a peripheral rim of consolidation

**Case: Yi-Jin Kuok**
- rID: 14111
  - Confluent dense peripheral consolidation in OP

**Case: Eric F Greif**
- rID: 32802
  - Patchy peripheral consolidation in OP
ILDs with Cysts: PLCH, LIP & LAM

Cysts: well defined round parenchymal lucencies, seen in PLCH, LAM, LIP, DIP, BHD

PLCH: centrilobular nodules (early) and cysts (late). Cysts are "bizarre shaped". GGO, septal thickening and mosaic attenuation.

LIP: GGO and scattered thin walled perivascular cysts, mid to lower lobe predominant. Compare with LAM where the background lung parenchyma is normal (except for cysts).


Differentiating features*

Case: Yune Kwong rID: 30051
Case: Craig Hacking rID: 48045
Case: Lukas Valkovic rID: 45448
Smoking Related ILDs: RB-ILD & DIP

RB-ILD is an **acute** ILD related to smoking, while DIP represents the **chronic** end-stage of the disease.

**RB-ILD**: upper zone GGOs and poorly defined centrilobular nodules.

**DIP**: Basal and peripheral reticulations and small cystic spaces.

**Case: Frank Gaillard**  
**rID: 6535**

**Case: Jayanth Keshavamurthy**  
**rID: 40280**

Biopsy proven **DIP**: Basal and peripheral reticulations and small cystic spaces.
Sarcoidosis

Perilymphatic nodules and patchy GGOs, +/- air trapping. Lymphadenopathy. Later fibrosis with honeycombing.

Perilymphatic nodules in sarcoidosis. Note how they are studded along the fissures and periphery. Architectural distortion in a case of sarcoidosis, with swirling, curved opacities.

Calcified nodes in sarcoidosis (above). The calcification is fine and powdery, like "icing-sugar" at first. Compare this to the coarser calcified nodes of silicosis (below).

Case: Frank Gaillard rID: 6545
Case: Oliver Hennessy rID: 34388
Case: James Harvey rID: 70938
Case: Eric F Greif rID: 27857
Hypersensitivity Pneumonitis (HP)

Caused by organic dusts.
Classification: Non-fibrotic and Fibrotic HP

Case: Melbourne Uni Radiology Masters rID: 38919
Fibrotic HP in a case of long history of exposure to pigeons. There is coarse reticulation, minimal honeycombing, and evidence of small airway disease (air trapping).

Case: Dalia Ibrahim rID: 72594
Non fibrotic HP in a case of exposure to birds. There is bilateral diffuse GGO and mosaic attenuation. Air trapping is implied by the mosaic attenuation on this inspiratory only image.

The three density pattern, formerly known as "headcheese sign" is pathognomonic for fibrotic HP.
It is a combination of 1. GGO (high attenuation), 2. air trapping (low attenuation), and 3. normal lung.
Checklists & Check Areas

Lung parenchyma

- Background emphysema?
- What is the dominant parenchymal abnormality?
  - Consolidation
  - GGO
    - Mosaic attenuation (versus mosaic perfusion)
  - Reticulation?
    - Smooth or nodular?
  - Signs of fibrosis:
    - Traction bronchiectasis
    - Architectural distortion
    - Honeycombing
    - Volume loss
  - Nodules
    - Solitary or multiple?
    - Centrilobular, perilymphatic, or random?
  - Cysts versus cystic lung disease

- Distribution of the abnormality within the lung
  - Upper versus lower?
  - Central versus peripheral?
- Severity of process
Checklists & Check Areas

**Airways**
- Central and peripheral airways
  - Tracheal dilatation or stenosis
  - Bronchial wall thickening
  - Dilatation
  - Endobronchial mass

**Everything else**
- Pleural effusion, plaques, calcification or thickening
- Nodal stations including lower neck nodal stations
- The heart size and degree of coronary artery calcification
- Evidence of pulmonary artery hypertension
- Esophageal dilatation
- Chest wall

**Don't forget**
- Upper abdomen
- Spine (Osteoporotic fractures in steroid using cohort)
Actionable Recommendations

Use of the **coronal** plane is useful when assessing apico-basal distribution.

**Clinical correlation:** Dig a little further through the patient record; what is the occupational and exposure history? Is the patient a smoker? Do they have a connective tissue disease? Are they on certain medications?

Devise a **differential**, listing conditions that are known to present with similar HRCT findings, ranking them by likelihood.

**Compare to old studies** - what is the tempo of the process?
Review the oldest and most recent studies at least, and ideally more in between.

**Look for a cause:**
Features suggesting:
- CTD: Pleural/pericardial effusion, esophageal dilatation
- Chronic aspiration: Hiatal hernia, esophageal thickening/dilatation

**Look for complications:**
- Pulmonary hypertension (Cardiac chamber and PA size)
- Signs of malignancy; elevated risk of lung cancer and lymphoma in ILD
Take Home Points 1

- Ensure good **quality**, including expiratory and prone imaging

- Identify the **dominant** interstitial abnormalities
  - Reticulation, architectural distortion, traction bronchiectasis, honeycombing, consolidation, GGO, nodules
  - Characterise the abnormality in the craniocaudal and axial plane

- Evaluate for typical **patterns** - UIP, NSIP, OP, cystic lung diseases
Take Home Points 2

- Compare to oldest and most recent studies at least, and ideally more in between; comment on the tempo and severity

  - **Clinical correlation**: occupational and exposure history? smoker? CTD? medications?
    - Look for a **cause**: features of CTD or aspiration

- Look for **complications**: PAH, malignancy

- Don’t forget **everything else** (pleura and chest wall, nodes, heart and PAs, upper abdomen and bones)
References

10. Sources for mnemonics not known- widely used.