

# **Imaging findings of COVID-19**

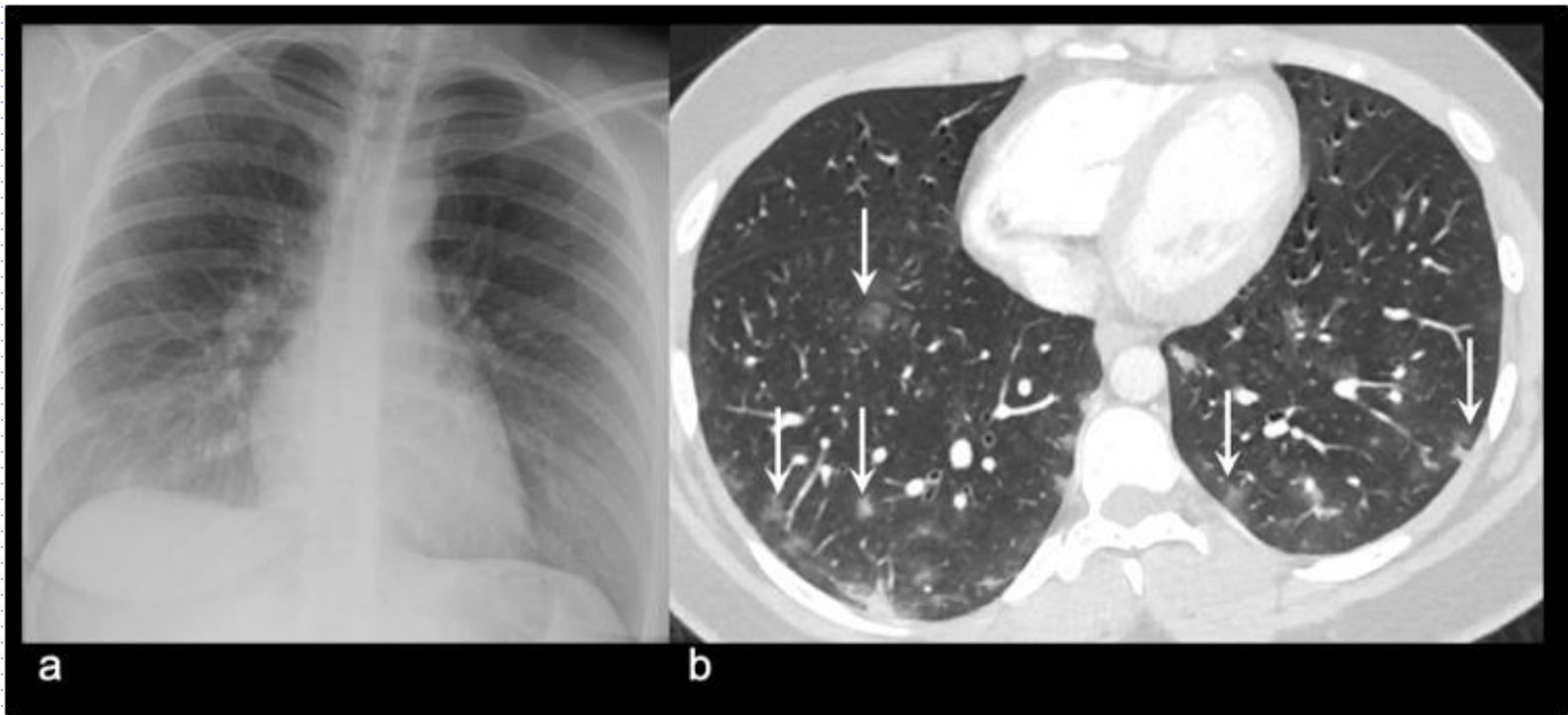
**Dr. Hamid dahmardeh**

**Assistant Professor of Radiology Department  
Of Radiology**

**ZAHEDAN University Of Medical Science**

# **Chest radiography findings**

- **CXR is negative in 40 %–66.7 % of cases despite positive findings on chest CT**
- **The most common radiographic finding is opacification, often with a peripheral and lower lung distribution**
- **Thus, CXR is not recommended for routine Dx, but may be helpful for follow-up.**



25-year-old female presenting with 7 days of fever and shortness of breath, with portable chest radiography (a) showing no abnormality. A subsequent CT angiogram of the chest (b) shows multifocal lower lobe rounded opacities, predominately ground-glass in attenuation (arrows). Patient tested positive for COVID-19.



60-year-old male with fever / cough for 7 days due to COVID-19. (a)C-Xray shows ill-defined opacities in the lateral aspect of the right lung (arrows). (b) Axial CT shows GGOs with a peripheral distribution in both upper lobes (arrows). There is superimposed interlobular and intralobular septal thickening (crazy-paving pattern). (c) Reconstructed CT image shows corresponding multifocal bilateral ground-glass opacities with a peripheral distribution (arrows).

# **Chest CT findings**

- **A low dose, chest CT without intravenous contrast is used for evaluation**

## A low dose chest CT

- improved detector
- highpitch settings
- lower tube voltage (80–100 kVp) and current (10–25 mAs)
- Reconstruction
- dose reduction options
- it is now feasible to minimize the radiation dose. We implemented a low-dose scanning protocol that reduced the patient's dose to 1/8 to 1/9 of the standard dose.
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# **Chest CT findings**

- The vast majority, 98%, show bilateral lung involvement. The typical chest CT findings of non-ICU patients are bilateral ground-glass opacity and sub-segmental consolidation.
- ICU patients are bilateral multi-lobe and sub-segmental consolidation

# Chest CT findings

The affected lungs are mostly located in the peripheral zone. Other imaging features include linear opacities, “crazy-paving” pattern, and the “reverse halo” sign

# Chest CT findings

- GGOs may have a rounded morphology in up to 54 % of the cases
- Superimposed interlobular septal thickening can also be present, resulting in a crazy-paving pattern .
- Vascular enlargement, air bronchograms, and a halo sign have also been described
- The GGOs and consolidative lesions are larger than 1cm in 91 % of cases.
- The lower lobes and posterior portions are more frequently involved

# Chest CT findings

- Mediastinal and hilar lymphadenopathy
- pleural effusions or thickening
- discrete pulmonary nodules
- pulmonary cavitation have been rarely described

# Chest CT findings

- CXR and chest CT can be negative in up to 17.9 % of patients, especially in early and/or non severe diseases.
- In mild cases, CT findings consist more frequently of GGO alone (65 %), followed by GGO with consolidation (44 %) .
- Severe cases with a clinical ARDS picture present with widespread dense consolidative opacification on CT

# Stages of COVID-19 on chest CT

- These were classified into 4 main successive stages:
- Early stage
- intermediate stage
- late stage
- resorptive stage

# Stages of COVID-19 on chest CT

- Early stage ( $\leq 2$  days):
- More than half of the patients have negative chest CT (56 %). The remaining patients have predominantly GGO (44 %) and consolidation (17 %). Imaging findings when present were often unilateral

# Stages of COVID-19 on chest CT

- Intermediate stage (3–5 days):
- As the disease progresses, more GGO (88 %) and consolidation (55 %) are noted bilaterally (76 %) and with a peripheral lung distribution (64 %).
- Only 9% of patients have negative chest CT

# Stages of COVID-19 on chest CT

- Late phase (6–12 days):
- Most of the patients in this phase have positive chest CT findings. 88 % and 60 % of patients have GGO and consolidation, respectively.
- The imaging findings are bilateral in 88 % and peripheral-predominant in 72 % of cases

# Stages of COVID-19 on chest CT

- Absorption stage/fourth stage (> 14 days)
- 65 % and 75 % of patients have GGO and consolidation, respectively.
- The imaging findings are bilateral in 88 % and peripheral-predominant in 72 % of cases

# Absorption stage/fourth stage

- When patients improve, the lung disease evolves and organizes, and fibrous bands may appear . A “reverse-halo sign” is occasionally observed and can be an indication of organizing pneumonia .

# Differential diagnosis

- severe acute respiratory syndrome (SARS)
- MERS
- influenza, parainfluenza
- adenovirus, respiratory syncytial virus (RSV), rhinovirus, human metapneumovirus, cytomegalovirus and others)], as well as community-acquired pneumonias (CAP) caused by *Streptococcus pneumonia* or mycoplasma infection

# Differential diagnosis

- COVID-19 tends to have a more peripheral distribution, greater GGO, increased vascular enlargement and a “reverse-halo sign”
- COVID-19 had more frequent bilateral GGOs compared to non-COVID-19 viral infections
- Key findings less frequent in COVID-19 compared to non-COVID included air bronchograms, centrilobular nodules, tree-in-bud opacities, bronchial wall thickening and a reticular pattern

# COVID-19/ SARS/MERS

- All three of these infections cause peripheral multifocal airspace opacities (GGO and/or consolidation), with rare pneumothorax, without cavitation or lymphadenopathy. Differences in the imaging appearances have been reported, as *SARS* tends to be unilateral and focal in distribution (50 %) and *MERS* patients can develop pleural effusion (33 %) . Both *SARS* and *MERS* are associated with constriction of the pulmonary vasculature, whereas enlargement of the vasculature has been reported in COVID-19

# COVID-19/ SARS/MERS

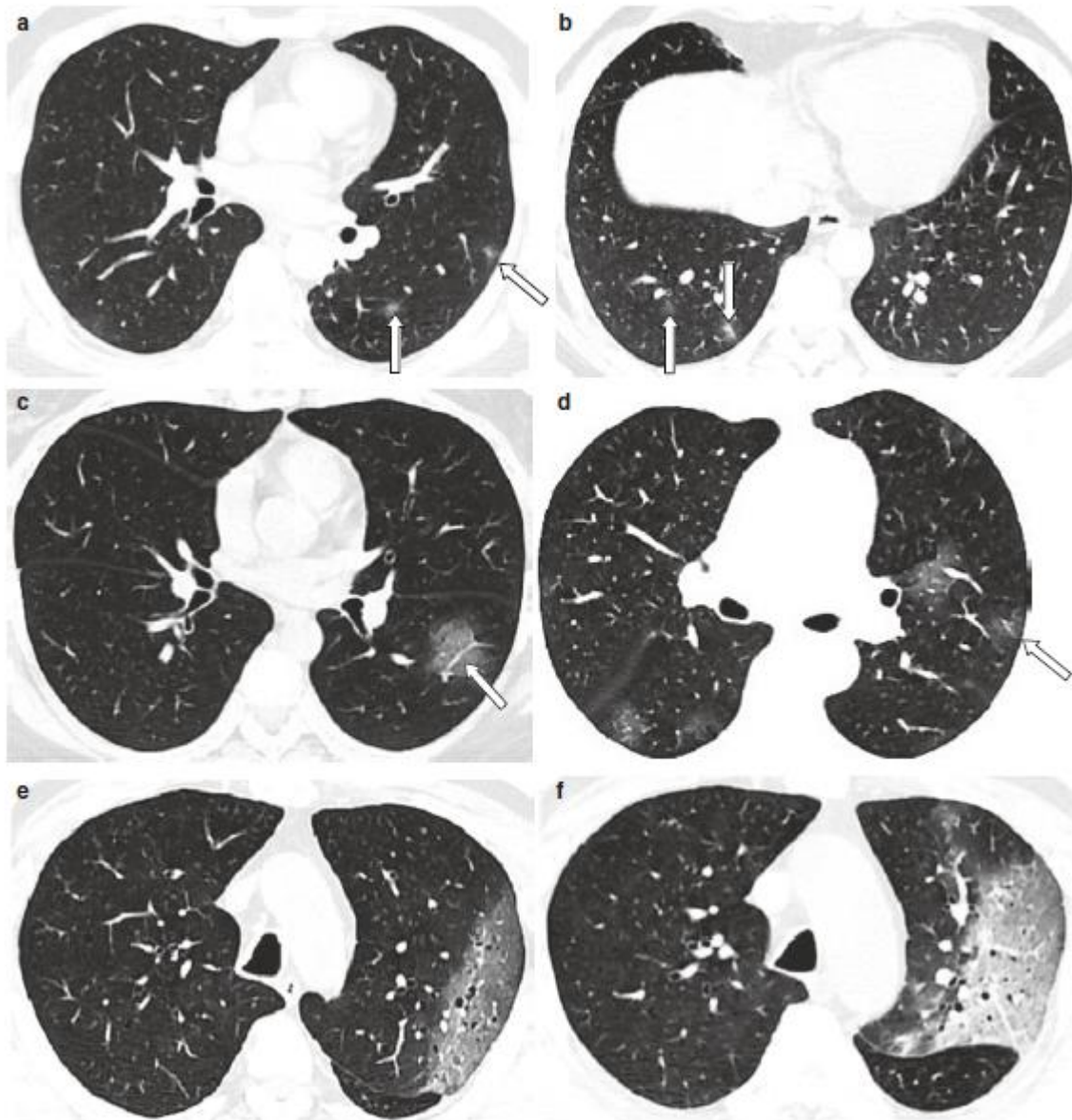
- Pulmonary fibrosis was reported as a late manifestation in MERS, but not in SARS. The long-term sequelae of COVID-19 remain to be determined; however, early publications indicate a fibrotic phase characterized by reticulation, interlobular septal thickening and traction bronchiectasis

# Ground-Glass Opacity

- At the early stage of COVID-19 pneumonia, CT scans show ground-glass opacity mainly distributing in the periphery of lung field or around the bronchial vascular bundle with unclear boundary, which implies inflammatory exudation in alveolar cavity and alveolar septum in pathological.
- The CT findings show nodule, patchy shadows. With the progression of disease, the focal lesion may develop into consolidation .

# Consolidation

- Consolidation refers to the alveolar air being replaced by pathological fluids, cells, or tissues, manifested by an increase in pulmonary parenchymal density that obscures the margins of underlying vessels and airway walls. Multifocal, patchy, or segmental consolidation are mainly distributed in subpleural areas or along bronchovascular bundles.
- Air bronchogram is a pattern of air-filled (tree branch-shape low-attenuation) bronchi on a background of pulmonary consolidation.



- A 33-year-old male patient. CT scan shows two ground-glass nodules in the left lower lobe, with unclear boundary. (b) A 26-year-old male patient. CT scan shows two ground-glass nodules in the right lower lobe, with unclear boundary. (c) A 32-year-old female patient. CT scan shows ground-glass opacity in the left lower lobe, with thickened vascular shadow (empty arrow). (d) A 55-year-old female patient. CT scan shows multiple ground-glass opacities in bilateral lungs, with thickened vascular shadow (empty arrow). (e) A 63-year-old male patient. CT scan shows patchy ground-glass opacity in the left upper lobe, with unclear boundary and bronchiectasis. (f) Follow-up CT scans after 3 days; the lung involvement and density of lesion increased, with larger patchy ground-glass opacity and focal consolidation. (g, h) A 65-year-old male patient. CT scans show diffuse ground-glass opacity in both lungs, with focal consolidation

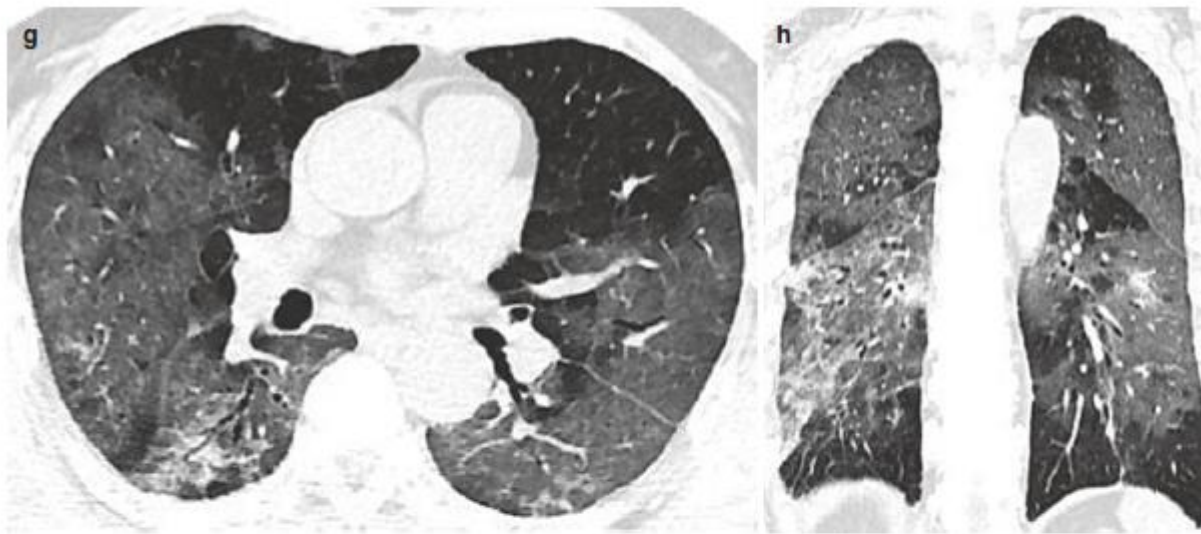
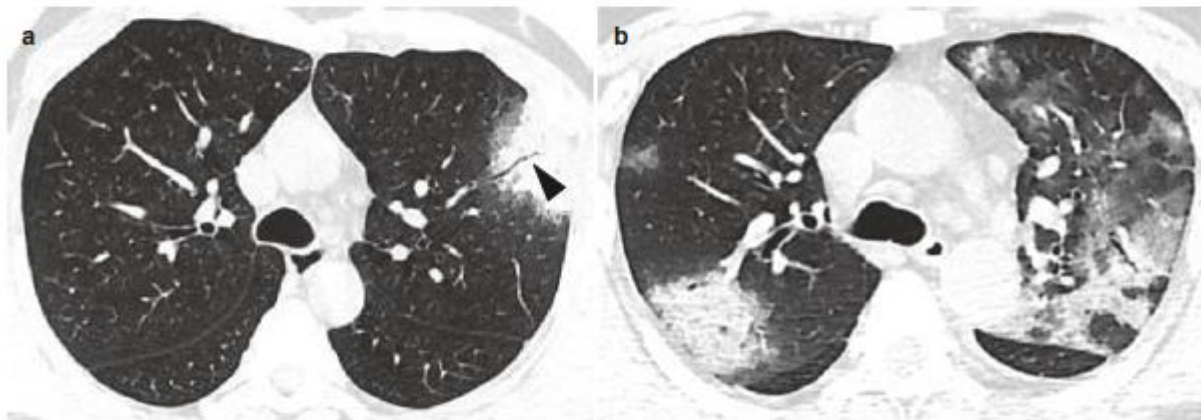
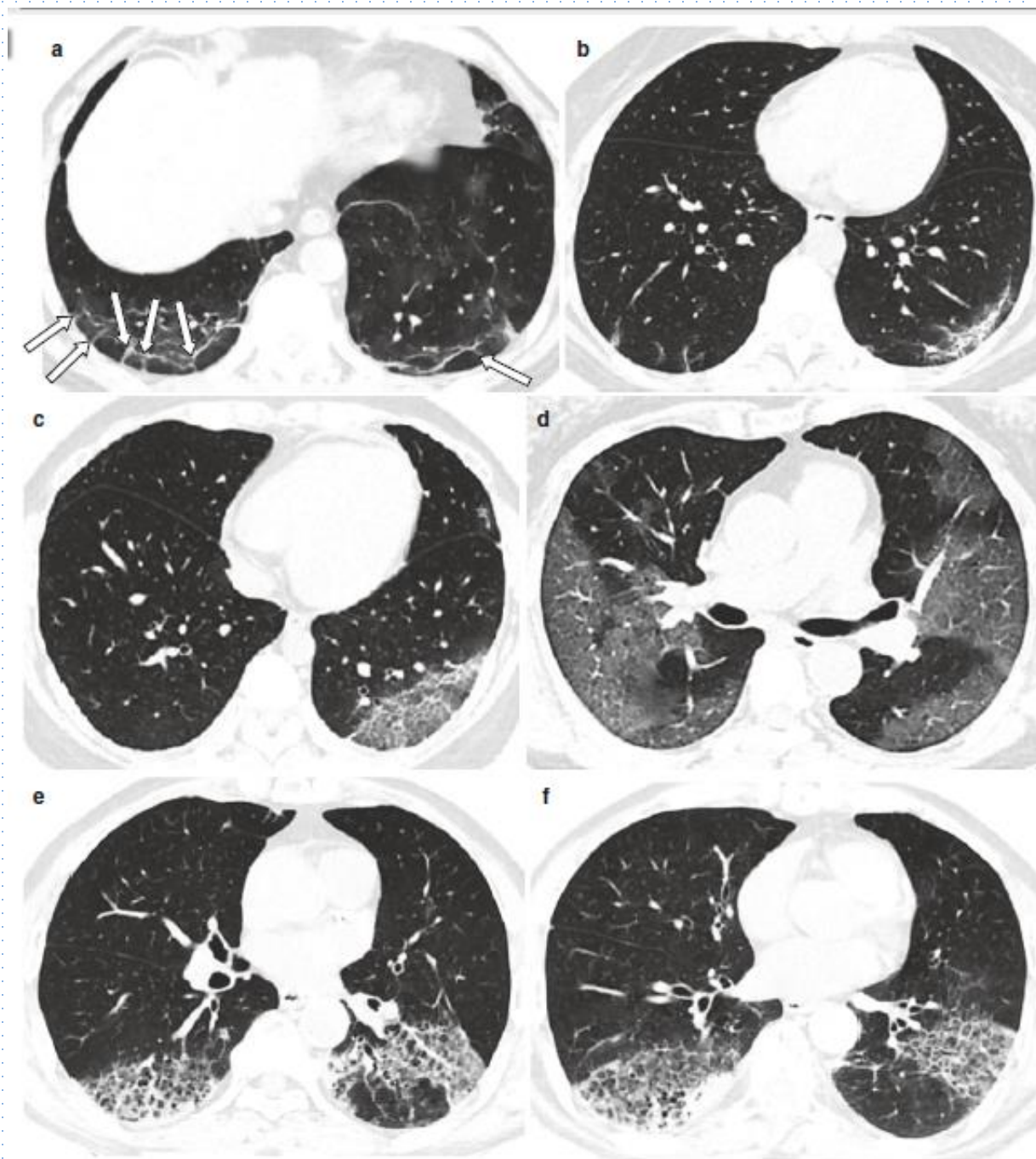


Fig. 2.1 (continued)



- (a) A 39-year-old male patient. CT scan shows patchy consolidation in the left upper lobe, with “air bronchogram” sign inside (black arrow). (b) A 43-year-old male patient. CT scan shows multiple ground-glass opacities and consolidation in bilateral lungs



# Pleural Thickening

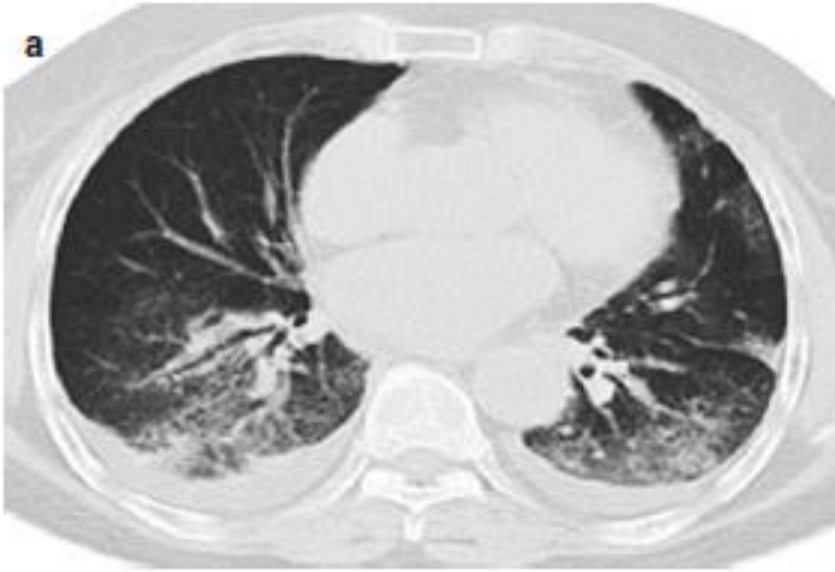
- The thickening of the pleura is the dense shadow of the band-like soft tissue along the chest wall, the thickness is uneven, the surface is not smooth, and the interface with the lung is mostly visible with small adhesions. It is more common in COVID-19 pneumonia.

# Pleural Effusion

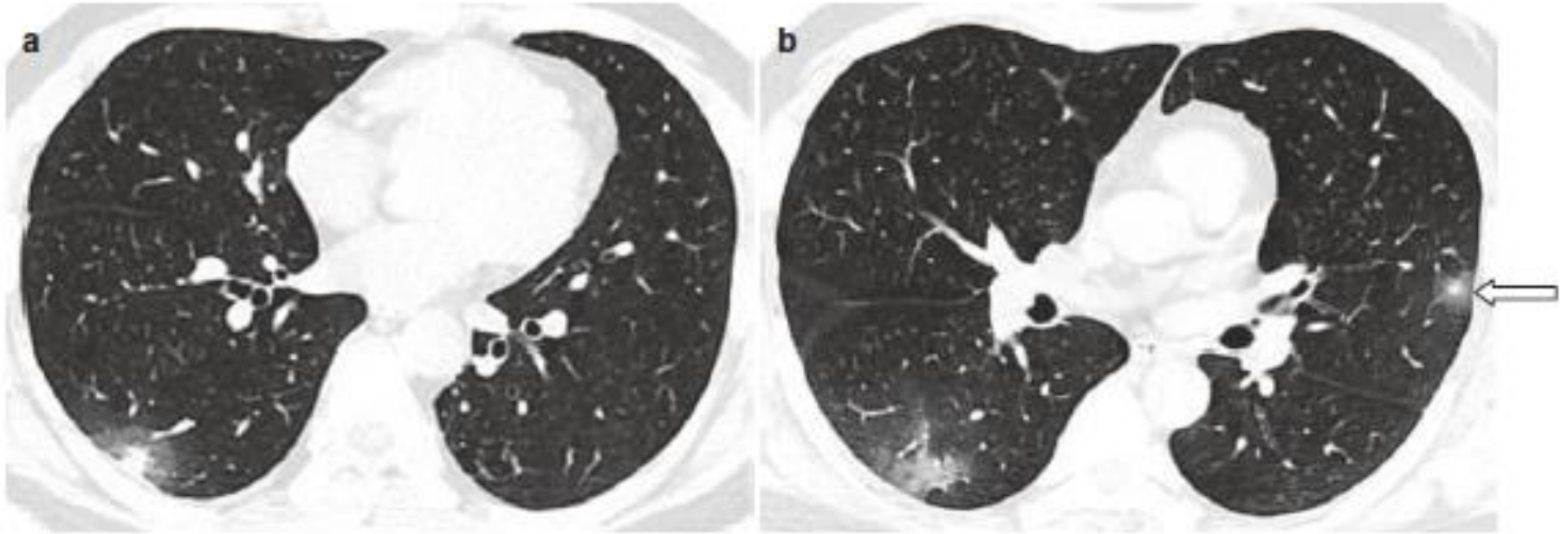
- Pleural effusion is uncommon in patients with COVID-19 pneumonia; some patients may have little pleural effusion and pleural thickening.

# Halo Sign

- The “halo sign” can be found in some nodules, surrounded by ground-glass opacity, suggesting inflammatory exudation and edema of the alveolar compartment



- (a, b) A 71-year-old female patient. CT scans show multiple ground-glass opacities and reticular pattern, accompanied by pleural effusions



- (a) A 33-year-old male patient. CT scan shows a nodule surrounded by ground-glass opacity in the right lower lobe, which manifests as “halo sign.” (b) A 43-year-old male patient. CT scan shows multiple ground-glass opacities in bilateral lungs. A nodule of the left upper lobe is surrounded by ground-glass opacity and presents as “halo sign” (empty arrow)

# Reversed Halo Sign

- Also called “atoll sign,” it is defined as a focal rounded ground-glass opacity surrounded by annular or crescent-shaped consolidation. After effective treatment, the “reversed halo sign” could disappear gradually

