

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



Radiologic findings in covid 19

Clinical presentation

Common:

Fever (85-90%)
Cough (65-70%)
fatigue (35-40%)
sputum production
(30-35%)
shortness of breath
(15-20%)

Less common:

Myalgia/arthritis
(10-15%)
headaches (10-
15%)
sore throat (10-
15%)
chills (10-12%)
pleuritic pain



Clinical presentation

Rare:

nausea, vomiting, nasal congestion (<10%),
diarrhoea (<5%)

Palpitation and chest tightness



Clinical presentation

Pediatric

In the main, the clinical presentation in children with COVID-19 is milder than in adults. Symptoms are similar to any acute chest infection, encompassing most commonly pyrexia, dry cough, sore throat, sneezing, myalgia and lethargy. Wheezing has also been noted. Other less common (<10%) symptoms in children included diarrhea, lethargy, rhinorrhea and vomiting.



Diagnosis

The definitive test for SARS-CoV-2 is the **real-time reverse transcriptase-polymerase chain reaction (RT-PCR) test** and is believed to be **highly specific** but with **sensitivity** reported as low as **60-70%** and as high as **95-97%**. Thus, false negatives are a real clinical problem and several negative tests might be required in a single case to be confident about excluding the disease.



Laboratory tests

The most common ancillary laboratory findings in a study of 138 hospitalized patients were the following :

lymphopenia

increased prothrombin time (PT)

increased lactate dehydrogenase

Mild elevations of inflammatory markers (**CRP and ESR**) **and D-dimer** are also seen



Radiographic features

The primary findings of COVID-19 on chest radiograph and CT are those of **atypical pneumonia or organizing pneumonia**.

Imaging has limited sensitivity for COVID-19, **up to 18%** demonstrate normal chest x-rays or CT when mild or early in the disease course but this **decreases to 3%** in severe disease. **Bilateral and/or multilobar involvement is common**



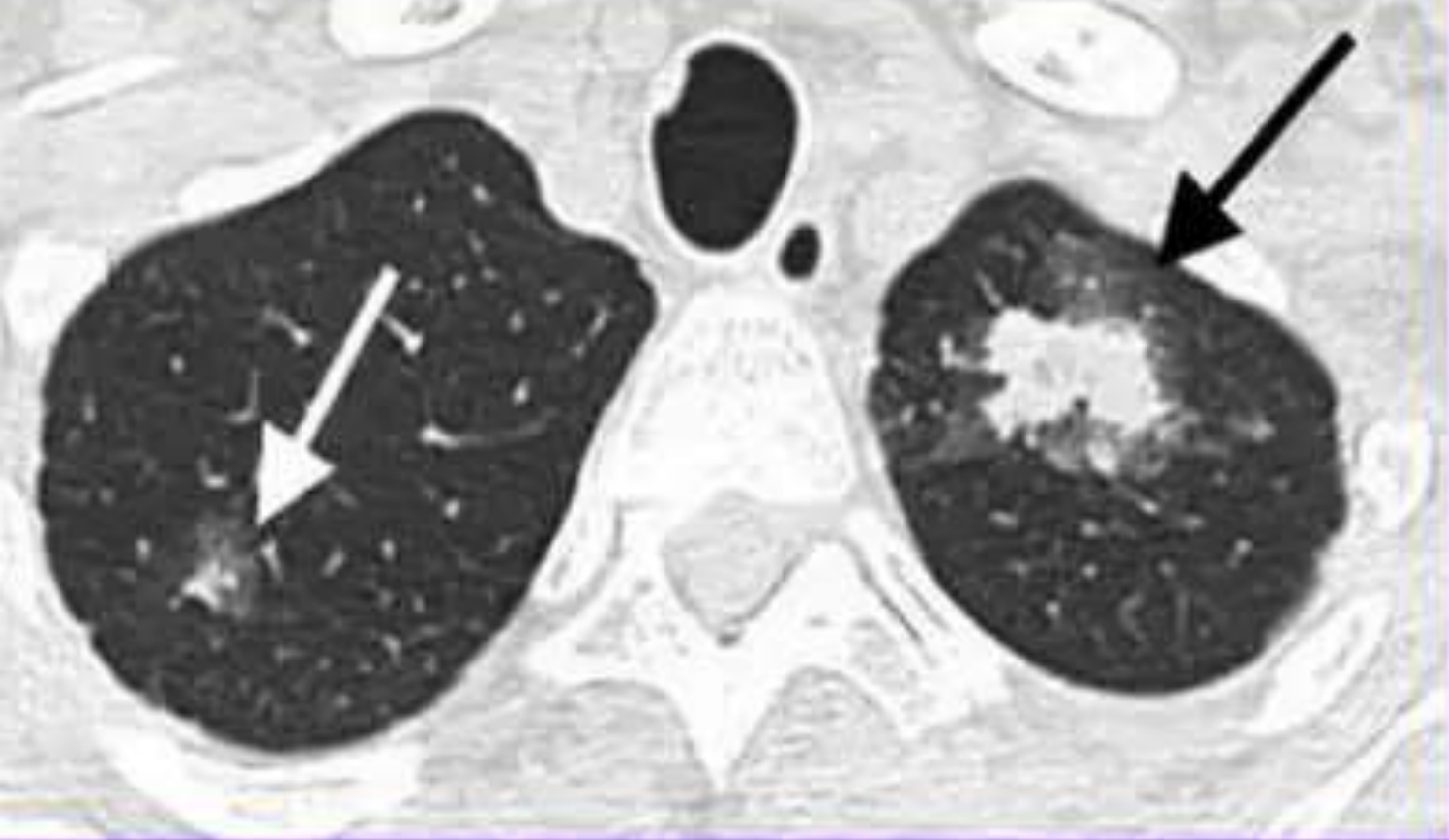
Radiographic features

Plain radiograph

may be normal in initial stages

asymmetric patchy or diffuse airspace
opacities have been described





nodular consolidation associated with a halo of ground-glass
(O) in both apices resulting from invasive pulmonary

presents hemorrhage.

in leukemic patients, is highly suggestive of the diagnosis of
monary aspergillosis.



CT Halo Sign

Infectious diseases

Fungus; aspergillosis^a, mucormycosis, candidiasis, coccidioidomycosis, cryptococcosis

Septic embolism

Mycobacteria; tuberculosis, *Mycobacterium avium* complex

Rickettsia; *Coxiella burnetii*

Virus; herpes simplex virus, varicella-zoster virus, cytomegalovirus, myxovirus

Neoplastic diseases

Primary tumours; squamous cell carcinoma, Kaposi sarcoma, bronchioloalveolar carcinoma^b, adenocarcinoma

Metastatic tumours; angiosarcoma, choriocarcinoma, osteosarcoma, melanoma, hydatidiform mole, metastatic tumours from gastrointestinal malignancies

Lymphoproliferative disorders

Non-neoplastic, non-infectious, inflammatory diseases

Wegener's granulomatosis

Eosinophilic lung disease; parasitic infestation (schistosomiasis), simple pulmonary eosinophilia, hypereosinophilic syndrome

Pulmonary endometriosis

Organizing pneumonia

Hypersensitivity pneumonitis

Iatrogenic injury; transbronchial lung biopsy, catheter-induced pulmonary pseudoaneurysm





Reverse Halo Sign

- Central ground-glass opacity surrounded by denser consolidation of crescentic or ring shape, at least 2 mm thick
- First described by Voloudaki in 1996
- Kim in 2003 used the term reverse halo
- Found to be relatively specific for cryptogenic organizing pneumonia (COP)



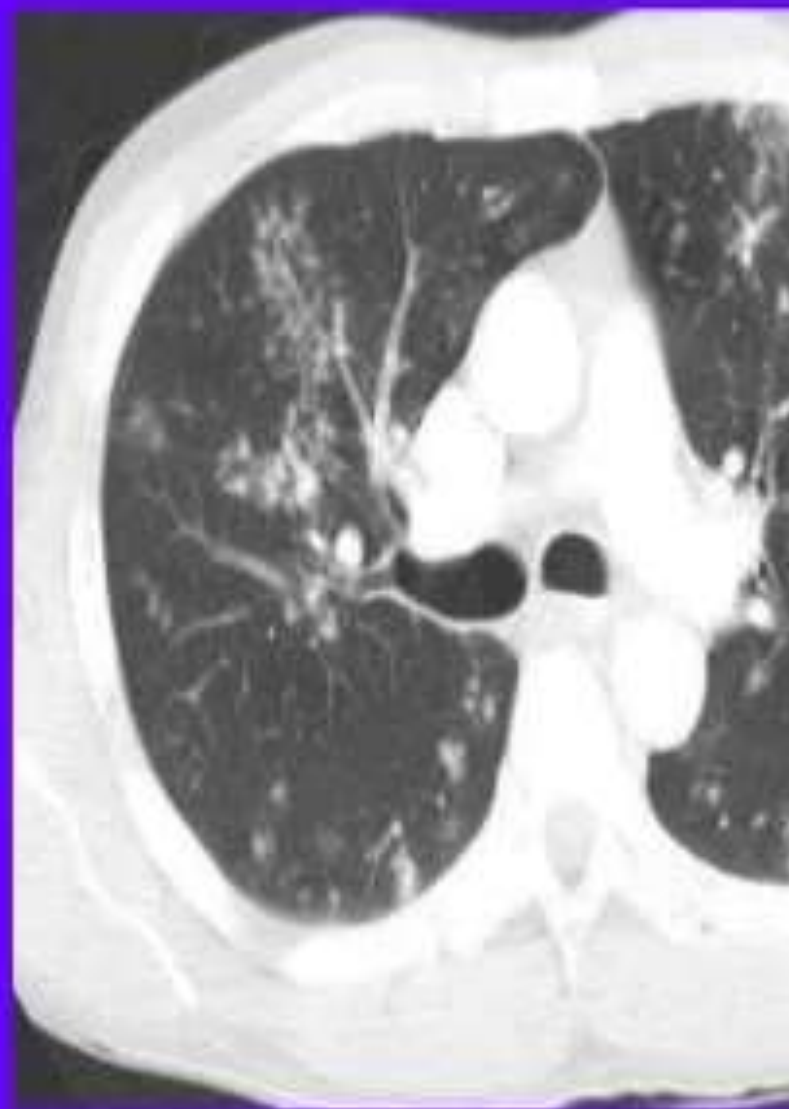
Reverse Halo Sign

Seen in other conditions:

- Wegener's granulomatosis
- lymphomatoid granulomatosis
- paracoccidioidomycosis
- neoplastic (metastasis)
- invasive aspergillosis
- lipoid pneumonia







Tree-in-Bud Sign

Peripheral airway disease

Infection

Bacterial

Mycobacterium tuberculosis

M avium-intracellulare complex

Staphylococcus aureus

Haemophilus influenzae

Fungal

Aspergillus

Viral

Cytomegalovirus

Respiratory syncytial virus

Congenital disorders

Cystic fibrosis

Kartagener syndrome

Idiopathic disorders

Obliterative bronchiolitis

Diffuse panbronchiolitis

Aspiration

Inhalation

Toxic fumes and gases

Immunologic disorders

Allergic bronchopulmonary aspergillosis

Connective tissue disorders

Rheumatoid arthritis

Sjögren syndrome

Peripheral pulmonary vascular disease

Neoplasms

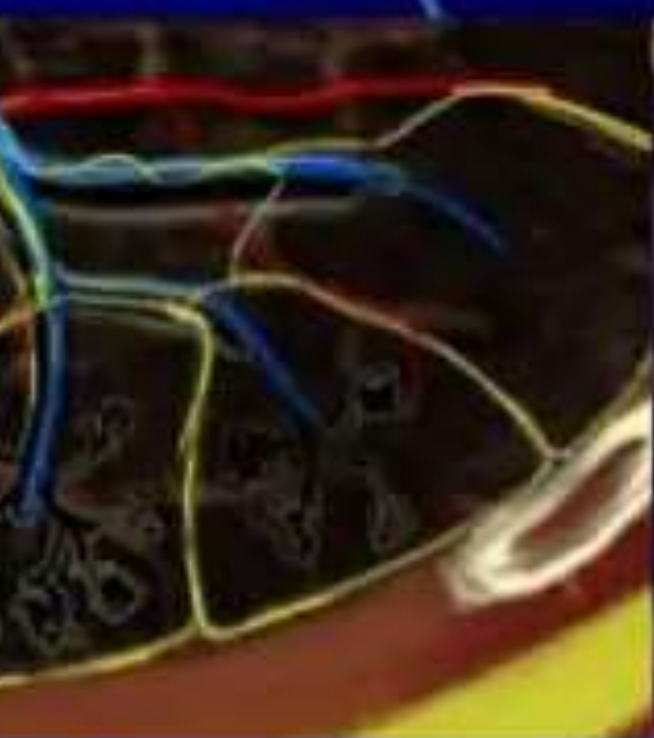
Gastric cancer

Breast cancer

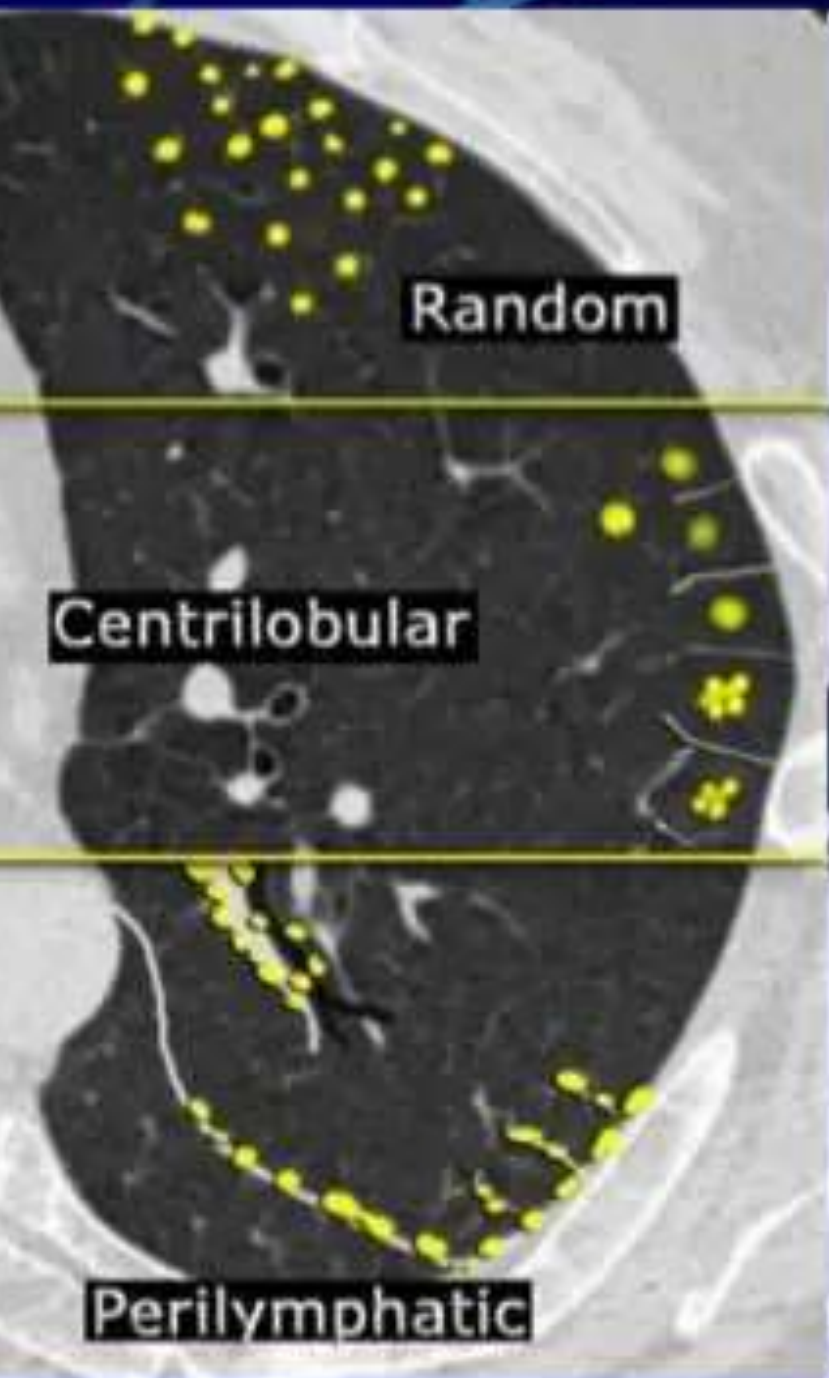
Ewing sarcoma

Renal cancer





- Basic anatomic unit of pulmonary structure and function.
- 1-2 cm and is made up of 5-15 pulmonary acini
- Supplied by a small bronchiole (terminal bronchiole) in the center, that is paralleled by the centrilobular artery.
- Pulmonary veins and lymphatics run in the periphery
- Two lymphatic systems:
 - central network
 - peripheral network



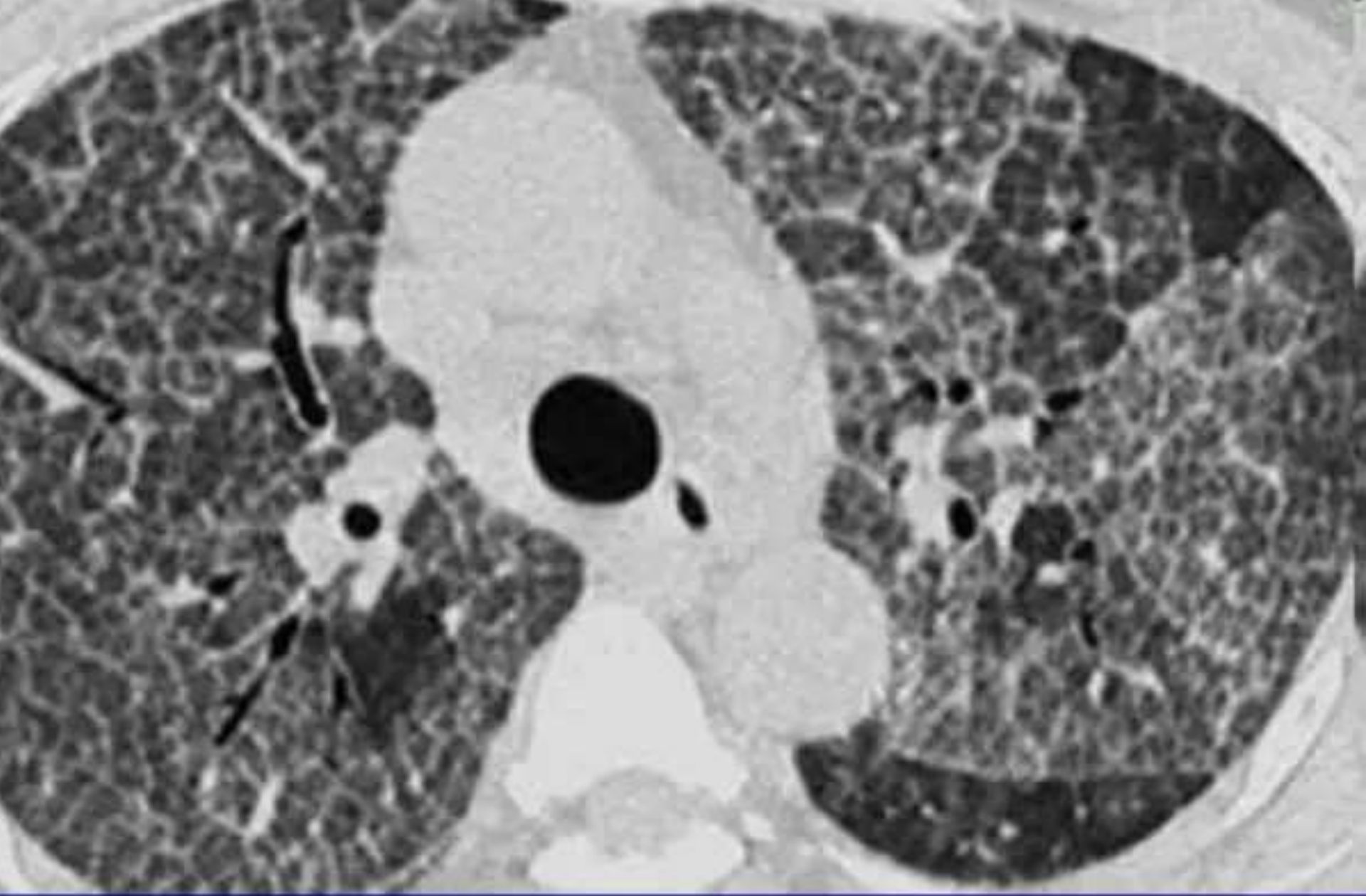
Random distribution

Centrilobular distribution

Perilymphatic distribution







Crazy Paving in a patient with Alveolar proteinosis.



Radiographic features

CT patterns



Pattern	Description
CLASSIC COVID-19 (100% confidence for COVID)	Lower lobe predominant, peripheral predominant, multiple, bilateral* foci of GGO ± <ul style="list-style-type: none">• Crazy-paving• Peripheral consolidation**• Air bronchograms• Reverse halo/ perilobular pattern**
PROBABLE COVID-19 (71-99% confidence for COVID)	<ul style="list-style-type: none">• Lower lobe predominant mix of bronchocentric and peripheral consolidation• Reverse halo/ perilobular pattern**• GGO scarce
INDETERMINATE (<70% confidence for COVID)	<ul style="list-style-type: none">• Does not fit into definite, probable or Non-Covid• Manifests above patterns, but the clinical context is wrong, or suggests an alternative diagnosis (e.g. an interstitial lung disease in a connective tissue disease setting)
NON-COVID (70% confidence for alternative)	<ul style="list-style-type: none">• Lobar pneumonia• Cavitating infections• Tree-in bud/ centrilobular nodularity• Lymphadenopathy, effusions• Established pulmonary fibrosis

*>1 lesion, but could still be unilateral; usually but not universally bilateral

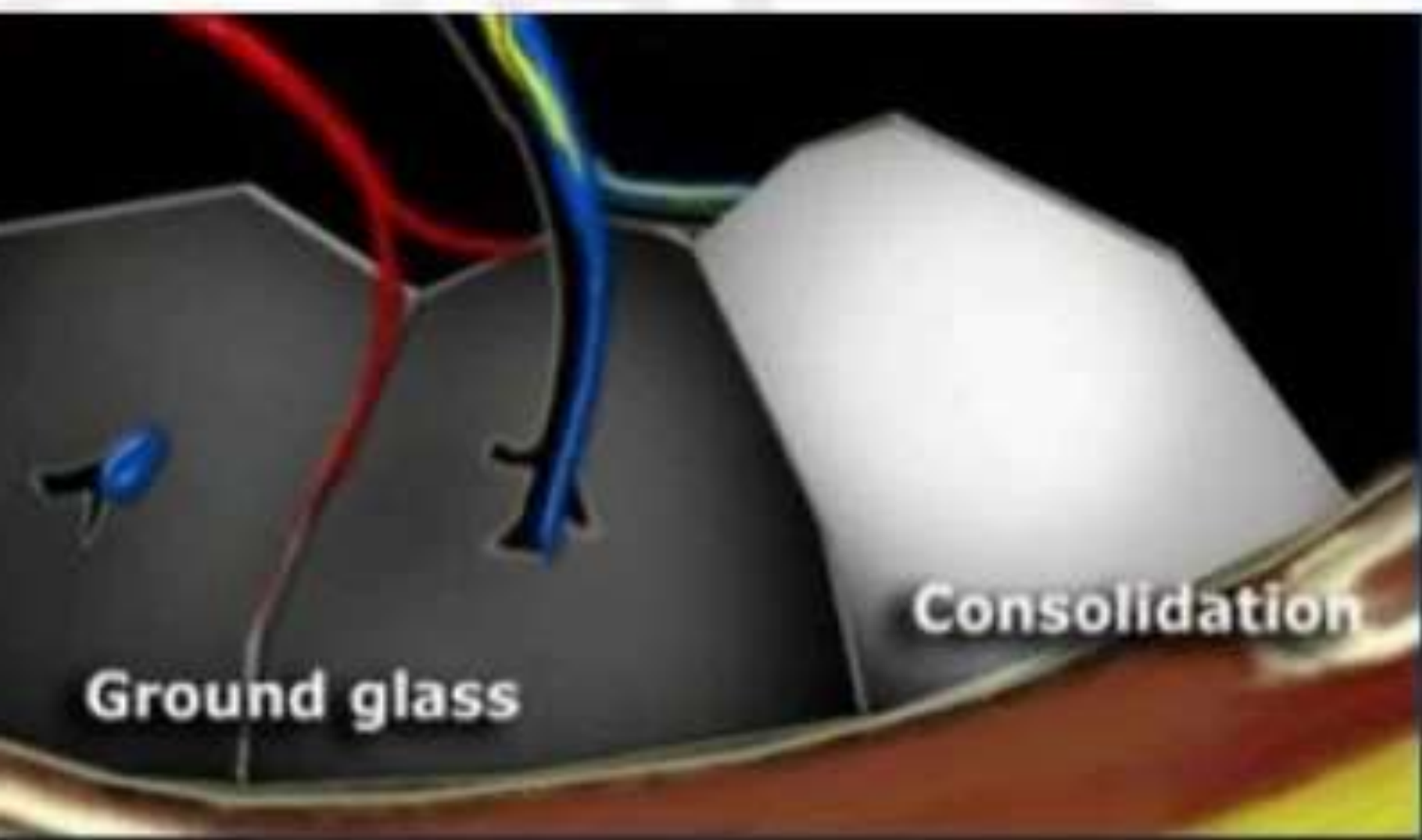
**i.e. organising pneumonia patterns



GGO(Ground glass opacity)



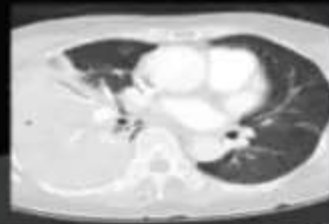
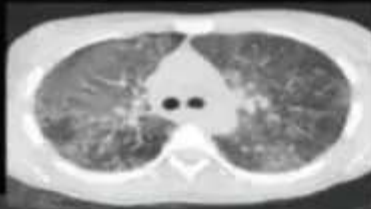
edge to consolidation



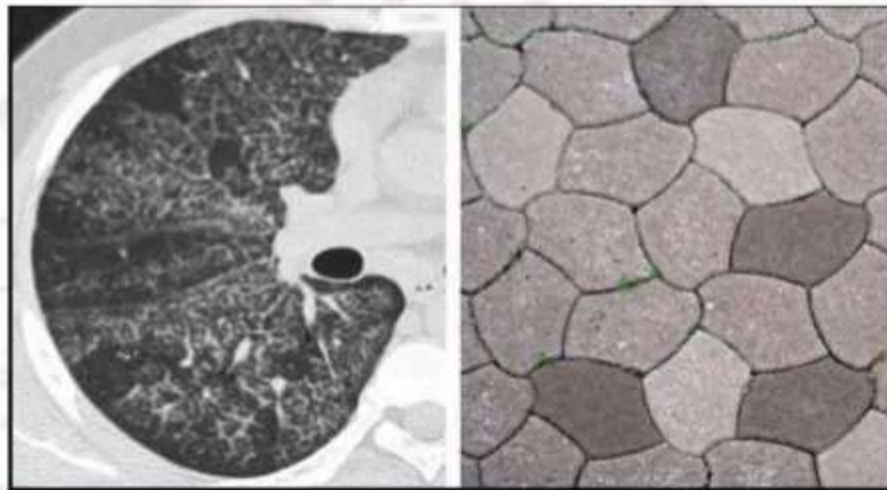
Ground glass opacity

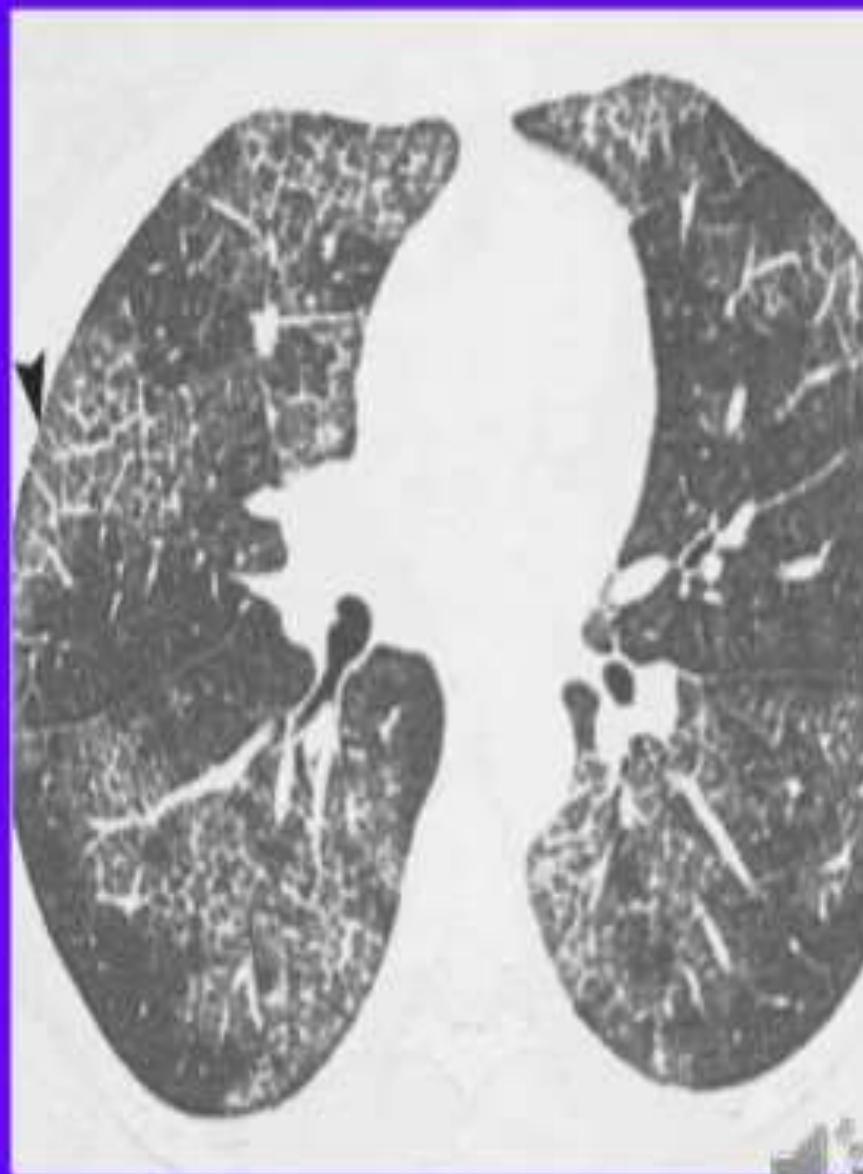


Consolidation



Crazy paving pattern





CT Signs of COVID 19

Ground glass

Ground glass (GGO) pattern is the most common finding in COVID-19 infections. They are usually multifocal, bilateral and peripheral, but in the early phase of the disease the GGO may present as a unifocal lesion, most commonly located in the inferior lobe of the right lung



CT Signs of COVID 1

CT-images of a young male, who had fever for ten days with progressive coughing and shortness of breath. Saturation at admission was 66%.The PCR test was positive for COVID-19.

There are widespread bilateral ground-glass opacities with a posterior predominance.



CT Signs of COVID 19

Crazy paving

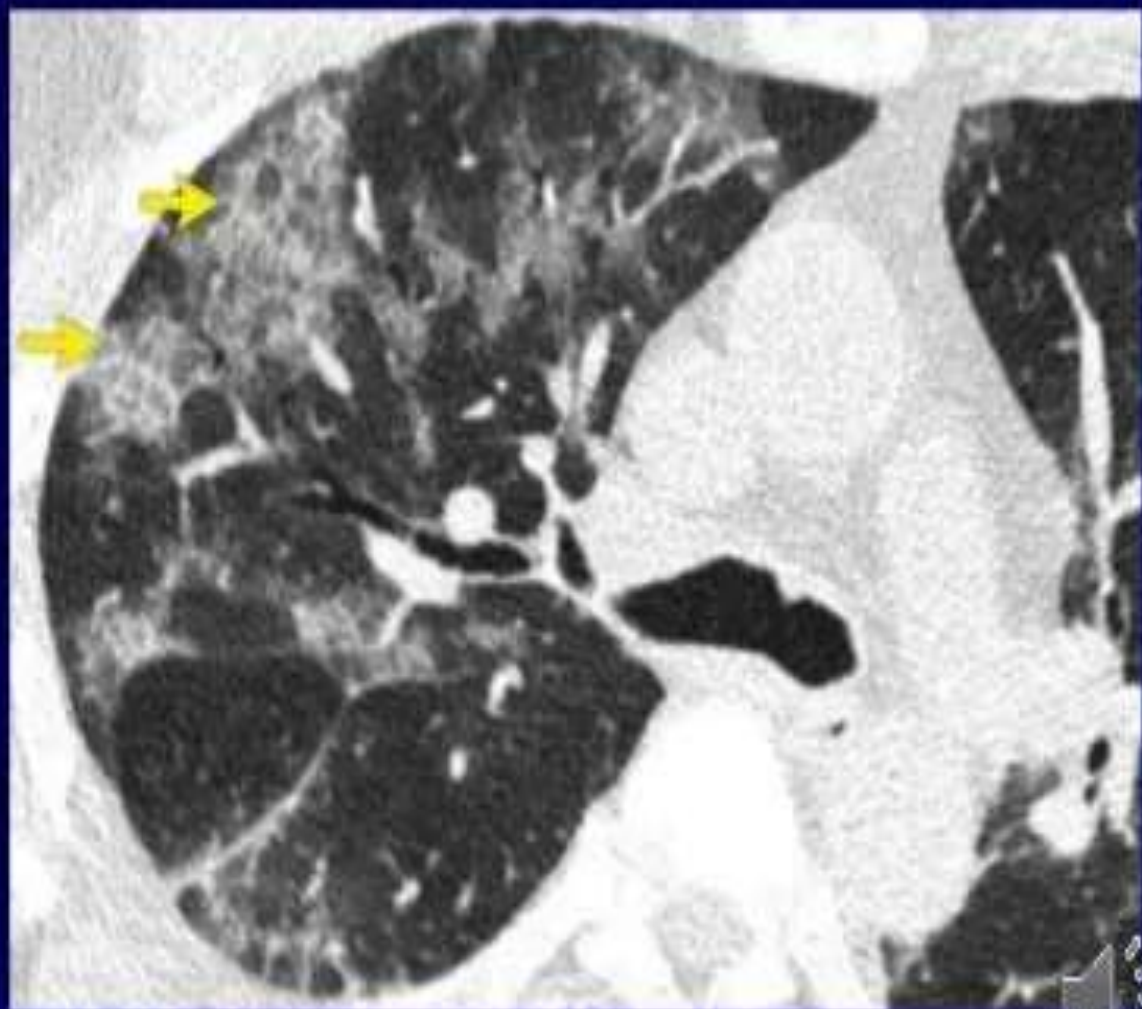
Sometimes there are thickened interlobular and intralobular lines in combination with a ground glass pattern. This is called crazy paving.

It is believed that this pattern is seen in a somewhat later stage.



CT Signs of COVID 19

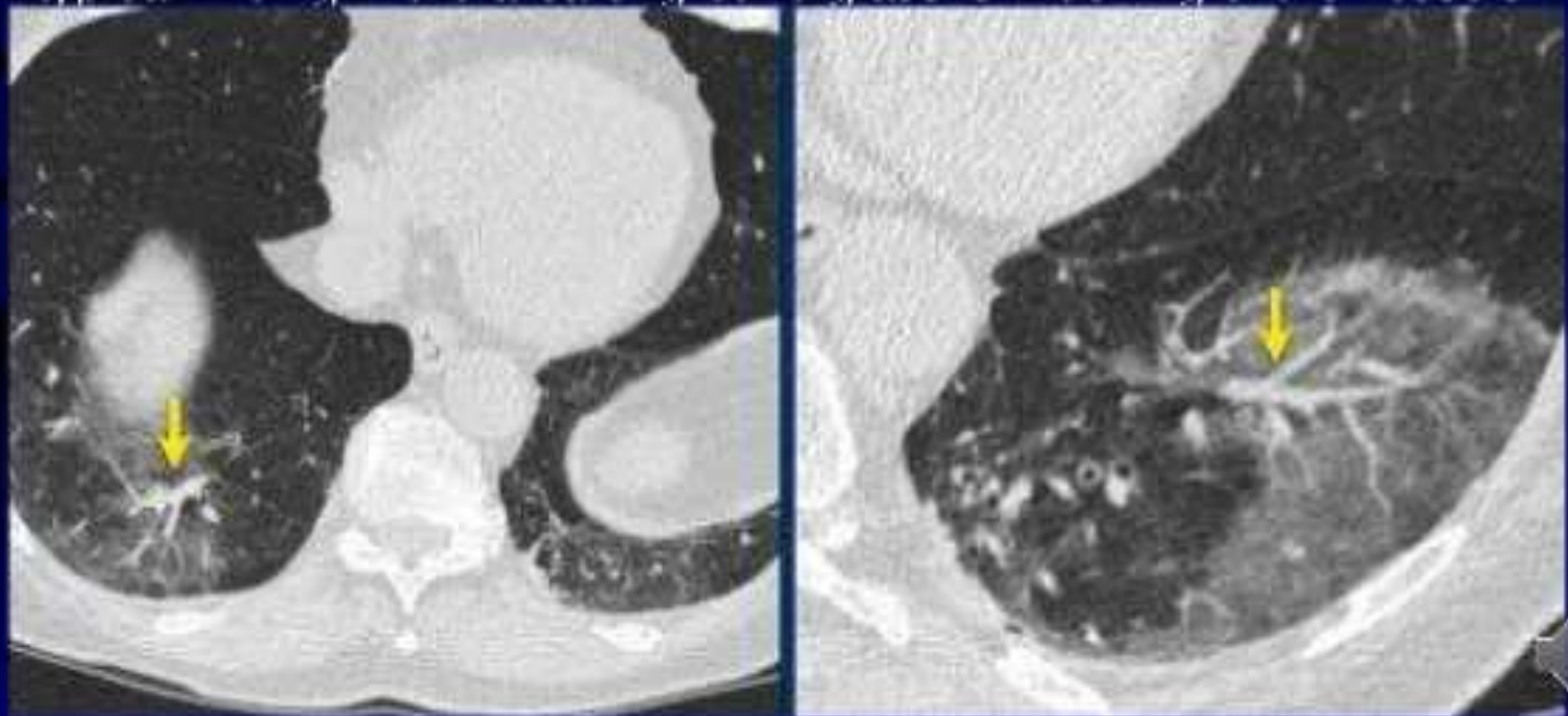
Crazy-Paving



CT Signs of COVID 19

Vascular dilatation

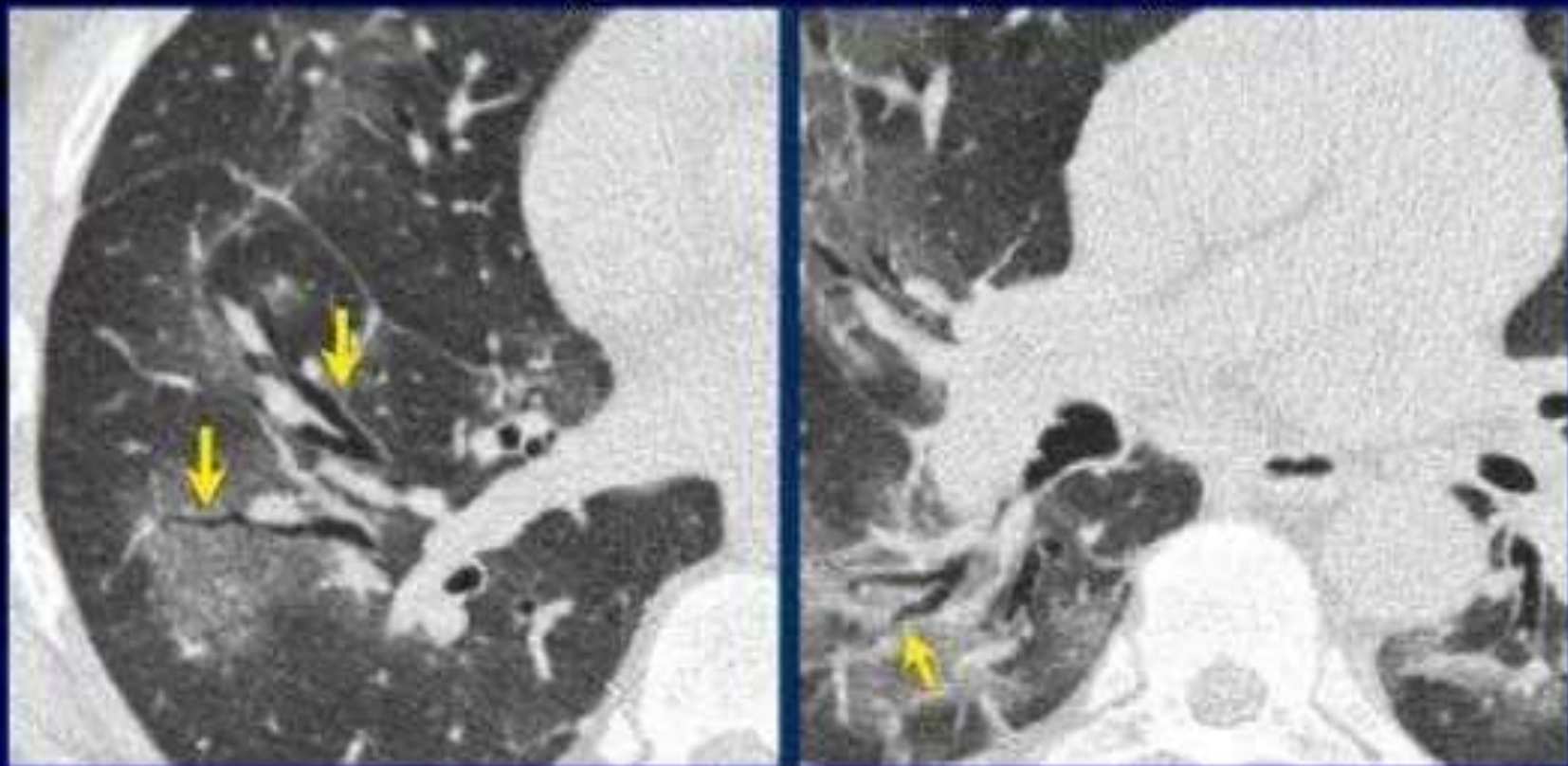
A typical finding in the area of ground glass is widening of the vessels .



CT Signs of COVID 19

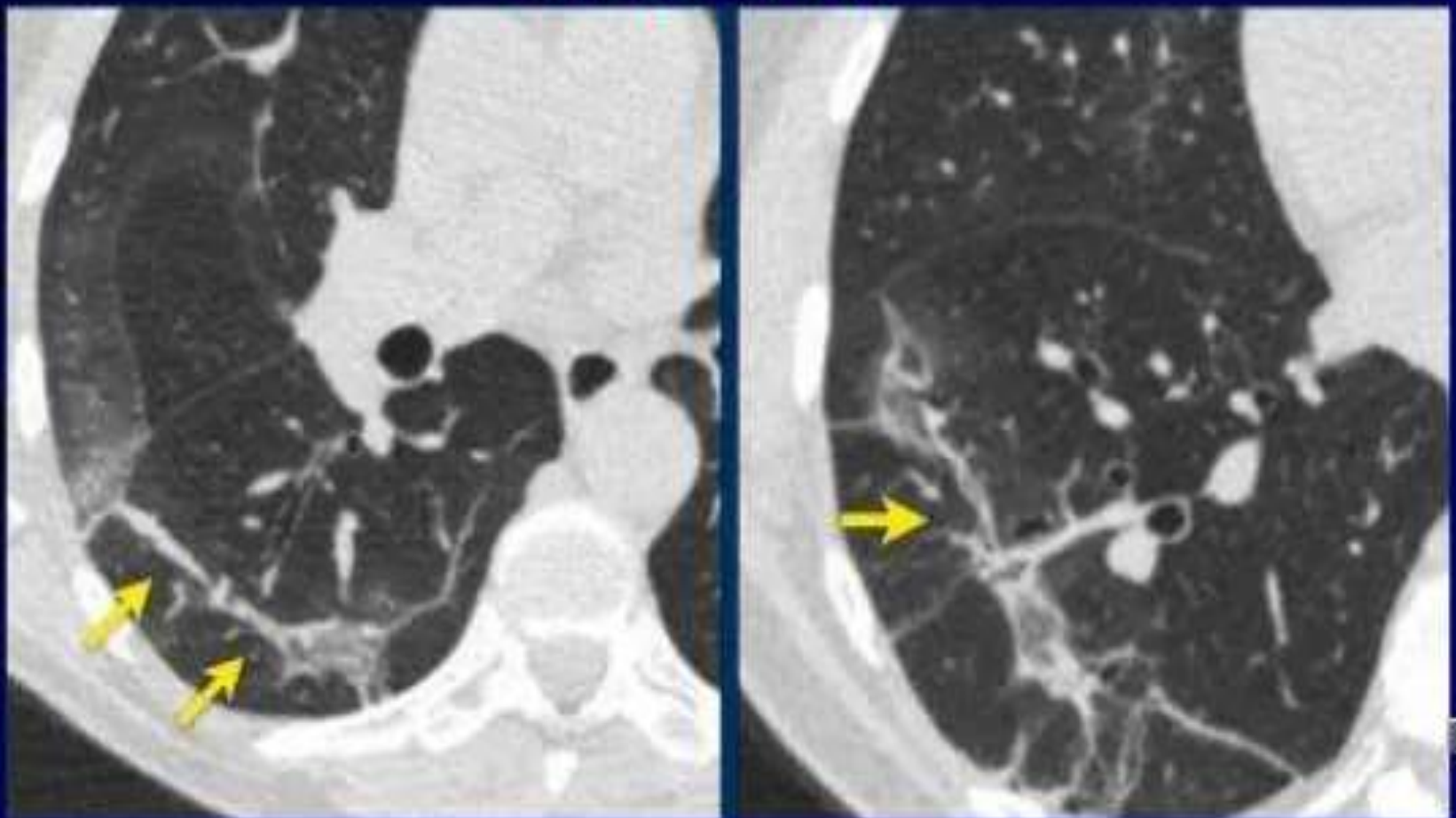
Traction Bronchiectasis

Another common finding in the areas of ground glass is traction



CT Signs of COVID 19

Subpleural bands and Architectural distortion



CT involvement score

Visual assessment

The severity on CT can be estimated by visual assessment. This is the easiest way to score the severity. The CT images show a 25% involvement by visual assessment.



CT involvement score

Severity score

Another method is by scoring the percentages of each of the five lobes that is involved:

≤ 5% involvement

6%-25% involvement

26%-49% involvement

50%-75% involvement

> 75% involvement.



CT involvement score

Severity score

The total CT score is the sum of the individual lobar scores and can range from 0 (no involvement) to 25 (maximum involvement), when all the five lobes show more than 75% involvement.





Initial CT-findings

Initial CT-findings in COVID-19 cases include bilateral, multilobar ground glass opacification (GGO) with a peripheral or posterior distribution, mainly in the lower lobes and less frequently in the middle lobe .

Consolidation superimposed on GGO as the initial imaging presentation is found in a smaller number of cases, mainly in the elderly population.

Septal thickening, bronchiectasis, pleural thickening, and subpleural involvement are some of the less common findings, mainly in the later stages of the disease.



intitial CT-patterns in COVID-19

Ground-glass opacification	88%
Bilateral involvement	88%
Posterior distribution	80%
Multilobar involvement	79%
Peripheral distribution	76%
Consolidation	32%

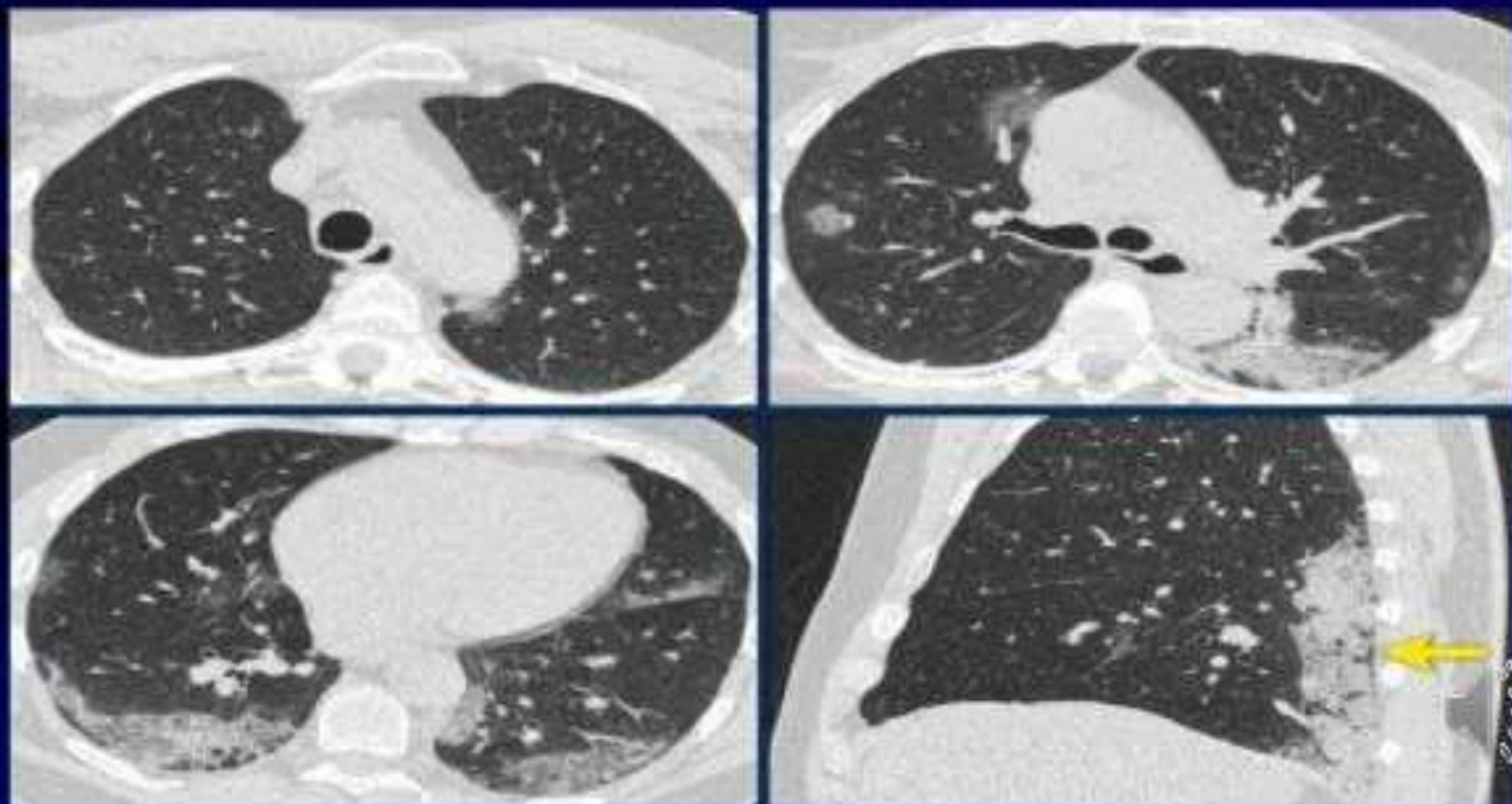


CT-images of a 78 year old male with coughing for 2 weeks and progressive shortness of breath, who tested positive for COVID-19.



Images of a 59 year old male who had fever for one week with non-productive cough. The PCR-test was negative.

Because of clinical suspicion a CT was performed which showed some areas of GGO and massive consolidation in the posterior parts of the lower lobes (arrow on sagittal reconstruction). Two days later PCR was positive for COVID-19.



Changes over time

Advanced-phase disease is associated with a significantly increased frequency of:

GGO plus a reticular pattern (crazy paving)

Vacuolar sign

Fibrotic streaks

Air bronchogram

Bronchus distortion

Subpleural line or a subpleural transparent line

CT-changes over time

Early stage 0-4 days GGO, partial crazy paving, lower number of involved lobes

Progressive stage 5-8 days Progressive (5-8 days): Extension of GGO, increased crazy paving pattern

Peak stage 10-13 days Consolidation

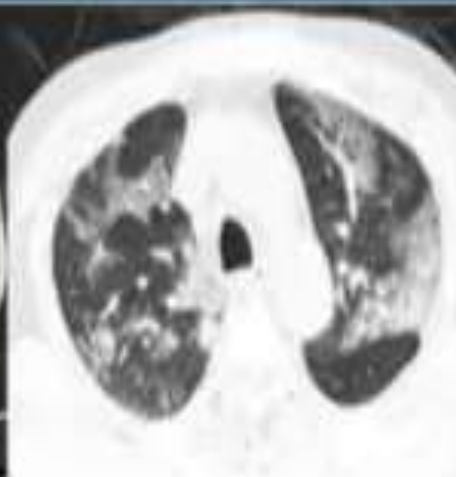
Absorption stage ≥ 14 days Gradual resolution





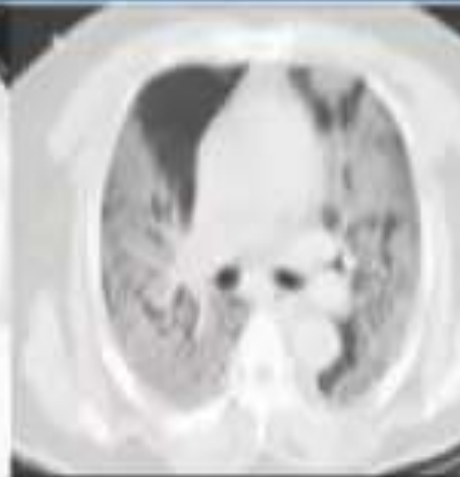
Early stage

Single or multiple scattered patchy ground-glass opacities, predominately distributed in the peripheral and subpleural area of the lung. A crazy-paving pattern, secondary to intralobular and interlobular septal thickening can be seen in this stage



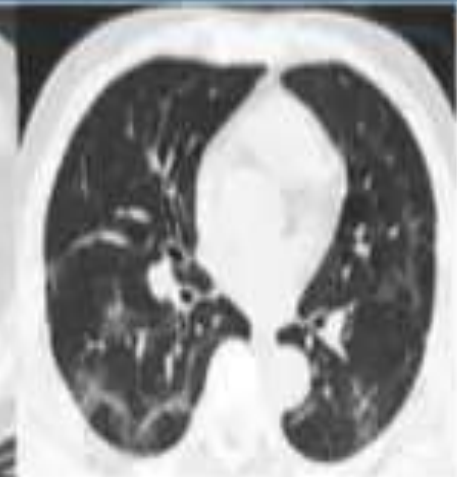
Advanced stage

Increased extent and density of bilateral lung parenchymal opacities. In this image, there are both areas of ground glass opacification and areas of consolidation in both lungs, which coexist and have varying sizes and presence of air-bronchogram.



Severe stage

Diffuse consolidation of the lung parenchyma with uneven density, air bronchi and bronchial dilation, which may be present as "whited out lung" on a corresponding chest radiograph



Dissipation stage

Areas of ground glass opacity and consolidation have nearly completely resolved, leaving some residual curvilinear areas of density.



Role of CT scan Chest

- Triage of patients:
 - no COVID-19
 - possible or most likely COVID-19
 - severity of the disease
- Prediction of worsening
- Prediction of improvement
- Problem solver



Radiographic features

CT patterns



Pattern

CLASSIC COVID-19
(100% confidence for COVID)

Description

Lower lobe predominant, peripheral predominant, multiple, bilateral* foci of GGO

- ±
- Crazy-paving
- Peripheral consolidation**
- Air bronchograms
- Reverse halo/ perlobular pattern**

PROBABLE COVID-19
(71-99% confidence for COVID)

- Lower lobe predominant mix of bronchocentric and peripheral consolidation
- Reverse halo/ perlobular pattern**
- GGO scarce

INDETERMINATE
(<70% confidence for COVID)

- Does not fit into definite, probable or Non-Covid
- Manifests above patterns, but the clinical context is wrong, or suggests an alternative diagnosis (e.g. an interstitial lung disease in a connective tissue disease setting)

NON-COVID
(70% confidence for alternative)

- Lobar pneumonia
- Cavitating infections
- Tree-in bud/ centrilobular nodularity
- Lymphadenopathy, effusions
- Established pulmonary fibrosis

*>1 lesion, but could still be unilateral: usually but not universally bilateral

**i.e. organising pneumonia patterns



Radiographic features

CT Typical findings (Radiopaedia)

The primary findings on CT in adults have been reported :

- **Ground-glass opacities (GGO): bilateral, subpleural, peripheral**
- Crazy paving appearance (GGOs and inter/intra-lobular septal thickening)
- **Air space consolidation**
- Bronchovascular thickening in the lesion
- **Traction bronchiectasis**



Radiographic features

(Radiopaedia) CT excluding findings

- **Mediastinal lymphadenopathy**
- **Pleural effusions**
- **Multiple tiny pulmonary nodules** (unlike many other viral pneumonia)
- **Tree-in-bud appearance**
- **Pneumothorax**
- **Cavitation**



Radiographic features

Temporal CT

Four stages on CT have been described :

- **Early/initial stage (0-4 days): normal CT or GGO only**

up to half of patients have normal CT scans within **2 days of symptom onset**

- **Progressive stage (5-8 days): increased GGO and crazy paving appearance.**

- **Peak stage (9-13 days): consolidation**

- **Absorption stage (> 14 days): with an improvement in the disease course, "fibrous stripes" appear and the abnormalities resolve at 1 month and beyond**



Radiographic features

Paediatric CT

In a small study of **five children** that had been admitted to hospital with positive COVID-19 RT-PCR tests and who had CT chest performed, **only three children had abnormalities. The main abnormality was bilateral patchy ground-glass opacities**, similar to the appearances in adults, but less florid, and **in all three cases the opacities resolved as they clinically recovered**.



Radiographic features

Paediatric CT

On 18 March 2020, the details of a much larger cohort of 171 children with confirmed COVID-19, and evaluated in a hospital setting was published as a letter in the *New England Journal of Medicine*. **Ground-glass opacities were seen in one-third of the total, whereas almost 16% of children had no imaging features of pneumonia .**



Table 2 The typical features on CT imaging of COVID-19

Parameter	Characteristic manifestations on CT imaging
Density	Ground glass opacity and consolidation, possible interlobular septal thickening
Shape	Patchy, sub-segmental, or segmental
Distribution	Mid and lower lungs along the bronchovascular bundles with bilateral involvement
Location	Peripheral and subpleural areas of the lung parenchyma
Concomitant signs (variable)	Air bronchogram, rare pleural effusion, no obvious lymphadenopathy

