Lung Atelectasis: Types, Mechanisms and Imaging Findings

M. F. F. Hanna, MD¹, V. F. A. Salama², MD; S. S. Saboo³, MD; S. A. Oldham¹, MD

¹ UT Health Science Center at Houston

² The University of Texas MD Anderson Cancer Center/UT Health Graduate School of Biomedical Sciences

³ UT Southwestern Medical Center at Dallas
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Atelectasis is derived from the Greek words “ateles” and “ektasis”, which mean incomplete expansion.

It is defined as diminished volume affecting all or part of a lung.

Pulmonary atelectasis is one of the most commonly encountered abnormalities on chest radiographs.

Whenever atelectasis is found, it should prompt a vigorous search for a cause as it is a sign of underlying disease process.

The term "atelectasis" is typically used when there is partial collapse, whereas the term “Collapsed Lung” is typically reserved for when the entire lung is totally collapsed.
1- Transpulmonary pressure:

- The difference between intrapulmonary pressure (= atmospheric pressure) and intrapleural pressure.
  
- Intrapleural pressure < atmospheric pressure which creates the suction to keep the lungs inflated and prevents lung collapse.

2- The surfactant:

- It is a lipoprotein molecule produced in the alveoli that forms a very thin layer which covers the surface of the alveolar cells.

- The components of surfactant work together to reduce surface tension from water molecules on the lung tissue and therefore reduce the tendency of the alveoli to collapse during expiration.
**Types and Mechanisms of Atelectasis**

**Obstructive**
- Causes
  - Foreign body
  - Mucus plugging
  - Tumor
  - Perihilar adenopathy
- Relaxation or passive (pleural effusion or a pneumothorax)
- Compression (any space-occupying lesion)
- Adhesive (surfactant deficiency; like ARDS)
- Cicatrization (sequela of severe parenchymal scarring or entire lobe filled by tumor) → replacement of parenchymal tissue (elastic) by scarring or infiltrative disease (stiff)

- Most common type.
- Results from reabsorption of gas from the alveoli when communication between the alveoli and the trachea is obstructed

(intrapleural pressure > intrapulmonary pressure) → alveolar collapse
43 year old man in the ICU.

A) and B) are AP chest radiographs few hours apart demonstrating slightly diminished right lung volume with moderate collapse of the right upper lobe (yellow arrow). Notice the elevation of the horizontal fissure (blue arrow).

C) Axial and D) coronal CECT images performed few hours after the 2nd chest (B) radiograph showing mucus plugging (red arrow) of the right main bronchus few centimeters distal to the carina with enhancing collapsed right lung.
67 year old woman presented with difficulty of breathing.

A) PA and B) lateral chest radiographs demonstrate diffuse opacification of the left upper lobe including lingula (Yellow arrows), concerning for collapse/consolidation of the left upper lobe with central obstructing hilar mass.

C) Axial and D) coronal CECT images demonstrate abrupt cut off of the left upper lobe bronchus (red arrow) and associated bulky left hilar and mediastinal lymphadenopathy (blue stars) was due to bronchogenic carcinoma with associated metastatic lymphadenopathy with post obstruction left upper lobe collapse and pneumonia given the heterogeneous post contrast enhancement.
67 years old woman with right pneumothorax. A) AP chest radiograph demonstrating right pneumothorax (yellow arrow) with mild right lower lobe collapse confirmed on the B) coronal and C) axial CT images. (chest tube → blue arrow)

- **Non-obstructive**
  - Relaxation or passive atelectasis
- Relaxation or passive atelectasis

54 years old man with right moderate and left small pleural effusions.
A) AP chest radiograph demonstrating blunting of costophrenic sulci bilaterally (yellow arrows). Mild right lung collapse is noted.
B) Axial CT image demonstrate right moderate and left small pleural effusions. (Blue arrows)
67-year-old man with recurrent pulmonary infections. Axial CECT images demonstrate peribronchial pneumonic consolidative changes in right middle lobe and superior segment of right lower lobe (red arrows) along with subsegmental cicatrization related atelectasis (yellow arrows) in left lower lobe.

- Cicatrization
- Atelectasis

(sequela of severe parenchymal scarring)
Middle lobe syndrome

- It is a disorder of recurrent or fixed atelectasis involving the right middle lobe (Red arrows) and/or lingula.
- It can result from either extraluminal (bronchial compression by surrounding lymph nodes) or by intraluminal bronchial obstruction.
- It may develop in the presence of a patent lobar bronchus without identifiable obstruction.
- Middle lobe syndrome has been reported as a pulmonary manifestation of primary Sjögren syndrome. Transbronchial biopsies performed in such patients revealed lymphocytic bronchiolitis in the atelectatic lobes.
Rounded atelectasis

- Rounded atelectasis represents folded atelectatic lung tissue with fibrous bands and adhesions to the visceral pleura (red arrow).
- Incidence is high in asbestos workers (65-70% of cases), usually seen in patients who have had prior pleural disease (Pleural calcifications → yellow arrow).
- Affected patients typically are asymptomatic, and the mean age at presentation is 60 years.
- Rounded atelectasis may mimic a neoplastic tumor.
- The comet tail sign or talon sign is its distinguishing radiographic characteristic.
Linear (Plate-like, band, discoid, sub-segmental) atelectasis:

- Minimal degree of collapse (blue arrows) as seen in patients who are not taking deep breaths ("splinting"), such as postoperative patients or patients with rib fracture or pleuritic chest pain; this is very common
- A mild-to-severe gas exchange abnormality may occur because of ventilation-perfusion mismatch and intrapulmonary shunt.
Direct Signs
(Lung responds as a direct result of the volume loss)

1. Increased Density (Non Specific)
2. Displacement of Fissures (the most reliable)
3. Crowding of the Bronchi (hard to detect on CXR)

Indirect Signs
(Lung responds indirectly to the volume loss)

1. Hilar Displacement (the most reliable indirect sign of collapse)
2. Shift of the Tracheal Shadow
3. Mediastinal Shift
4. Elevation of a Hemidiaphragm
5. Approximation of the Ribs
6. Approximation of pulmonary vessels
7. Compensatory Hyperaeration
Dr. Woodring mentioned that,

1. The chest radiograph is an excellent diagnostic tool for showing segmental or lobar atelectasis.

2. The chest radiograph can be used to document central tumor as the cause of atelectasis in most cases in which tumor is present on the basis of two major findings:
   - evidence of central hilar mass (S sign of Golden)
   - evidence of central bronchial narrowing or occlusion.

   Using both findings as plain film signs, He found that the chest radiograph had 96% specificity for obstructing tumor and a low false-positive rate.

3. CT is an excellent means of visualizing the lobar bronchi and proximal portions of the segmental bronchi in normal subjects.

Lobar atelectasis or lobar collapse is an important finding on a chest x-ray and has a limited differential diagnosis.

The most common causes of atelectasis are:

1. Bronchial carcinoma in smokers
2. Mucus plug in patients on mechanical ventilation or asthmatics (Allergic Bronchopulmonary Aspergillosis)
3. Mal-positioned endotracheal tube
4. Foreign body in children
AP chest radiograph demonstrates right upper lobe collapse with elevation of the horizontal fissure (blue arrow), elevation of the right hemidiaphragm (yellow arrow) and right sided deviation of the trachea (red arrow).
What forms the Golden S sign?

The upper concavity is formed by the edge of the collapsed lobe (yellow arrow) while the more medial convexity is due to the obstructing tumor or enlarged hilar LN (blue arrow).

Although classically described in the right upper lobe, the sign can sometimes be observed in other lobes.
A) PA and B) lateral chest radiographs demonstrate right middle lobe collapse with silhouetting of the right cardiac border on the PA view (yellow arrow) and approximation of the horizontal and oblique fissures on the lateral view (red arrows).
Chest radiographs and non-contrast CT for lung screening in a 58 year old woman demonstrate collapsed right middle lobe (yellow star) which was shown on follow up CECT to be due to middle lobar endobronchial tumor.
63 years old Female with lung cancer.
Axial CECT chest demonstrates collapse of the posterior basal segment of the right lower lobe with bronchial crowding (blue arrows)
PA chest radiograph demonstrates diffuse haziness of the left lung with volume loss and related crowding of the ribs while the lateral chest radiograph demonstrates LUL collapse with related posterior concavity of the oblique fissure (red line) and complete opacification of the left upper lobe (LUL).
Luftsichel Sign (Crescent): Compensatory hyperinflation of the superior segment of the left lower lobe (shaped like Sickle) (blue line) which insinuates between the collapsed left upper lobe (yellow line) and the mediastinum (red star)

Why does left upper lobe collapse present with a veil-like opacity over the hemithorax?
The left lung tends to collapse anteriorly to lie against the anterior chest wall. The left lower lobe overinflates to fill in the space.

Axial CT chest image of the same patient demonstrates abrupt cut off of the left upper lobe bronchus (red arrow) due to bronchial malignancy related complete collapse of the left upper lobe (black star).
Note: Extensive centrilobular emphysema in the rest of both lungs.
45-year-old man with left lower lobe bronchial carcinoid causing its obstruction and retrocardiac opacification on radiograph (A) correlating with left lower lobe collapse giving flat waist sign (yellow line).

(B) Axial CECT chest demonstrates collapsed left lower lobe (red arrow) with dilated mucus filled bronchi (yellow arrow).
Mimickers of lobar collapse on chest radiograph:

- Mimicker of right middle lobe collapse:
  - On Lateral chest radiograph:
    1. Fluid within the oblique fissure (pseudotumour): horizontal fissure should be visible as separate to the opacity.
    2. Fat within the oblique fissure,
    3. Consolidation of the right middle lobe (e.g. Pneumonia)
  - On P.A. chest radiograph:
    1. A pectus excavatum, but the lateral view should solve this problem.
    2. Pericardial cyst.
Lateral CT scout (A) and lateral chest radiograph (B) showing complete opacification of the middle lobe (yellow star); A) demonstrates superior bulging of the horizontal fissure (red arrow) ➔ volume preservation or increase volume ➔ Pneumonia or tumor infiltration. B) demonstrates concave horizontal fissure (blue arrow) ➔ Volume loss ➔ Collapse
35 years old man presented with cough.

A) PA chest radiograph demonstrates silhouetting of the right cardiac border (simulating middle lobe collapse) with smooth rounded margin (red arrows), likely of mediastinal origin.

B) CECT demonstrates well defined rounded lesion at the right pericardiophrenic recess with mass effect on the right side of the heart and CT density of fluid (yellow star) → pericardial cyst.
Lateral chest radiographs for complete opacification of the left upper lobe (LUL); A) demonstrates posterior bulging of the oblique fissure (yellow line) → volume preservation or increase volume → Pneumonia or tumor infiltration. B) demonstrates concave oblique fissure (red line) → Volume loss → Collapse Mimicker of left upper lobe collapse:
Mimicker of lingula or partial left lower lobe collapse:

Lateral chest radiograph (A) demonstrates triangular opacity related to the left oblique fissure mimicking partial lower/lingular lobe collapse (yellow arrow).

However, sagittal CT chest image of the lung (B) demonstrates fat density within correlating left oblique fissure and just few linear bands of atelectasis within inferior lingula and anterior left lower lobe. Note density of left oblique fissure fat is similar to left upper abdomen fat and was better characterized as fat on mediastinal window and on attenuation value (not shown).
Mimicker of lower lobe collapse:

Dense large breast can mimic lower lobe collapse

AP chest radiograph demonstrating dense large Right breast mimicking right lower lobe collapse (silhouetting the right hemidiaphragm) (yellow arrows), however there is only mild atelectasis in the right middle lobe (silhouetting the right heart border)
Mimicker of whole lung collapse:

Frontal CT scout (A) demonstrates left hemi thorax volume suggestive of underlying lung collapse (this would prompt a bronchoscopy).

However, axial non contrast CT chest images; lung (B) and mediastinal (C) windows demonstrate left hypoplastic lung with short left main bronchus (yellow arrow) and no ventilated left lung tissue with compensatory hyperinflation of the right lung and left sided mediastinal shift.
REFERENCES


Thank You!
Mina.f.hanna@uth.tmc.edu