Radiologists toolbox to differentiate alveolar versus interstitial lung diseases

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Why “Tools”?

- The intricate lung anatomy and the complex spectrum of lung pathologies makes imaging interpretation of alveolar and interstitial diseases sometimes difficult and puzzling.

- Radiologist needs to have robust navigation “tools” to accurately localize the pathology on the alveolar land or in the interstitial canals, helping him to distinguish the abnormality as alveolar or interstitial, thereby limiting the differential diagnosis.

- To solve this imaging puzzle, here we present a few useful tricks.. which we call “Radiologist's tool box !!”.
Tool box opens...!!

Decoding alveolar and Interstitial anatomy

Comparison of previous imaging

ALD: Radiographic tools

Differentiating patterns of Alveolar and ILD

ILD: Radiographic tools

Role of CT

Clinical history
Secondary pulmonary nodule (SPL)

- The lung parenchyma consists of two main components: Alveoli & the supporting structures. SPL is the smallest fundamental unit of the lung and has three principal components:
  - Lobular parenchyma and acini
  - Centrilobular structures
  - Interlobular septa and contiguous subpleural interstitium.
The substance of the secondary lobule consists of alveoli and the associated pulmonary capillary bed, supplied by small airways and branches of the pulmonary arteries and veins.
Interstitium

**AXIAL:**

- **Centrilobular Interstitium:** surround the artery and centrilobular bronchiole in the lobular core (a).

- **Intralobular Interstitium:** Septal fibers extending throughout the substance of the lobule in relation to the alveolar walls (b).

**PERIPHERAL:**

- **Subpleural Interstitium:** Located beneath the visceral pleura, envelopes the lung into fibrous sac, sends connective tissue septa into the lung parenchyma (b).

- **Interlobular septa:** Septa arising from subpleural Interstitium marginating the lobule.
Tool 2
ALD - Radiographic tools

ALD tools at a glance..

Morphology patterns
- Air space opacification

Distribution patterns
- Solitary/multiple
- Lobar / segmental
- Bats wing
- Reverse bats wing

Associated signs:
- Air bronchogram

ALD tools
+ - x /

Clinical history
Morphology pattern: ALD

Margins: Ill defined

Appearance: Coalescing/merging

Shape: Fluffy or blobby
### Distribution pattern

<table>
<thead>
<tr>
<th>Solitary</th>
<th>Multiple</th>
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<tr>
<td>Pneumonia - infection, aspiration, organizing, eosinophilic. (Fig 1)</td>
<td>Pneumonia (Fig 5)</td>
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<td>Infarct (Fig 3)</td>
<td>Infarction</td>
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<td>Hemorrhage (Fig 4)</td>
<td>Connective tissue disease/ vasculitis.</td>
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<tr>
<td>Bronchoalveolar carcinoma (Fig 2), lymphoma.</td>
<td>Bronchoalveolar carcinoma, metastases, lymphoma</td>
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Solitary air space opacification

Fig 1 A 54-year-old man with fever and cough. (a) Chest radiograph shows an ill-defined air space opacity in the right upper zone. (b) Axial CT thorax confirms the presence of infective consolidation in the right upper lobe.

Fig 2 A 48 year old male with h/o weight loss. (a) Chest radiograph shows air space opacity in the right lower zone mimicking infection. (b) CT thorax shows consolidation with air bronchogram and cystic lucencies in the right lower lobe. With given history and high suspicion, CT guided biopsy was performed and histopathology result came as bronchoalveolar carcinoma.
Fig 3 A 58 year old male with h/o breathlessness. (a) Chest radiograph shows a wedge-shaped juxta-pleural opacification in the right lower zone (arrows). (b) CT pulmonary angiogram shows wedge shaped consolidation in right lower lobe supplied by thrombosed pulmonary artery in keeping with pulmonary infarct.

Fig 4 A 32 year old male with history of trauma. (a) Chest radiograph shows airspace opacity in the right lower zone. (b) CT thorax shows focal consolidation in the right middle lobe with associated rib fracture and subcutaneous emphysema. Findings are in keeping with pulmonary contusion.
Multiple airspace opacification

Fig 5 A 59 year-old woman with h/o fever and cough. (a) Chest radiograph shows air space opacification in bilateral lower and mid zones with air bronchogram (arrows). (b) CT thorax confirms the presence of extensive areas of parenchymal consolidation with air bronchogram and ground glass opacities.

Air bronchogram

Alveoli opacified (air replaced by fluid/cells/protein) + Bronchi are filled with air. This appearance gives rise to air bronchogram sign. Important marker for identifying alveolar disease.
• Pulmonary edema (Fig 6)
• ARDS (Fig 7)
• Infection - Pneumocystis jirovecii (Fig 8)
• Hemorrhage (Fig 9)
• Hypersensitivity pneumonitis

Bronchoalveolar carcinoma
Lymphoma

Eosinophilic pneumonia (Fig 11)
Organizing pneumonia (Fig 10)
Bat’s wing appearance

Fig 6 A 60 year old female. Chest radiograph shows bilateral perihilar airspace opacities with interstitial thickening, cardiomegaly and prominent pulmonary artery in keeping with cardiogenic pulmonary edema.

Fig 7a Chest radiograph in critically ill patient shows diffuse airspace opacities in both the lungs. (b) CT thorax shows dependent areas of consolidation with non-dependent areas of "ground glass" opacities on both sides with small pleural effusion bilaterally. Diagnosis: ARDS.
Fig 8 A 37 year old immunocompromised male with fever and breathlessness. (a) Chest radiograph shows bilateral symmetrical airspace opacities giving "bat’s wing" appearance. (b) CT thorax shows bilateral "ground-glass" opacities with interlobular septal thickening. Diagnosis: Pneumocystis jerovici infection.

Fig 9 A 62 year old male on warfarin presenting with hemoptysis. (a) Chest radiograph shows bilateral symmetrical airspace opacities. (b) CT thorax shows dense consolidation in bilateral perihilar region. Diagnosis: Pulmonary haemorrhage.
Fig 10 A 51 year old male with history of chronic cough. (a) Chest radiograph shows patchy areas of airspace opacity in the lung periphery (arrows). (b, c, d) CT thorax at day 1 & 2 & 4 months show migratory areas of peripheral consolidation predominantly in upper lobes with Atoll sign(*). Diagnosis: Organizing pneumonia.
Fig 11 A 49 year old male with history of cough and fever. (a) Chest radiograph shows patchy areas of airspace opacity in the lung periphery (Reverse bat’s wing appearance). (b, c) Axial and coronal CT thorax shows peripheral areas of ground glass opacities in both lungs. Diagnosis: Eosinophilic pneumonia.
Tool 3:ILD: Radiographic tools

**Morphologic Patterns:**
- Septal lines
- Reticular opacities
- Reticulonodular opacities
- Nodular opacities
- Ground glass changes

**Associated findings:**
- Kerley lines
- Traction bronchiectasis
- Honeycombing
- Cystic changes

**Distribution Patterns:**
- Perilymphatic
- Upper lobe
- Lower lobe predominant

**Clinical history**
Septal opacities

- Septal thickening results from the thickening of the interlobular septa and connective tissue caused by infiltration of cells or fluid.

- **Classification:**
  - **Kerley A:** Intraparenchymal, straight, 2-4 cm, generally seen at the apex of lung. (Fig 12)
  - **Kerley B:** Basal, peripheral, 2 cm long. (Fig 13)
  - **Kerley C:** Tend to form polygons, in basal region.

- **Cardiogenic Pulmonary edema**
- **Non cardiogenic Pulm. edema**
  - -Lymphangitis
  - -Carcinomatosis
1: Kerley A lines in lung apices in known case of lung malignancy. Chest radiograph shows linear septal thickening seen as interlobular septal thickening on CT image. Diagnosis: lymphangitis carcinomatosa.

2: Kerley B lines at base on chest radiograph with cardiomegaly. CT thorax shows smooth septal thickening and ground glass opacity - Pulmonary edema
Reticular opacities

- Diffuse reticular thickening, 1 - 5 mm; progresses to web (coarse polygonal look) and late stage results in honeycombing.
- More evident at the costophrenic angles and at lung bases.
- Common differentials:
  - Fibrosing alveolitis- UIP, NSIP, collagen vascular diseases (Fig 14, 17)
  - Chronic Sarcoidosis
  - Chronic hypersensitivity pneumonitis
  - Asbestosis
  - Lymphangioleiomyomatosis (Fig 15)
  - Drug toxicity (Fig 16)
  - Langerhans cell histiocytosis
Fig 14 A 50 year old man with history of systemic sclerosis. (a) Chest radiograph shows reticular opacities in bibasal regions. (b) HRCT image shows reticular thickening in bibasal subpleural lung with honeycombing and traction bronchiectasis with lower lobe predominance. Diagnosis: UIP-scleroderma.

Fig 15 A 32 year young female with breathlessness. (a) Chest radiograph shows hyperexpanded lungs with prominent reticular markings in the left lung and right pneumothorax. (b) CT thorax shows multiple cystic lesions in both lungs with smooth septal thickening and pneumothorax. Diagnosis: Lymphangioleiomyomatosis.
Fig 16 A 75 year old patient with h/o myocardial infarction and on amiodarone drug. (1a) Chest radiograph shows reticular markings in bilateral lower zone. (1b) HRCT chest confirms UIP pattern of ILD and CT upper abdomen (1c) shows hyperdense liver secondary to amiodarone therapy with calcification in left ventricular apex (arrow).

Fig 17 A year old patient with breathlessness and h/o rheumatoid arthritis. (1a) Chest radiograph shows reticular markings in right lower zone with erosion of clavicles (arrow). (1b) HRCT chest shows interstitial thickening in bilateral lower lobes with honeycombing and absent ground glass opacity in keeping with usual interstitial pneumonia.
**Nodular opacities**

- Nodular opacities are round, with a diameter between 1 and 10 mm, with well-defined margins and well-separated from each other.

**Common differentials:**

- **Granulomatous diseases:** Sarcoidosis, TB, Histoplasmosis (Fig 18).
- **Pneumoconiosis:** CWP, Silicosis (Fig 19)
- **Lymphangitis carcinomatosis**
- **Extrinsic allergic alveolitis (Subacute HSP).**

**Tool:** nodules are always well defined, as these are located within the interstitium and surrounded by air filled acini.
Fig 18 A 45 year old male with history of fever. (a) Chest radiograph shows multiple well defined lung nodules on both sides (military pattern). (b) HRCT chest confirms bilateral lung nodules. Diagnosis: miliary tuberculosis.

Fig 19A 60 year old mine worker. (a) Chest radiograph: multiple well defined nodules predominantly in bilateral upper lobes. (b) HRCT chest shows bilateral lung nodules with features of progressive massive fibrosis. Few of the nodules and lymph nodes show calcification. Pneumoconiosis.
**Reticulonodular**

These opacities anatomically correspond to the co-existence of diffuse interstitial involvement and multiple focal nodules.

Common differentials:
1. Sarcoidosis (Fig 20)
2. LCH
3. Lymphangitis carcinomatosis. (Fig 21)

**Ground Glass opacities**

Common differentials:
1. Acute interstitial pneumonia. (Fig 22)
2. Hypersensitivity pneumonitis (subacute)
3. Desquamative interstitial pneumonitis.
5. Sarcoidosis.
6. Alveolar proteinosis
Fig 20 A 48 year old female with history of chronic cough. (a) Chest radiograph shows reticulonodular opacities in both lungs predominantly in bilateral upper lobes with hilar lymphadenopathy. (b, c) Axial HRCT scan shows multiple micronodules with a peribronchovascular (arrow) and fissural distribution (arrowhead) in both lungs, predominantly in the upper and middle lobes characteristic for sarcoidosis.
Fig 21A 55 year old male with history of weight loss and known gastric malignancy. (a) Chest radiograph shows reticulonodular opacities in both lungs. (b, c) Coronal and axial HRCT scan shows smooth and nodular interstitial thickening in both lungs in keeping with lymphangitis carcinomatosis.

Fig 22 A 60 year old male with fever and breathlessness. (a) Chest radiograph shows scattered areas of ground glass and reticular opacities. (b) CT chest shows diffuse areas of ground glass opacification with interlobular septal thickening (crazy paving pattern) and pleural effusion. In view of acute onset - acute interstitial pneumonia.
Tool 4: Other Radiographic tools for ILD

- Thoracic and extra thoracic associations with ILD

  - Example:
    - Mediastinal adenopathy = Sarcoidosis, TB.
    - Calcified hilar lymph nodes = Silicosis
    - Pleural plaques, calcification = Asbestosis.
    - Distal end of clavicle erosion = Rheumatoid arthritis.
    - Dilated oesophagus - scleroderma.

  - Associated changes:
    - Traction bronchiectasis, Honeycombing, Perilymphatic and Fissural nodules.

  - Topographic distribution: As shown in image

  **Topographic distribution**

  - **UPPER LOBE**
    - Chronic HSP
    - Sarcoidosis, TB
    - Silicosis
    - Langerhans cell histiocytosis

  - **LOWER LOBE**
    - UIP, NSIP - RA, SLE, scleroderma.
    - Asbestos related lung disease.
    - Drug toxicity
Tool 5: Role of CT

ALD
- Characterize suspicious airspace opacities seen on radiographs.
- Better lesion localization.
- Identify other opacities not visible on radiograph (disease load).
- Road map for CT guided biopsy.
- For staging in case of malignant consolidations (BAC).
- Post treatment, follow-up tool for suspicious mass like consolidations.

ILD
- Superior characterization and delineation of ILD patterns.
- Severity and staging of ILD/IPF.
- Post treatment, follow up tool to assess disease progression/regression.
- Evaluation of patients in whom radiographic findings are not concordant with clinical findings or pulmonary function tests.
Tool 6: Importance of clinical history

A few examples which show importance of clinical correlation

Alveolar disease

- Airspace opacities -
- Due to pneumonia is usually accompanied by cough and fever.
- In bilateral lower lobes in elderly and alcoholics point towards aspiration.
- In patients with hemoptysis often indicates pulmonary haemorrhage.
- Bilateral symmetrical and acute onset point towards cardiogenic pulmonary edema.

Interstitial diseases

- Work history: exposure to allergens/ mining.
- Drug toxicity: Ongoing Chemotherapy/ Amiodarone t/t
- Abnormal immunological serum markers for collagen vascular disease in cases of UIP/NSIP pattern.
- Abnormal Pulmonary function tests – restrictive/ obstructive.

Tool 7: Comparison of previous radiographs

(Last but not the least)

- Acute or chronic disease process – e.g benign or malignant consolidation.
- Interval progression of the disease - slow or rapid or stable.
Summary

- Alveolar and interstitial lung diseases encompass a wide spectrum of pathologies. Knowledge of the different presentations, radiographic patterns and key signs help to formulate the most suitable diagnostic hypotheses, taking into account the clinical and laboratory context and also paves way to CT as next diagnostic tool in selected cases.

- Formulating an imaging algorithm for both spectrums and knowing common differentials is of utmost importance for a Radiologist.

- This “pocket toolbox” helps one to develop a systematic approach to ALD – ILD and provides key to accurate diagnosis.
Relevant references/suggested readings


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