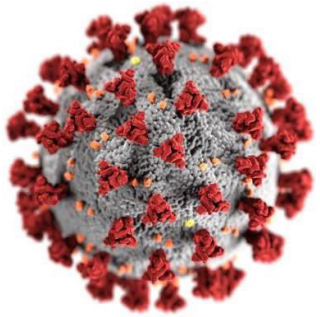


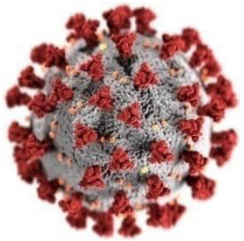
IMAGING FEATURES – COVID-19

– Dr.Sravan Krishna Reddy
Asst Prof
Dept of Radiology

Introduction

- **COVID-19** (coronavirus disease 2019) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)
- **In December 2019** - outbreak of (**SARS-CoV-2**) infection occurred in Wuhan, Hubei Province,China.
- **On February 12, 2020 -** WHO officially named the disease caused by novel coronavirus as coronavirus disease 2019(COVID-19)
- **On March 11 2020 –** WHO – recognized, the current outbreak – Pandemic.

CLINICAL MANIFESTATIONS:



Common:

- Fever(85-90%)
- Cough(65-70%)
- Anosmia(40-50%)
- Fatigue(35-40%)
- Sputum production(30-35%)
- SOB(15-20%)

Less Common:

- Myalgia /Arthralgia
- Headache
- Sore throat
- Chills
- Pleuritic pain
- Diarrhea

Rare:

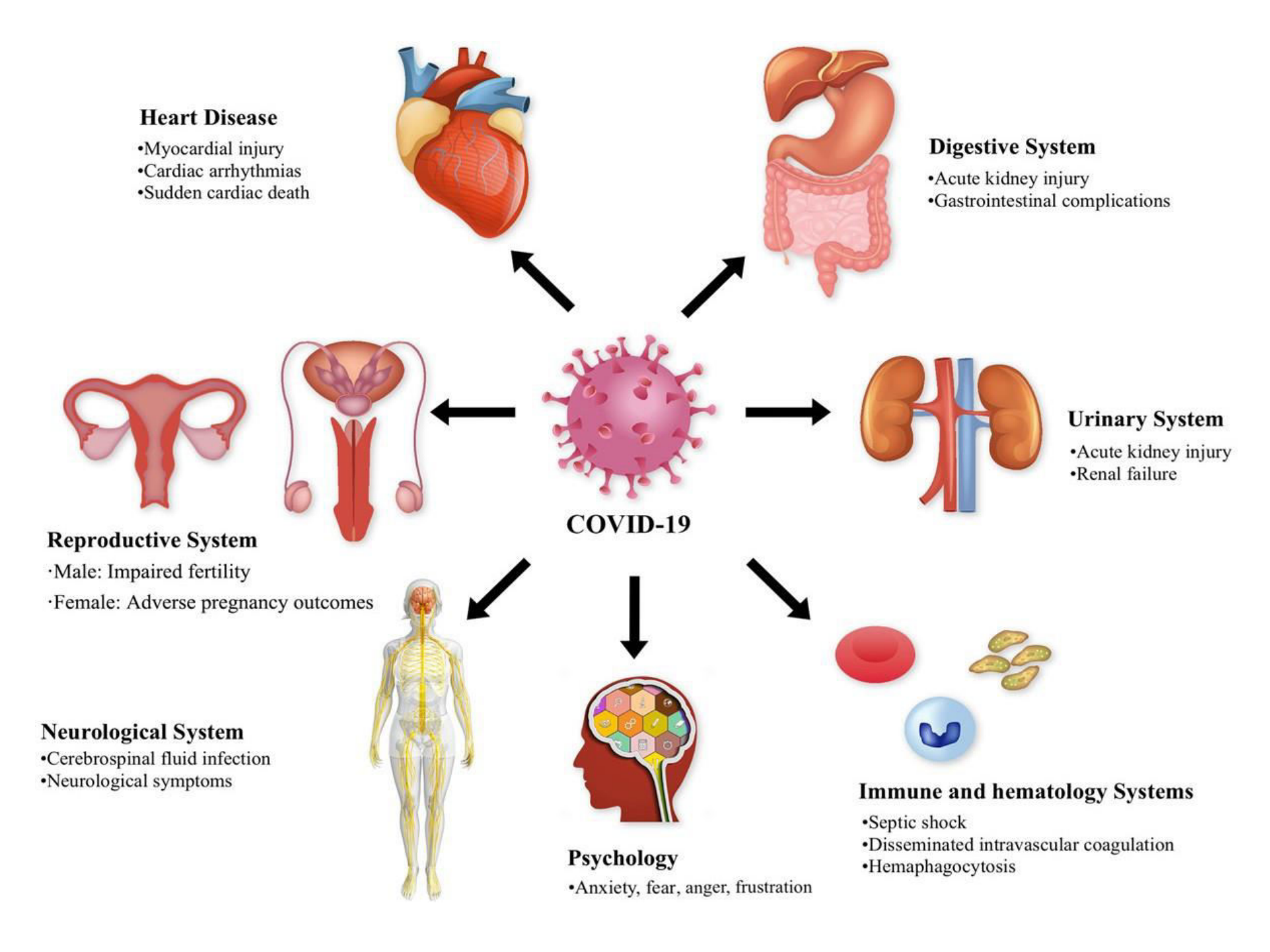
- Nausea, Vomiting, Abdominal pain, Nasal congestion, stroke

Most common ancilliary lab findings:

- Lymphopenia
- Increased prothrombin time(PT)
- Increased lactate dehydrogenase
- Mild elevation of inflammatory markers CRP, ESR & d-Dimer.

SYSTEMIC COMPLICATIONS

- Acute respiratory distress syndrome
- Acute thromboembolic disease
  Pulmonary embolism, DVT
- Acute cardiac injury: elevated troponin levels
  myocardial ischemia
  Cardiac arrest
  myocarditis
- CNS
  delirium
  Viral encephalitis
  diffuse leukoencephalopathy
  microhaemorrhage- juxtacortical white matter&corpus callosum
  stroke
- Secondary infections, e.g. bacterial pneumonia, sepsis
- AKI
- Coagulopathy-
  DIC , Multiorgan failure


Heart Disease
•Myocardial injury
•Cardiac arrhythmias
•Sudden cardiac death
Digestive System
•Acute kidney injury
•Gastrointestinal complications
Urinary System
•Acute kidney injury
•Renal failure
COVID-19
Reproductive System
·Male: Impaired fertility
·Female: Adverse pregnancy outcomes
Neurological System
•Cerebrospinal fluid infection
•Neurological symptoms
Psychology
•Anxiety, fear, anger, frustration
Immune and hematology Systems
•Septic shock
•Disseminated intravascular coagulation
•Hemaphagocytosis

COVID 19 testing;

RT PCR

-Current gold standard.

-Specificity(100%) and low sensitivity(59-71%)

-Turn around time-6-72hrs

-Irregular sampling of samples, laboratory error, insufficient viral material in specimen, improper extraction of nucleic acid from clinical materials-False negatives.

COMPUTED TOMOGRAPHY-CHEST

-Controversial

-Specificity(7-100%),Sensitivity(70-90%)

Short scan time

-Radiation exposure, scanner contamination.

Fleischer society -7th april,2020;Imaging-

- Not indicated in patients –suspected COVID-19 & mild clinical features unless they are at risk for disease progression.
- Indicated- patients with COVID-19& worsening respiratory status.
- Indicated for medical triage-patients with suspected COVID-19 who present with mod-severe CF & high pretest possibility of disease.

IMAGING FEATURES

PLAIN RADIOGRAPH:

-Not routinely recommended-insensitive –Early stage of disease.

-Potential- to serve –screening tool on the front lines in medical settings with limited resources.

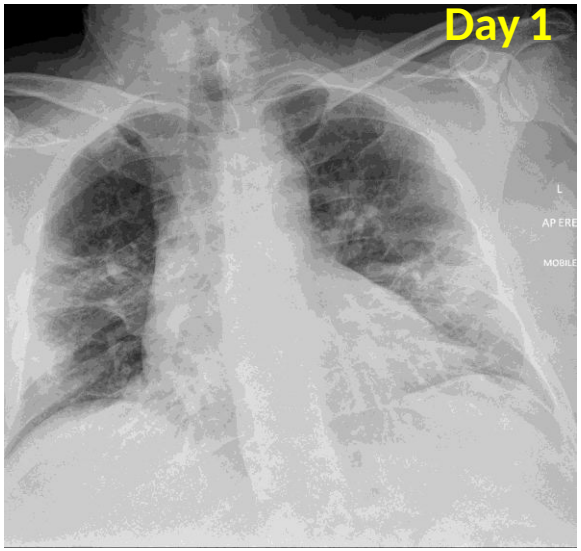
Portable radiography units- Easily decontaminated

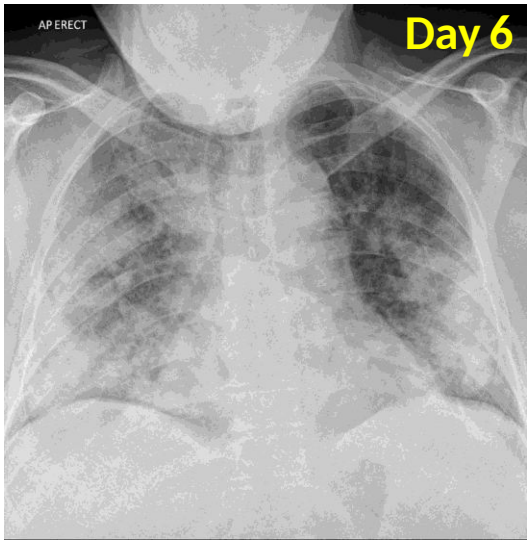
Most frequent findings- Air space opacities, whether described as consolidation or less commonly GGO's.

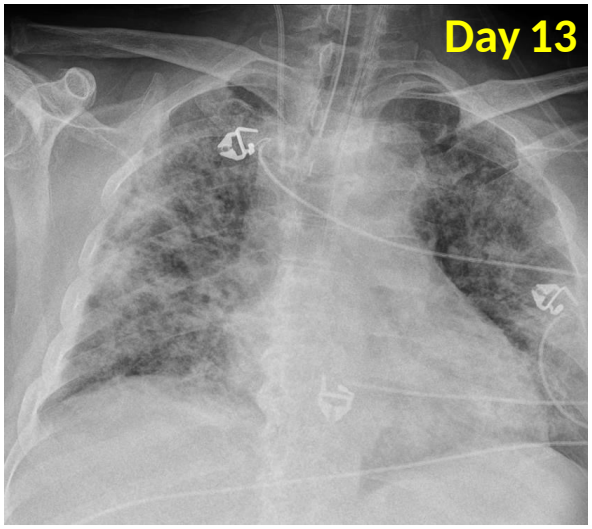
Distribution-often bilateral, peripheral and predominant in lower zones

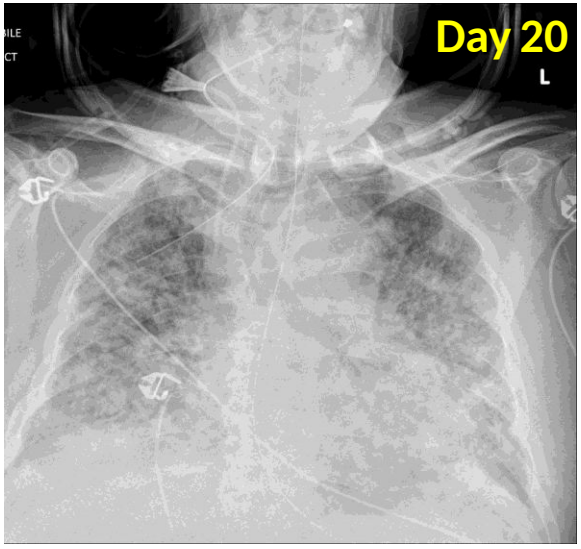
Pleural effusion- rare(3%)

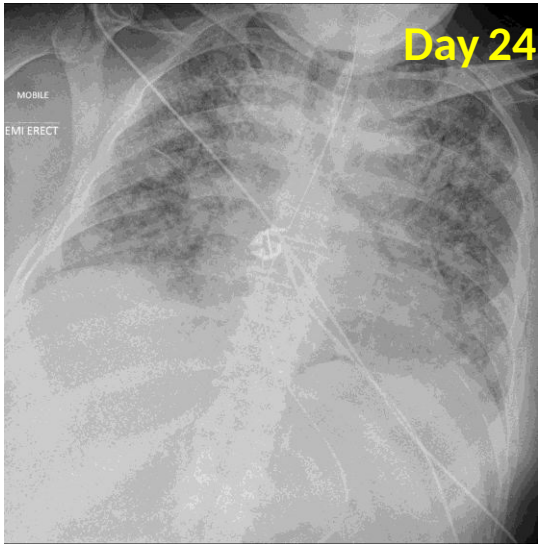
SERIAL CHEST RADIOGRAPHS OVER A MONTH-illustrating progression of changes & subsequent regression.

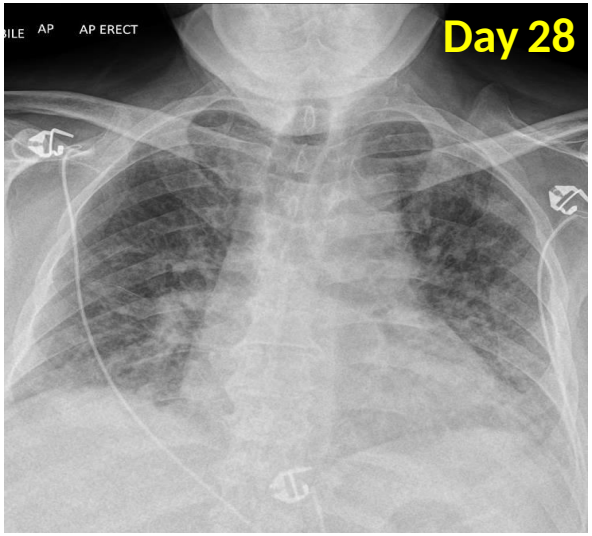












SOURCE: Radiopaedia

The British Society of Thoracic Imaging (BSTI) have published a reporting proforma for the plain chest radiographic appearances of potential COVID-19 cases .

classic/probable COVID-19

lower lobe and peripheral predominant multiple opacities that are bilateral (>> unilateral)

Indeterminate for COVID-19

does not fit classic or non-COVID-19 descriptors

Non-COVID-19

pneumothorax / lobar pneumonia / pleural effusion(s) / pulmonary edema / other

Normal

COVID-19 not excluded

ULTRASOUND

Multiple B-lines.

-ranging from focal to diffuse with spared areas

-representing thickened subpleural interlobular septa

may also manifest as a light beam sign, an evanescent, broad-based vertical reverberation artifact arising from a regular pleural line

Irregular, thickened pleural line with scattered discontinuities

subpleural consolidations.

-can be associated with a discrete, localized pleural effusion

- relatively avascular with color flow Doppler interrogation

- pneumonic consolidation typically associated with preservation of flow or hyperemia

Alveolar consolidation.

-tissue-like appearance with dynamic and static air bronchograms.

-associated with severe, progressive disease

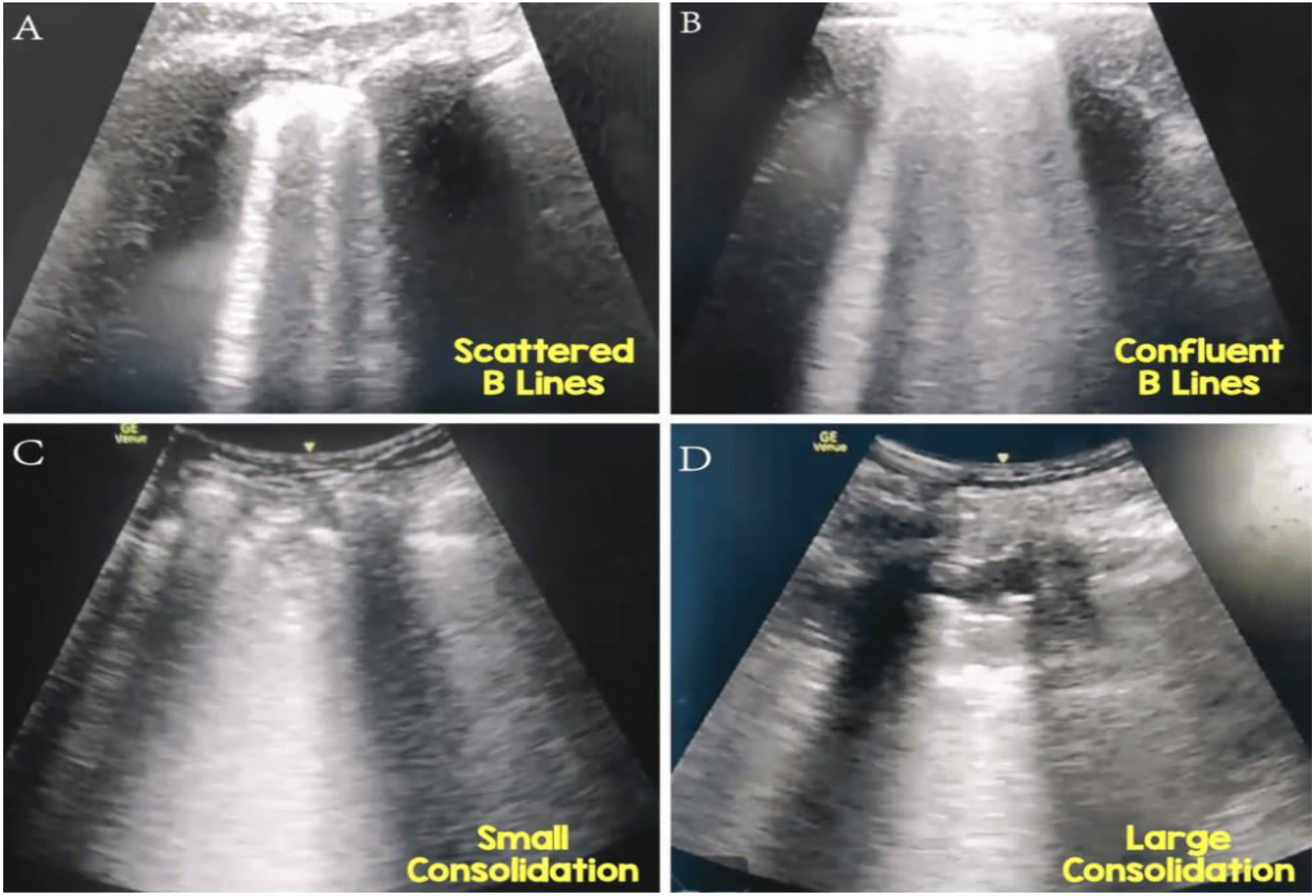
Restitution of aeration during recovery.

-reappearance of bilateral A-lines.

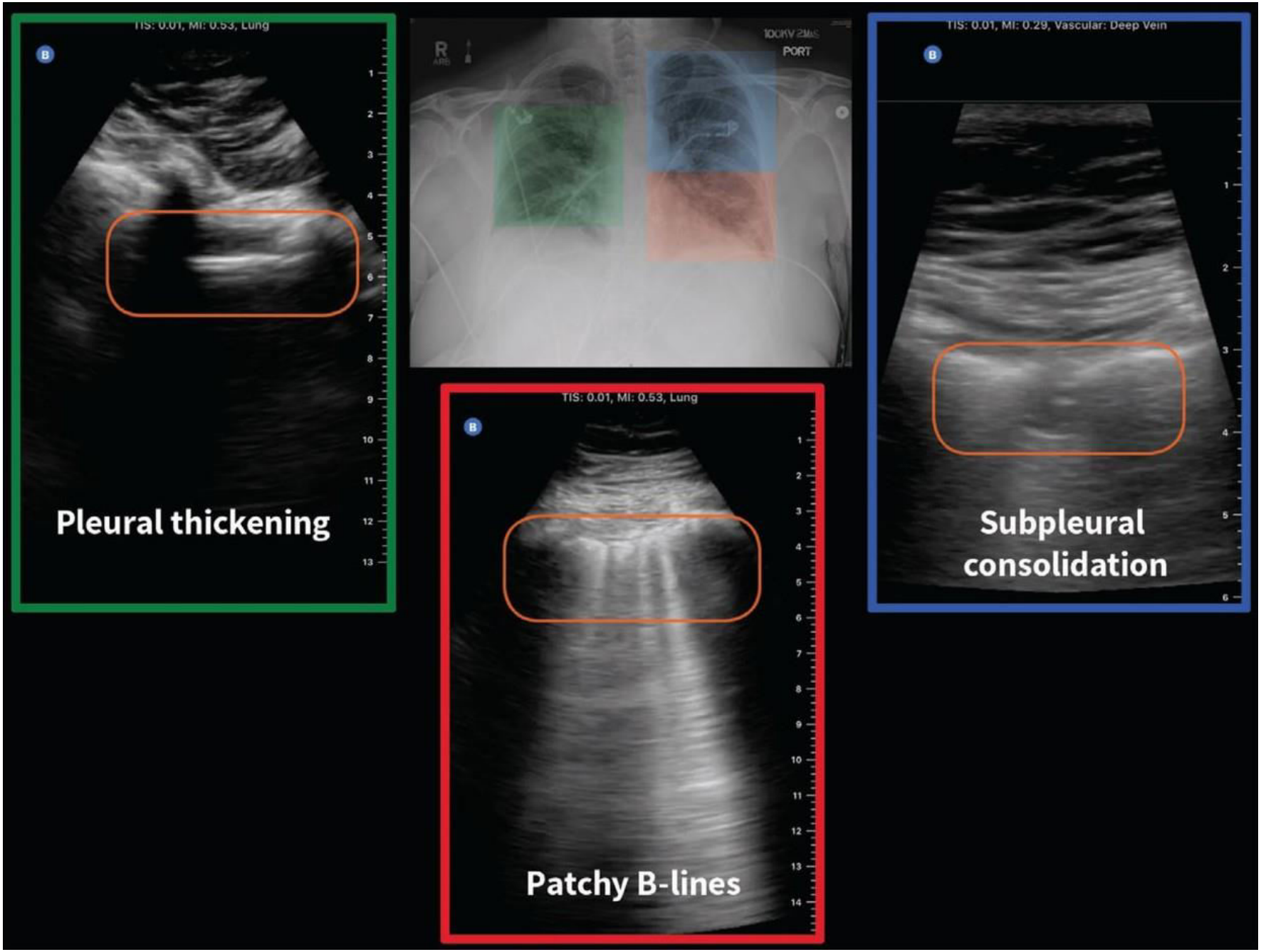
LIMITATION:

Cannot detect lesions that are deep in the lung(aerated lung blocks the transmission)

Abnormality must extend to the pleural surface to be visible with lung US Risk of transmission to radiologist.



Lung US Images from Springer Link 2020


TIS: 0.01, MI: 0.53, Lung
Pleural thickening
PORT
TIS: 0.01, MI: 0.53, Lung
Patchy B-lines
TIS: 0.01, MI: 0.29, Vascular: Deep Vein
Subpleural consolidation

• COMPUTED TOMOGRAPHY:

Typical/Primary findings:

•GGO's-Bilateral, subpleural, peripheral Crazy paving appearance

(GGO's &inter/intra lobular septal thickening)

- Air space consolidation.
- Bronchovasular thickening.
- Traction bronchiectasis.

Atypical findings:

- Mediastinal lymphadenopathy Pleural effusions
- Multiple tiny pulmonary nodules
- Tree in bud opacities
- Pneumothorax
- Cavitation

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-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

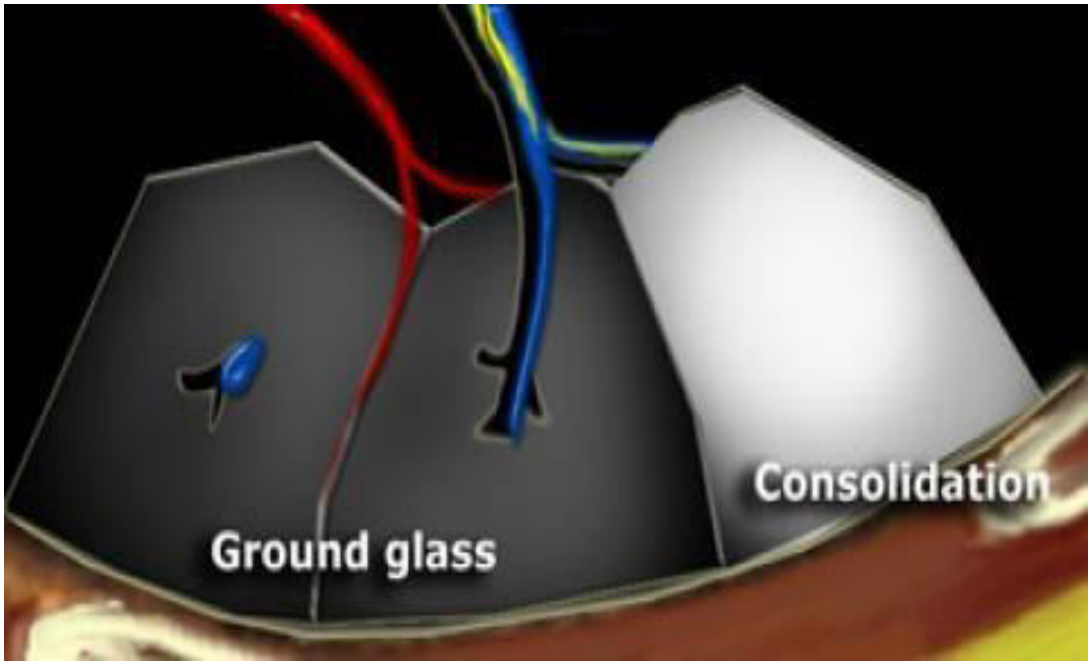
- Ground glass opacities in COVID 19

-Most common finding

-Multifocal, bilateral& peripheral.

In early stages:

(unifocal – M/C located in inferior lobe of right lung)



Secondary pulmonary lobule

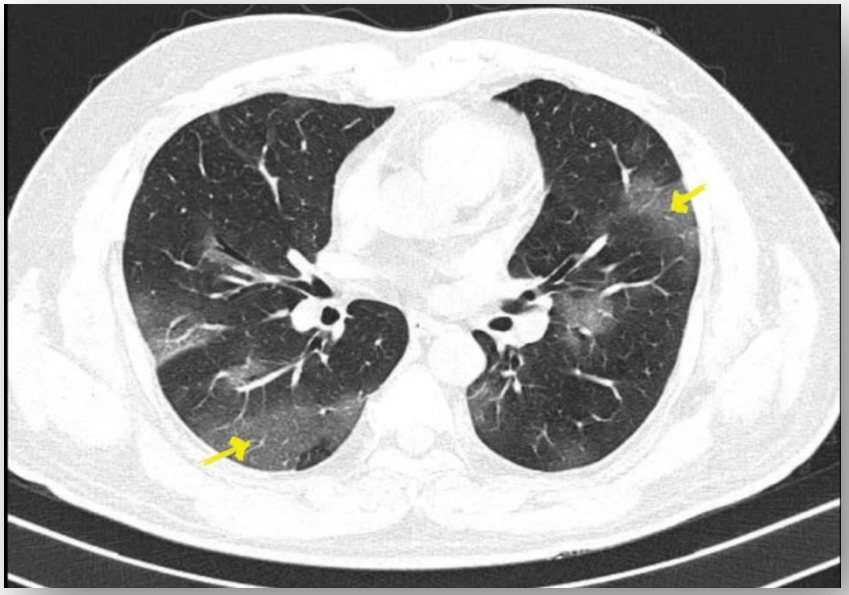


Image courtesy:
Narayana Medical college and Hospital, Nellore

D.D's

Ground Glass Opacity	
Acute	**Chronic**
Pulmonary edema - Heart failure - ARDS	Hypersensitivity pneumonitis Organizing pneumonia Chron Eosinoph. pneumonia Alveolar proteinosis
Pulmonary hemorrhage	Lung fibrosis - UIP - NSIP
Pneumonia - PCP - Mycoplasma - Viral	Bronchoalveolar carcinoma
Acute Eosinoph pneumonia Acute Hypersensitivity	

The location of the abnormalities in ground glass pattern can be helpful:

Upper zone predominance:

Respiratory bronchiolitis,
Pneumocystis pneumonia.

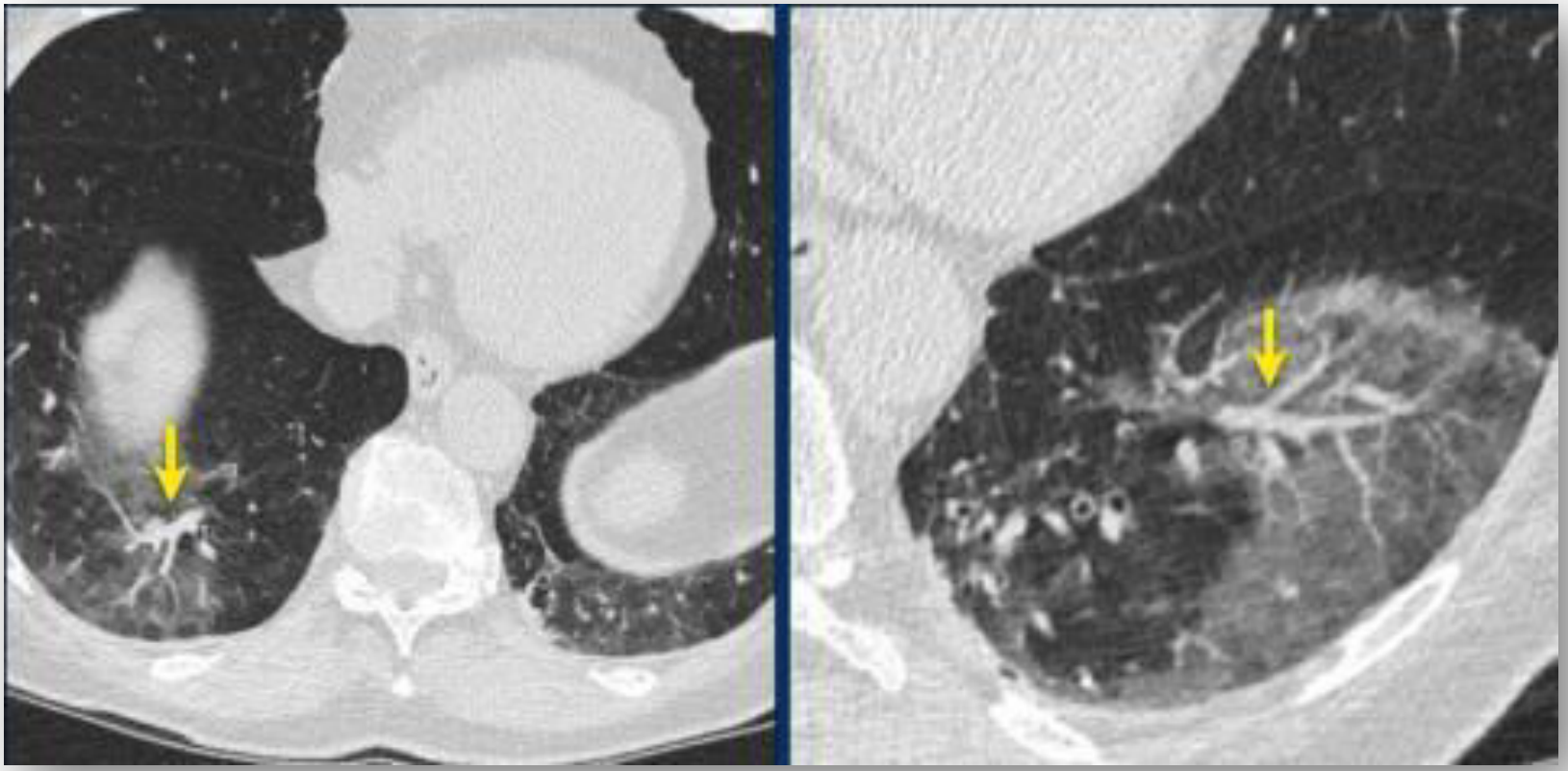
Lower zone predominance:

UIP, NSIP, DIP.

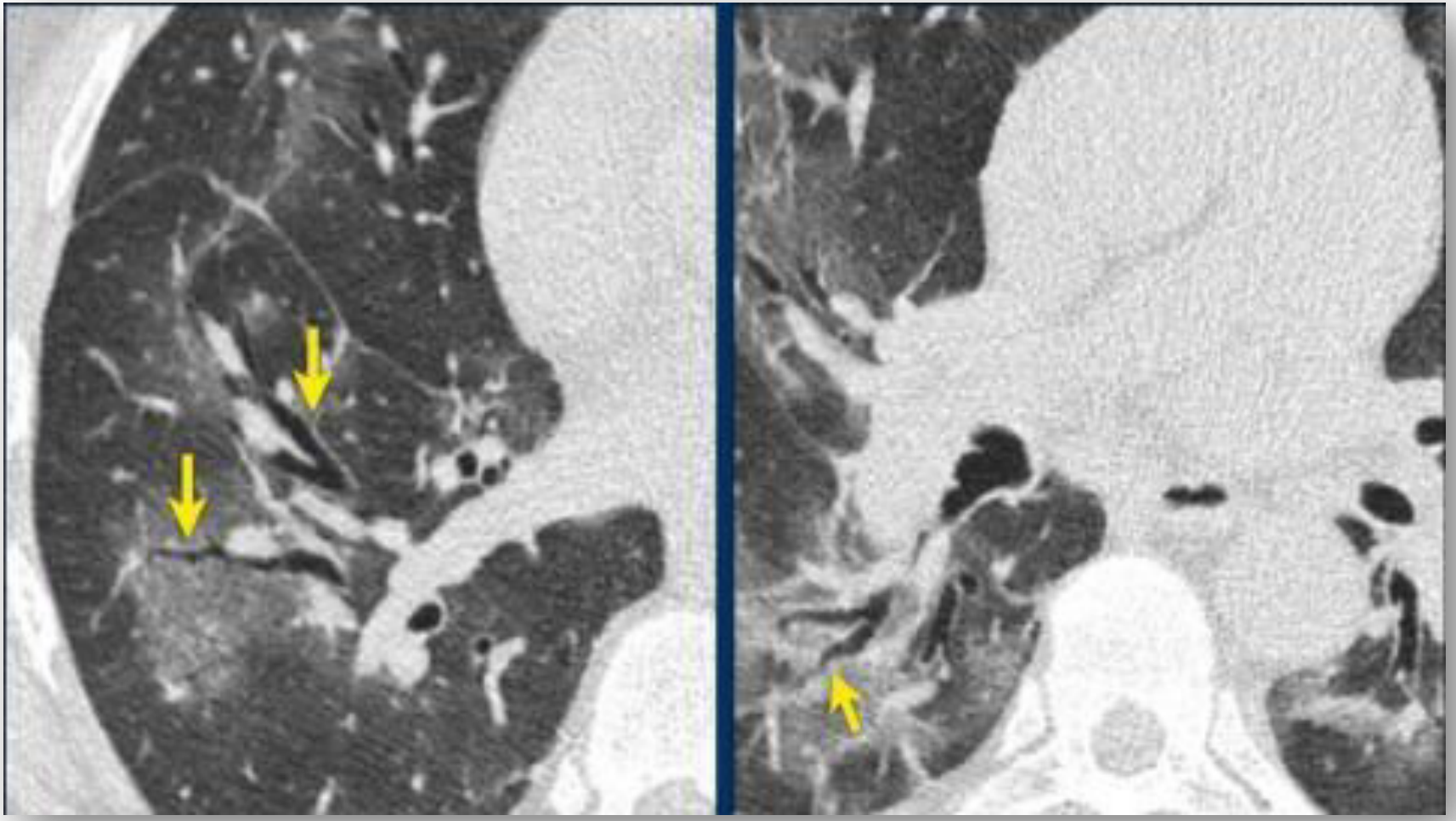
Centrilobular distribution:

Hypersensitivity pneumonitis,
Respiratory bronchiolitis

VASCULAR DILATATION:



TRACTION BRONCHIECTASIS



CONSOLIDATION

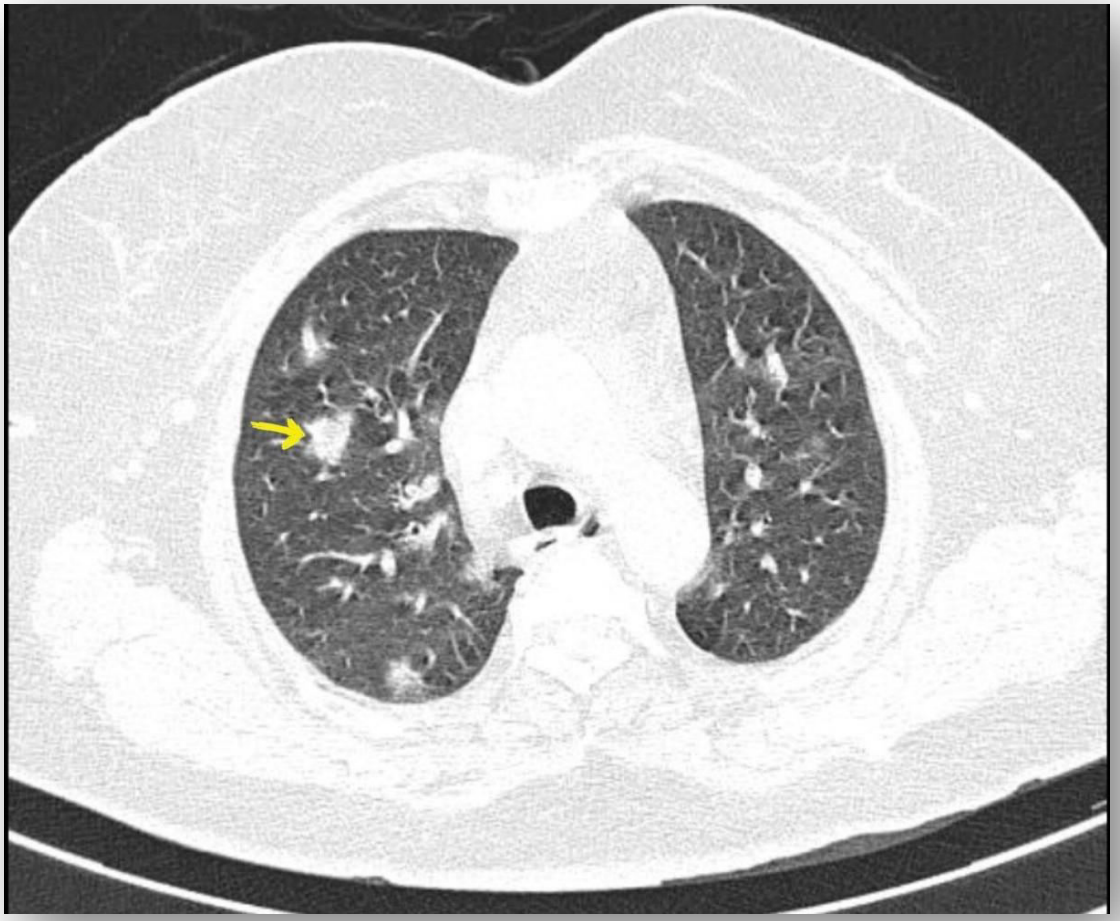
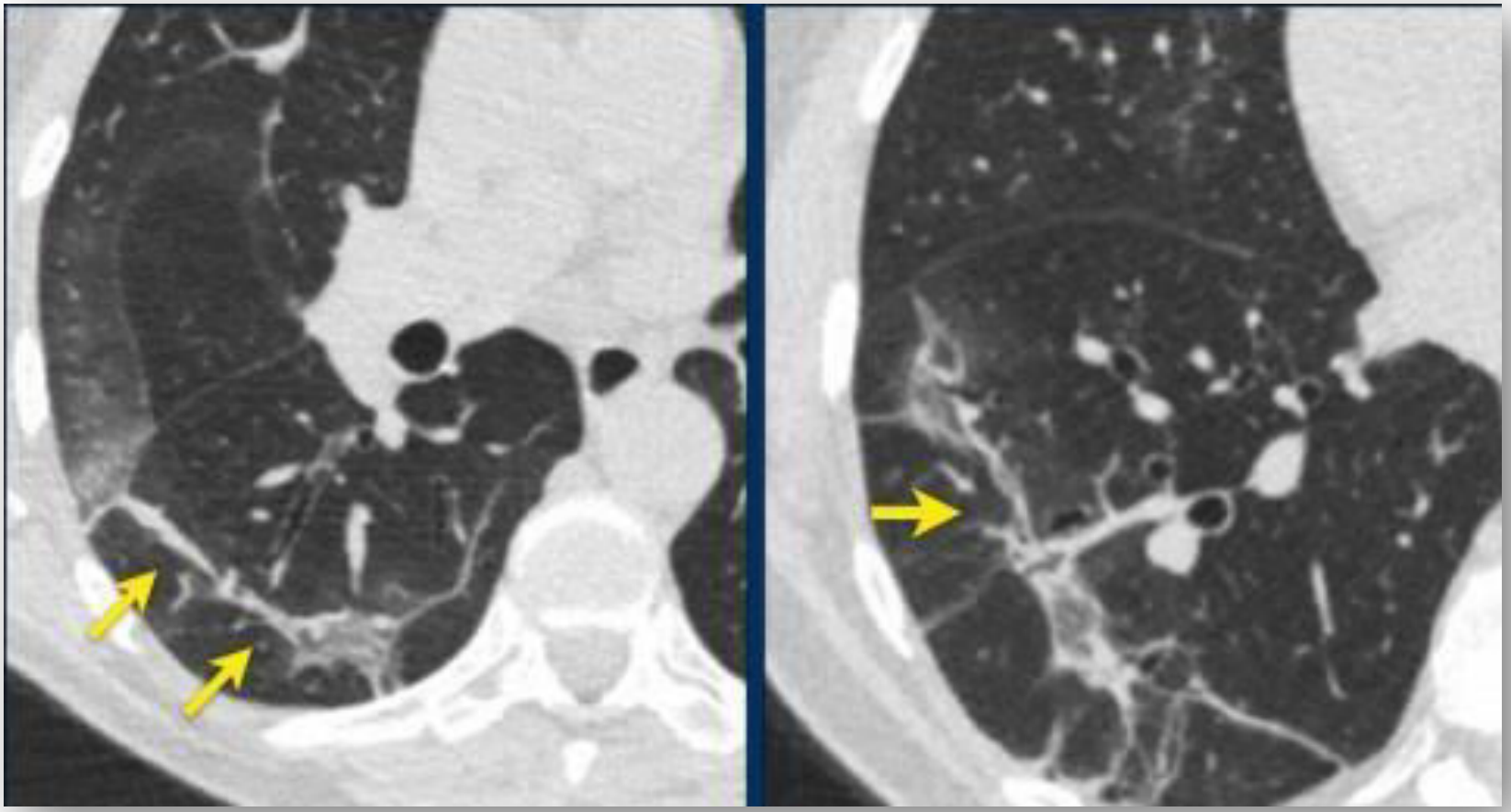
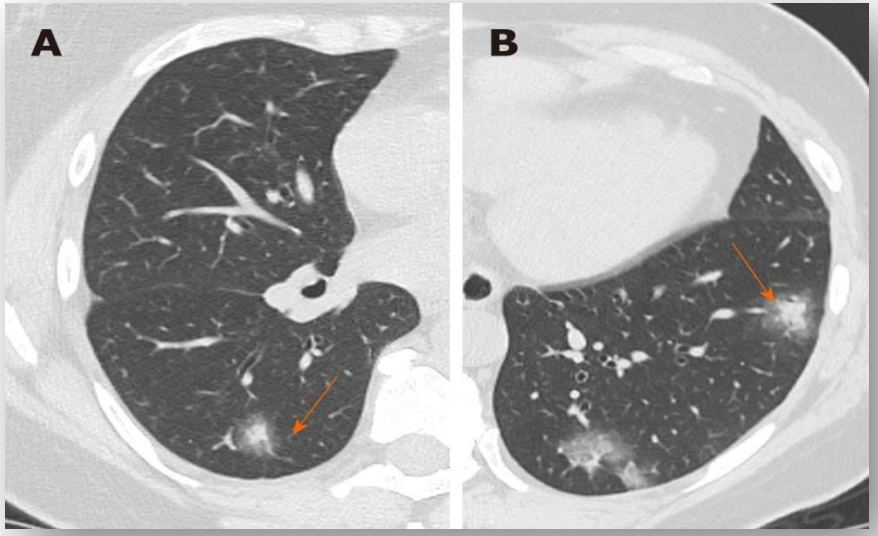


Image courtesy:
Narayana Medical college and Hospital, Nellore

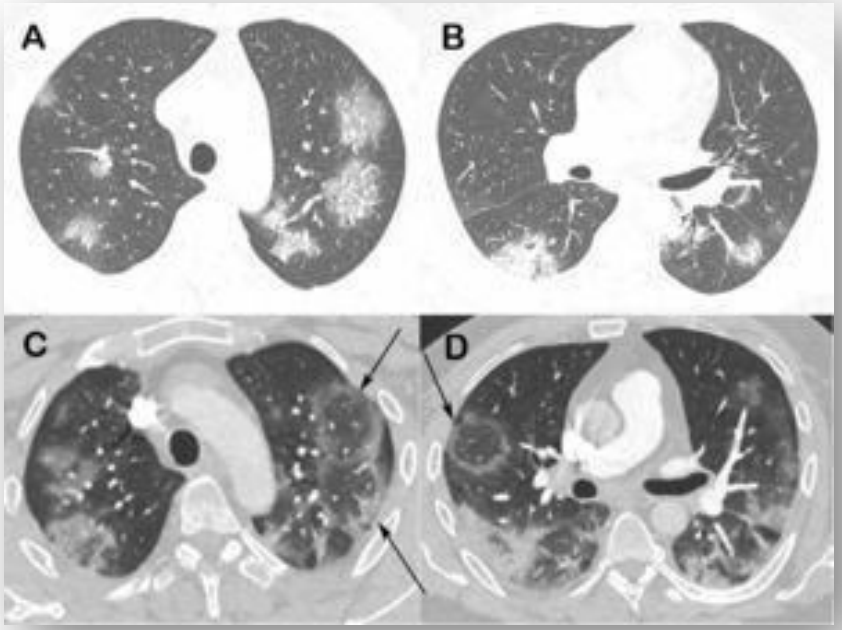
- **SUBPLEURAL BAND& ARCHITECTURAL DISTORTION**



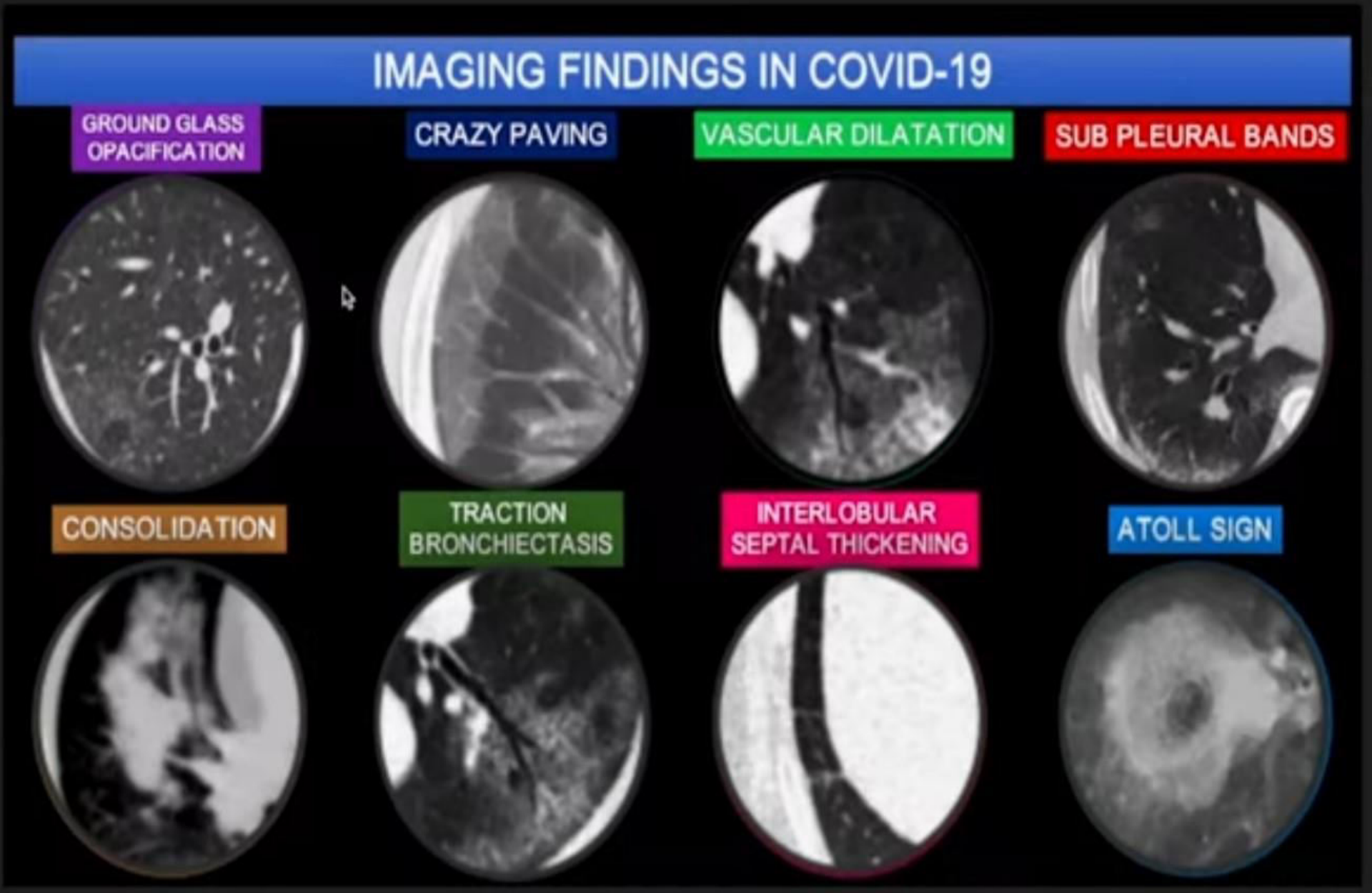
HALO SIGN



REVERSED HALO SIGN/ATOLL SIGN



IMAGING FINDINGS IN COVID-19



Proposed Reporting Language for CT Findings Related to COVID-19

Routine screening CT for diagnosis or exclusion of COVID-19 is currently not recommended by most professional organizations or the US Centers for Disease Control and Prevention

COVID-19 pneumonia imaging classification	Rationale (6-11)	CT Findings+	Suggested Reporting Language
Typical appearance	Commonly reported imaging features of greater specificity for COVID-19 pneumonia.	Peripheral, bilateral , GGO* with or without consolidation or visible intralobular lines ("crazy-paving") Multifocal GGO of rounded morphology with or without consolidation or visible intralobular lines ("crazy-paving") Reverse halo sign or other findings of organizing pneumonia (seen later in the disease)	"Commonly reported imaging features of (COVID-19) pneumonia are present. Other processes such as influenza pneumonia and organizing pneumonia, as can be seen with drug toxicity and connective tissue disease, can cause a similar imaging pattern." [Cov19Typ]^
Indeterminate appearance	Nonspecific imaging features of COVID-19 pneumonia.	**Absence of typical features AND** **Presence of:** Multifocal, diffuse, perihilar, or unilateral GGO with or without consolidation lacking a specific distribution and are non-rounded or non-peripheral. Few very small GGO with a non-rounded and non-peripheral distribution	"Imaging features can be seen with (COVID-19) pneumonia, though are nonspecific and can occur with a variety of infectious and noninfectious processes." [Cov19Ind]^
Atypical appearance	Uncommonly *or* not reported features of COVID-19 pneumonia.	**Absence of typical or indeterminate features AND** **Presence of:** Isolated lobar or segmental consolidation without GGO Discrete small nodules (centrilobular, "tree-in-bud") Lung cavitation Smooth interlobular septal thickening with pleural effusion	"Imaging features are atypical or uncommonly reported for (COVID-19) pneumonia. Alternative diagnoses should be considered." [Cov19Aty]^
Negative for pneumonia	No features of pneumonia	No CT features to suggest pneumonia.	"No CT findings present to indicate pneumonia. (Note: CT may be negative in the early stages of COVID-19.) [Cov19Neg]^

CO RADS

CO-RADS (COVID-19 Reporting and Data System) to ensure CT reporting is uniform and replicable.

What is CO-RADS

- **CO-RADS** is a categorical assessment scheme used for reporting of chest CT patients, suspected of COVID-19.

- It represents the level of suspicion for pulmonary involvement.

But it does not tell the severity

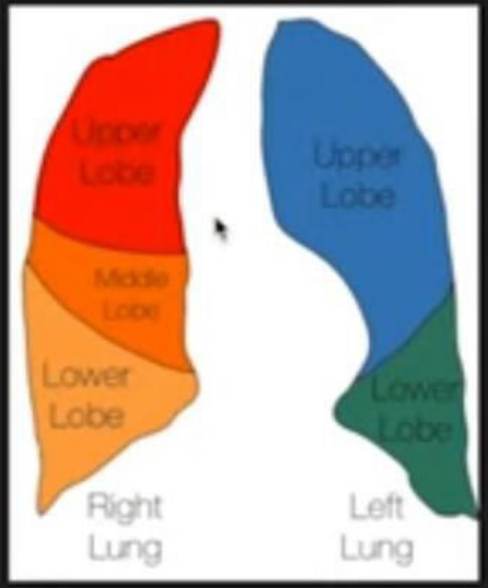
For example, if CO-RADS is level 5 then there is very high chance of COVID-19 .

CO-RADS
LEVEL OF SUSPICION FOR COVID-19 INFECTION

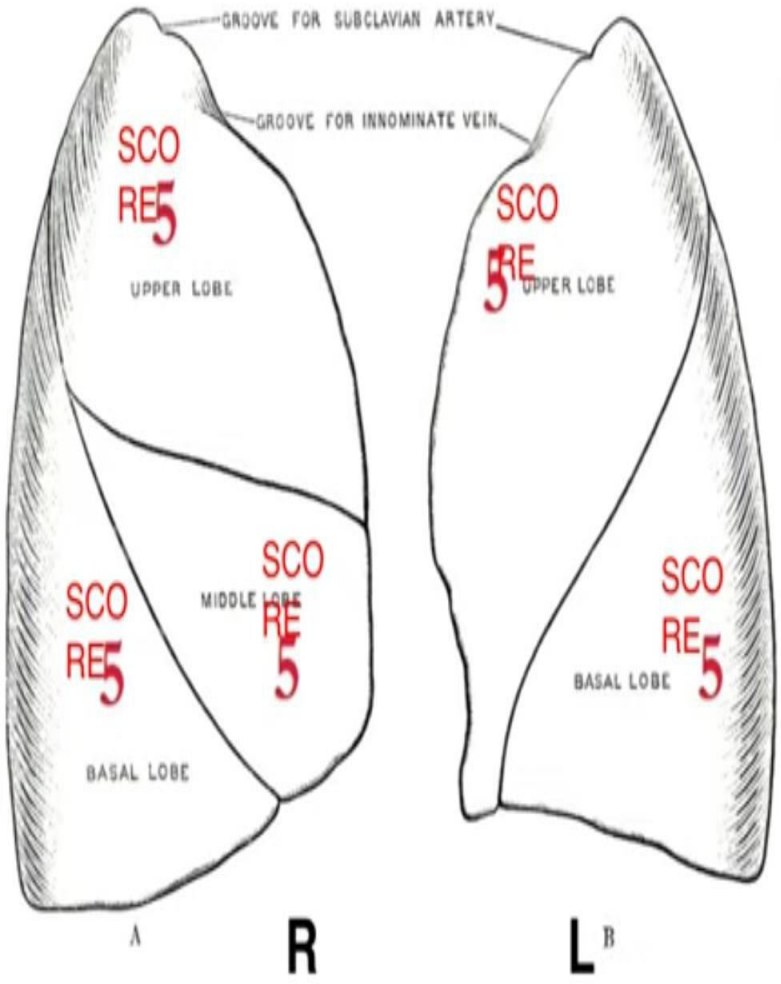
		CT Findings
CO-RADS 1	No	Normal or non-infections abnormalities
CO-RADS 2	Low	Abnormalities consistent with infections other than COVID-19
CO-RADS 3	Intermediate	Equivocal findings for COVID-19 infections
CO-RADS 4	High	Abnormalities suspicious for COVID-19 infection
CO-RADS 5	Very high	Typical COVID-19 findings
CO-RADS 6	PCR +	

CT SEVERITY SCORE

- The CT-Severity Scoring a method used to identify the severe forms of COVID-19.
- Provides an approach to rapidly identify patients who need hospitalization.
- CT-SS is used to quickly and objectively evaluate the severity of lung involvement.



LOBAR SCORING



(TOTAL SCORE 25)

THERE ARE TWO LUNGS.

Right Lung and Left Lung

Right lung is divided in three lobes.

UPPER LOBE, MIDDLE LOBE, LOWER LOBE

Left lung is divided in two lobes.

UPPER LOBE AND LOWER LOBE

EACH LOBE IS GIVEN SCORE 1 TO 5 BASED ON LUNG INVOLVEMENT.

INFECTION CRITERIA (SINGLE LOBE)

5 % INFECTED SCORE 1

5-25 % INFECTED SCORE 2

25-50 % INFECTED SCORE 3

50-75 % INFECTED SCORE 4

➢ 75 % INFECTED SCORE 5

Score calculation is done based on each lobe involvement.
Each lobe has maximum score **5.**
And so 5 lobes has maximum score of **25.**
For example, score 5 means that lobe is > 75% involved or affected by COVID- 19.

SCORE	CT SEVERITY
< 8	MILD
9 - 15	MODERATE
> 15	SEVERE

SEGMENTAL SCORING

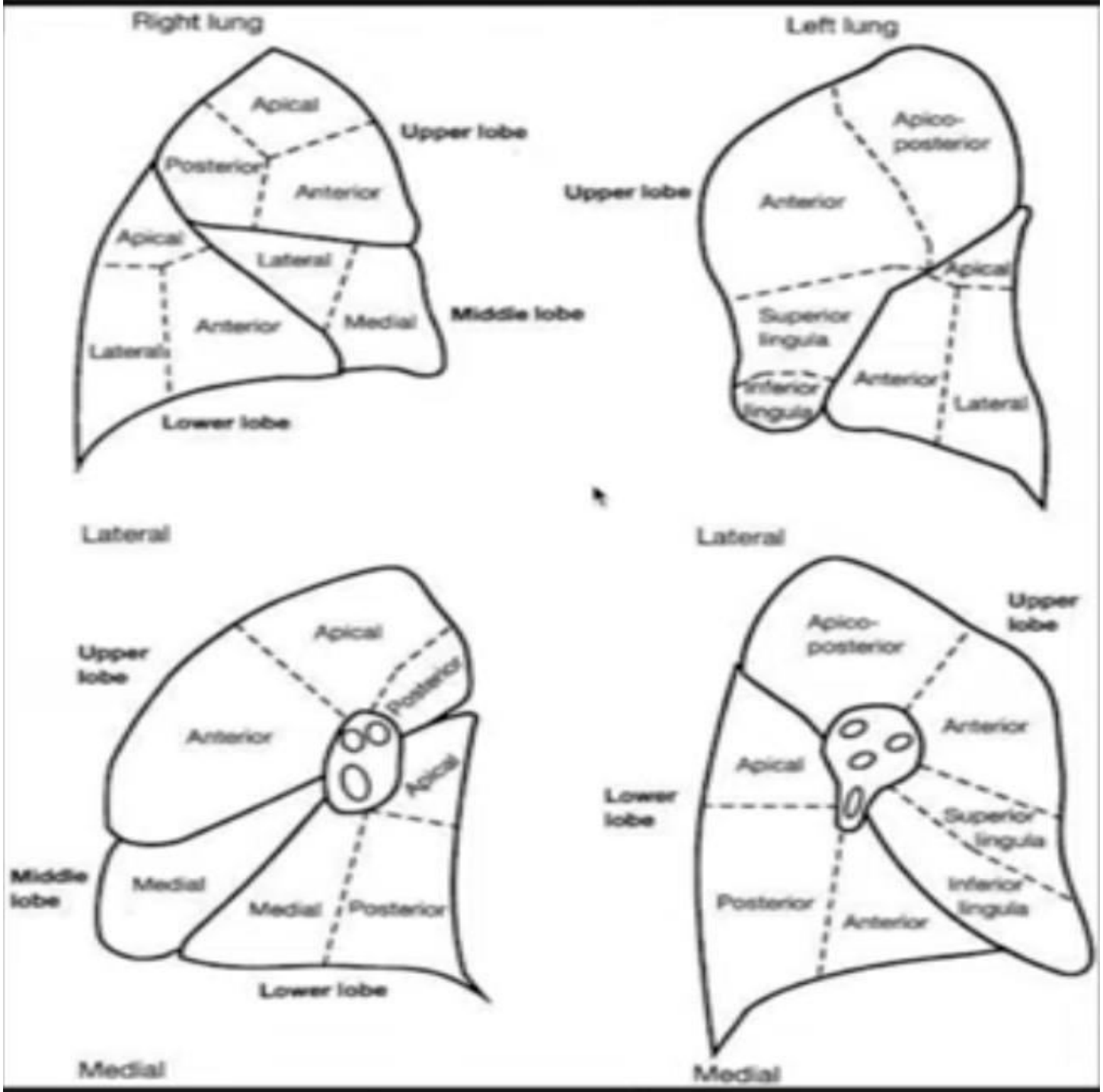
CT - Severity score

- CT-SS is obtained from 20 regions of the lung (by adding individual scores from each region).
- 0 - No parenchymal opacification.
- 1 - <50% involvement.
- 2 - >50% involvement.
- Mild and Severe forms
- Mild - Score < 20
- Severe - Score > 20

HIGHEST SCORE OF 40 IS POSSIBLE

Chest CT Severity Score: An Imaging Tool for Assessing Severe COVID-19

Rui Yang, Xiang Li, Huan Liu, Yanling Zhen, Xiaoxiang Zhang, Qiuxia Xiong, Yang Luo, Cailiang Gao, Wenbing Zeng


Right lung
Apical
Upper lobe
Posterior
Anterior
Apical
Lateral
Anterior
Medial
Middle lobe
Lateral
Lower lobe
Lateral
Left lung
Apico-
posterior
Upper lobe
Anterior
Apical
Superior
lingula
Anterior
Inferior
lingula
Lateral
Lateral
Upper
lobe
Apical
Anterior
Middle
lobe
Medial
Medial
Posterior
Lower lobe
Medial
Upper
lobe
Apico-
posterior
Anterior
Apical
Lower
lobe
Superior
lingula
Inferior
lingula
Posterior
Anterior
Medial

CASES

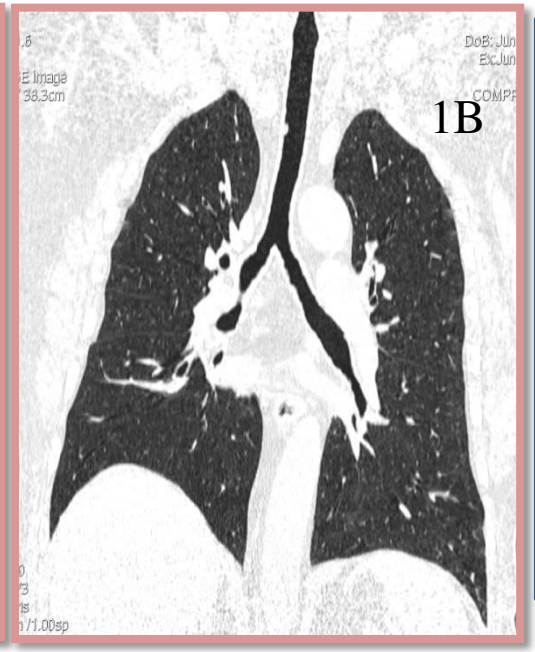


Figure 1. A-B. Non-contrast chest CT images of a 28-year-old male with mild COVID-19 pneumonia. No obvious ground- glass opacities or consolidatory changes are noted in the bilateral lung parenchyma.

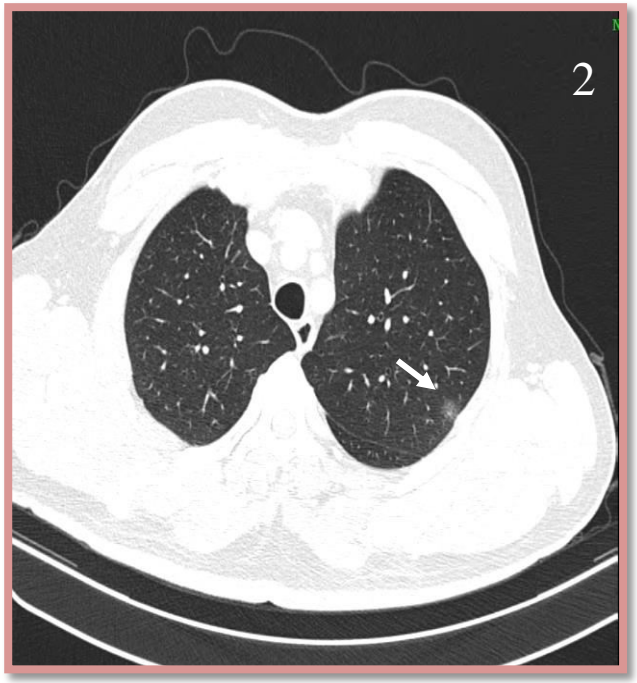


Figure 2. Non-contrast chest CT images of a 36-year-old
female with COVID-19 pneumonia. CT scan shows focal ground-glass opacity in the posterior segment of the left
upper lobe(arrow).The CT-SS is 1 .

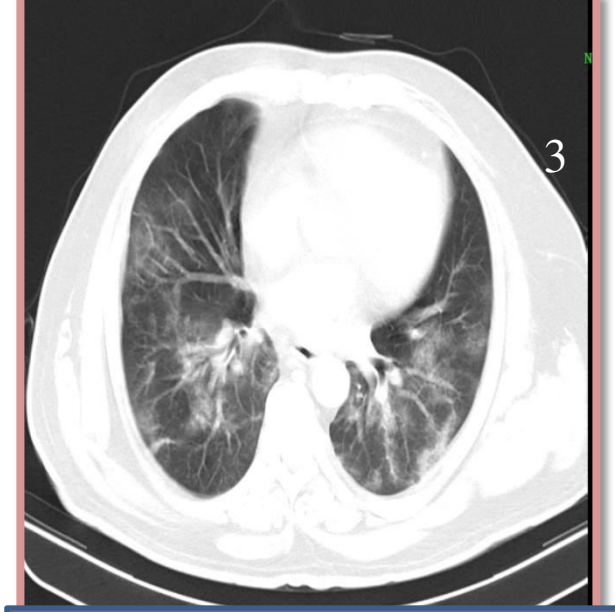
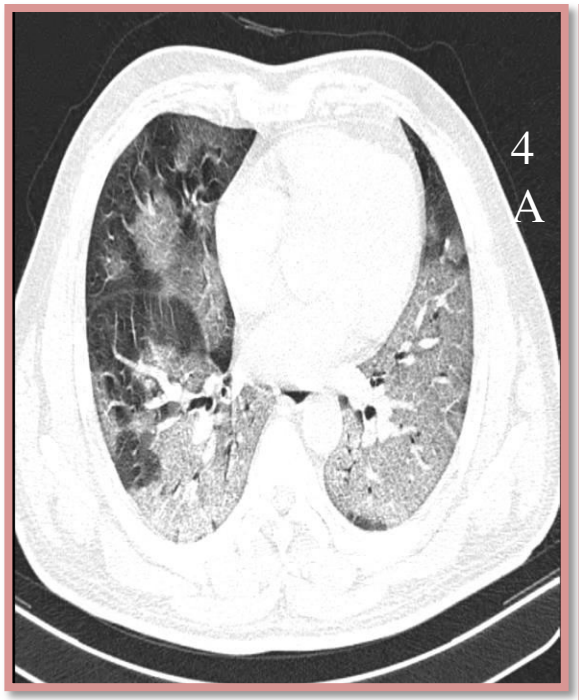
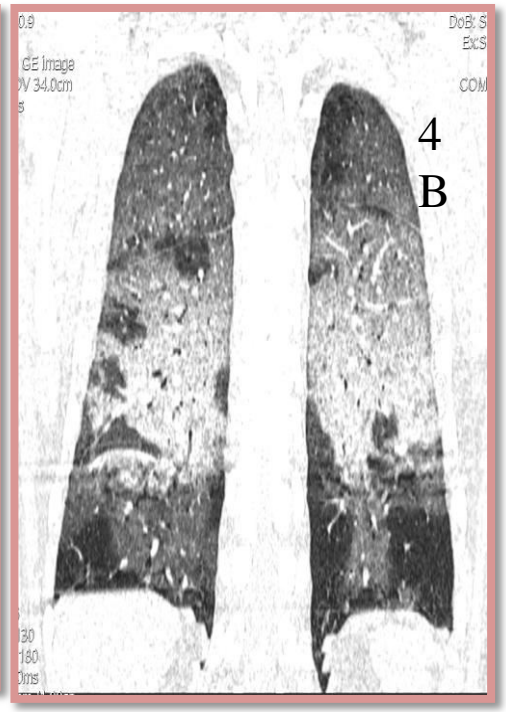


Figure 3. Non-contrast chest CT images of a 46-year-old male with COVID-19 pneumonia. CT scan shows multiple ground-glass opacities in all segments of bilateral lung parenchyma. The CT-SS is 20.

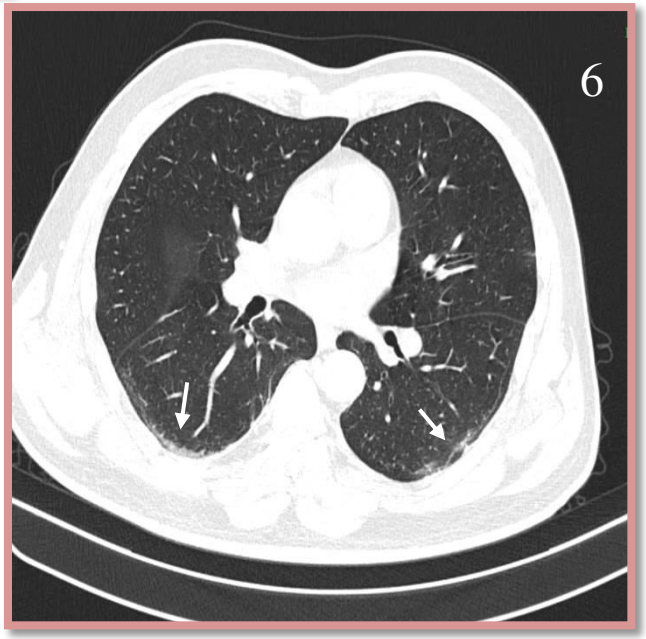
Figure 4. A-B. Non-contrast chest CT images of a 48-year-old female with COVID-19 pneumonia. CT scan shows multiple confluent ground-glass opacities in all segments of bilateral lung parenchyma. These ground-glass opacities are associated with interlobular septal thickening presenting as the crazy-paving pattern, and focal consolidation in bilateral basal segments giving the appearance of "white lung." The CT-SS is 37.





chest CT images of a 70-year-old male with COVID-19 pneumonia. CT scan shows multiple patchy consolidatory changes with adjacent ground-glass opacities involving all segments of bilateral lungs except the anterior segment of the left upper lobe. The

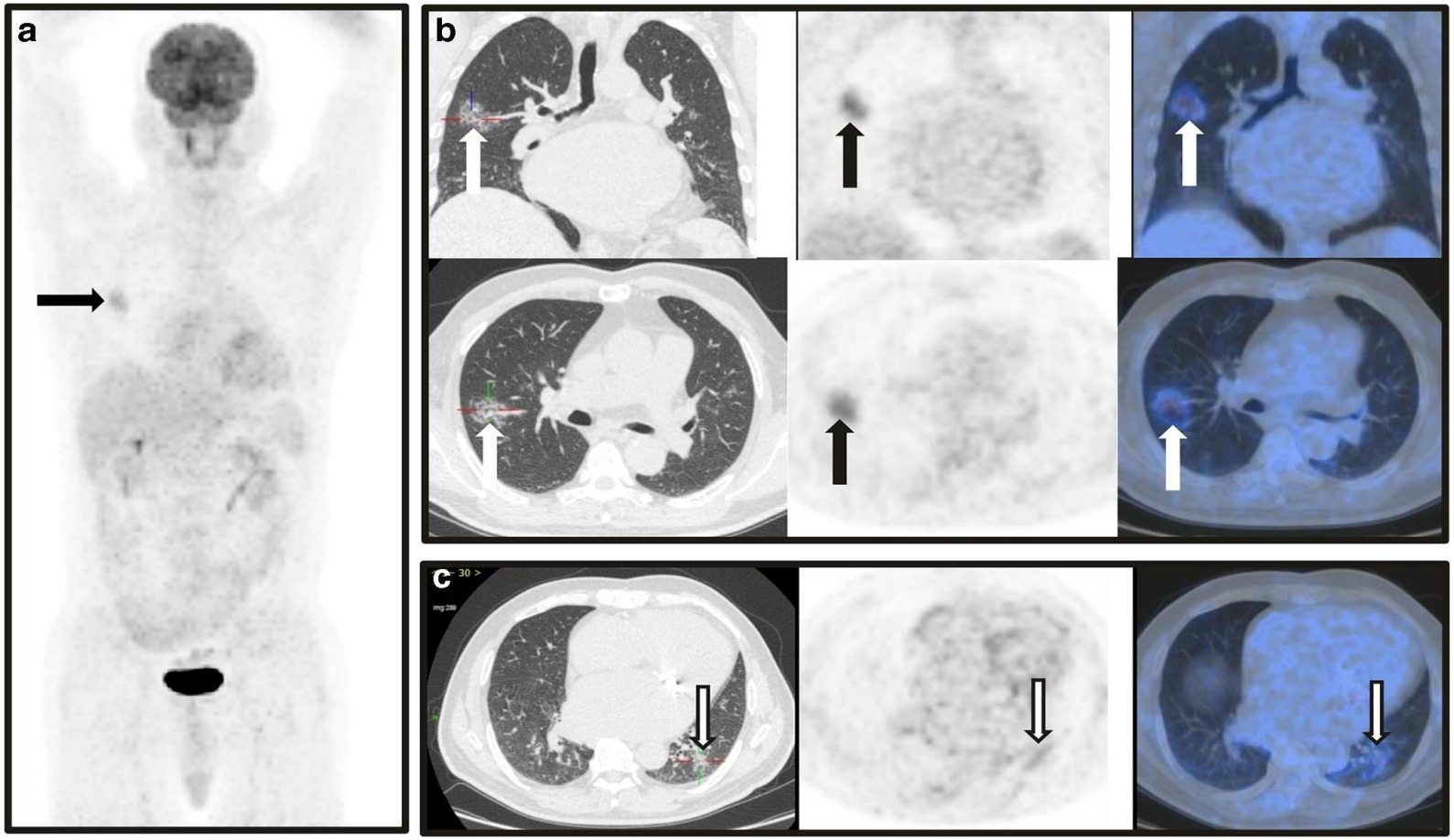
Figure 6. Non-contrast chest CT images of a 58-year-old male with COVID-19 pneumonia. CT scan shows subpleural bands with adjacent ground-glass opacities in superior, posterior, and medial basal segments of bilateral lung parenchyma(arrows).
The CT-SS is 6.



PET CT

FDG uptake is increased in GGO's in those with suspected/confirmed COVID-19

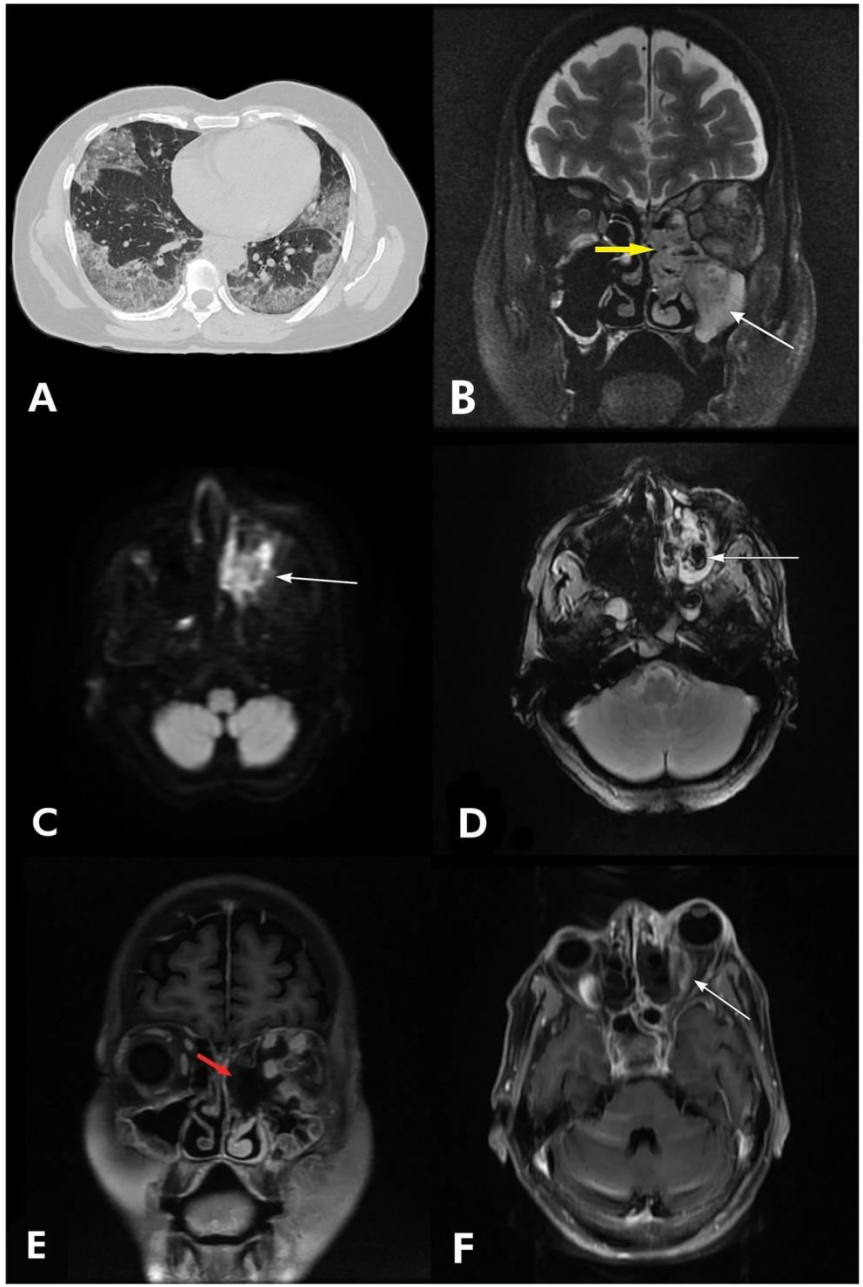
It has been hypothesized that those with higher Standard Uptake Values in lung lesions take longer to heal



Mucormycosis

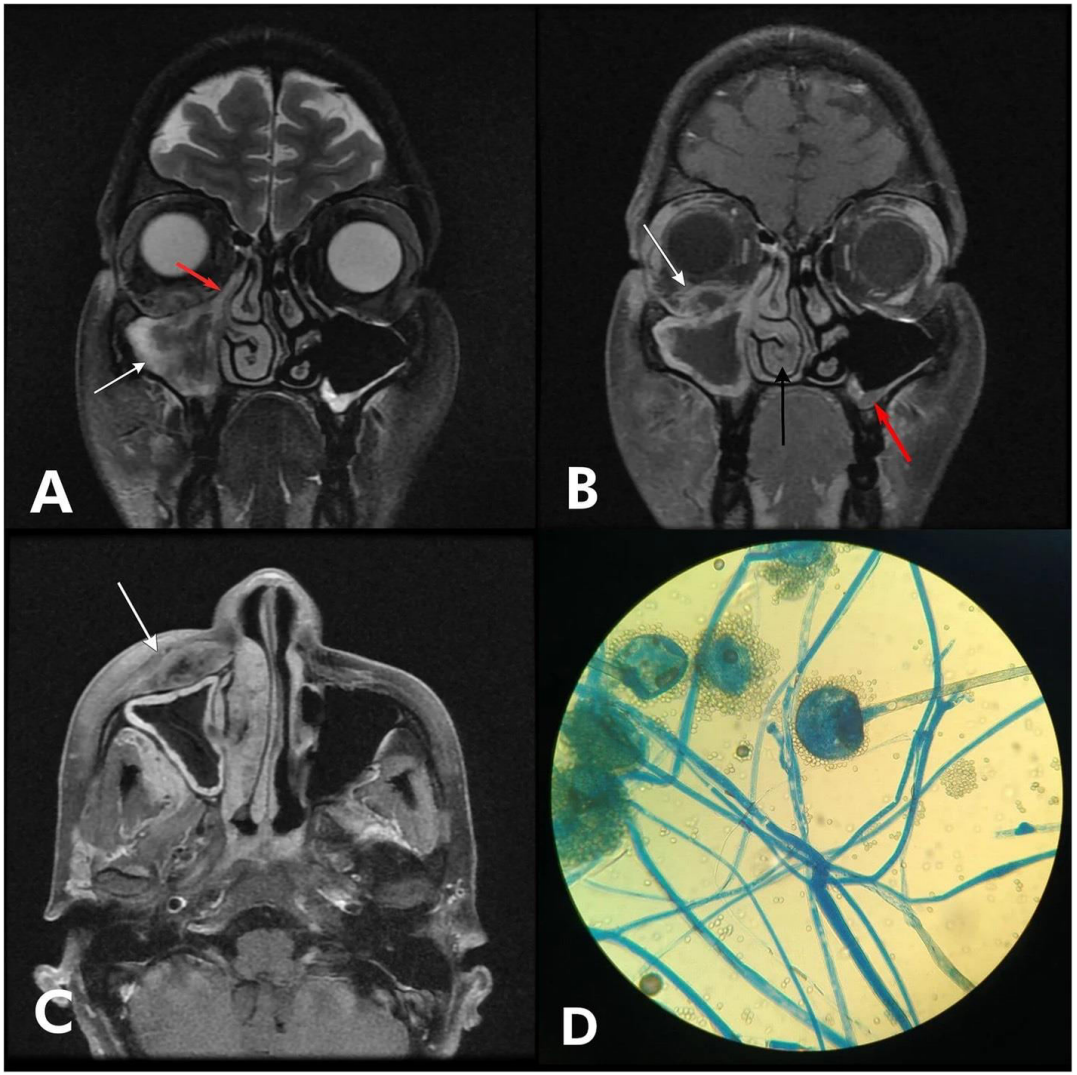
- Rhino orbito cerebral
- Pulmonary

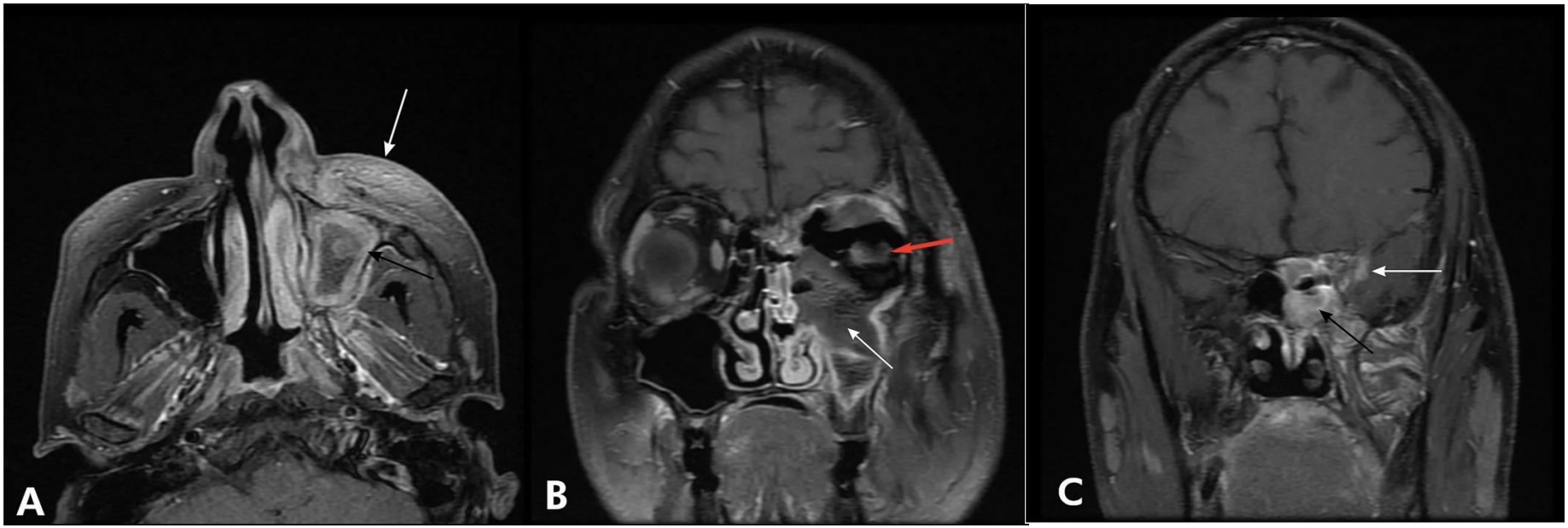
- Uncontrolled diabetes mellitus and the use of corticosteroids for the treatment of respiratory symptoms are possible etiological factors
- Mucormycosis can be life threatening as it has a high mortality rate of over 50%
- Rhino-orbital mucormycosis can have aggressive necrosis of the involved paranasal sinuses and orbits with or without cerebral extension.
- Hence, the correct diagnosis is imperative as prompt antifungal drugs and surgical debridement can significantly reduce mortality and morbidity.
- it is crucial to be familiar with the imaging features of rhino-orbital mucormycosis.



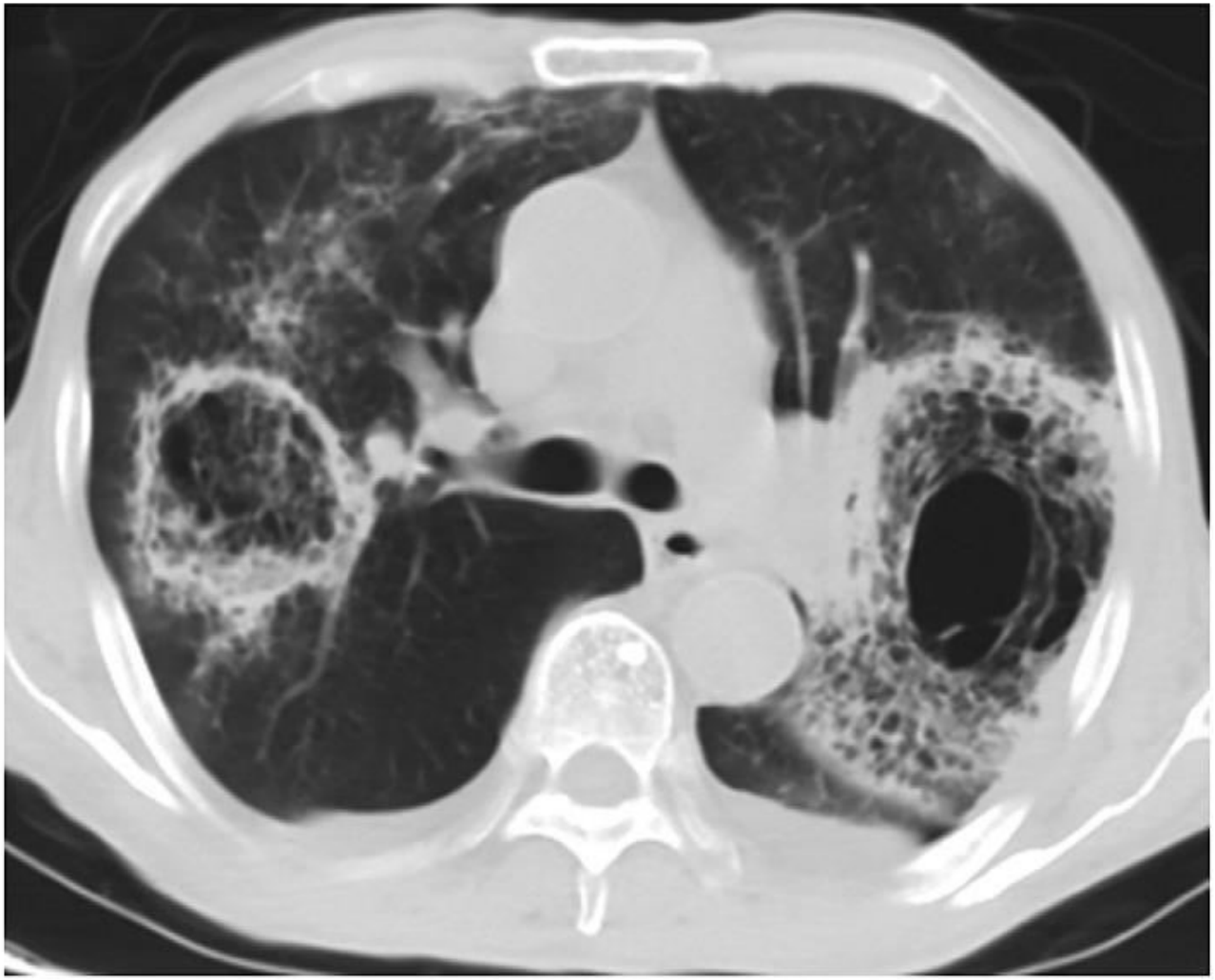
a Axial HRCT thorax image showing ground-glass opacities in subpleural regions of bilateral lung parenchyma with “crazy paving appearance.” **b** Coronal T2 FS image showing mucosal thickening and collection in the left maxillary sinus (white arrow), left ethmoidal sinus, and left middle nasal turbinate (yellow arrow) with inflamed extraocular muscles. **c** Axial DWI image showing restricted diffusion in the left maxillary sinus and left middle nasal turbinate. **d** Axial GRE image showing foci of blooming in the left maxillary sinus (white arrow). **e** Coronal T1 post-contrast image showing area of non-enhancing soft tissue in left middle nasal turbinate and within the left maxillary antrum (“black turbinate sign”). **f** Axial T1 post-contrast image showing enhancement and inflammation involving extraocular muscles of left orbit causing proptosis

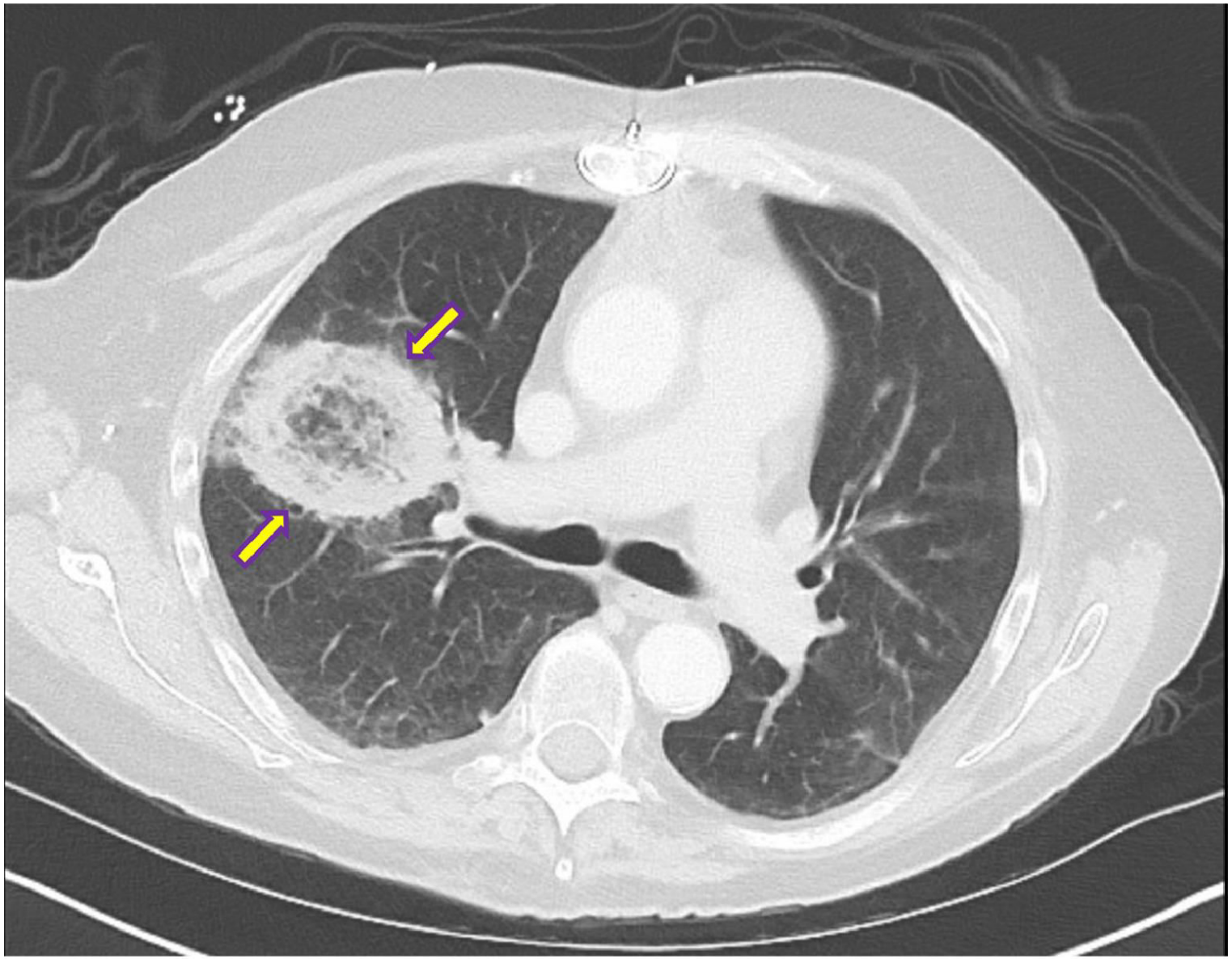
a Coronal T2 image showing mucosal thickening in right maxillary sinus (white arrow) causing blockage of the right osteomeatal unit (red arrow). **b** Coronal T1 FS post-contrast image showing extension of inflammation in right inferior orbit (white arrow) with post-contrast peripheral enhancement, right inferior turbinate hypertrophy (black arrow), and left maxillary wall thickening (white arrow). **c** Axial T1 FS post-contrast image showing right pre-maxillary soft tissue swelling with enhancement (white arrow). **d** Lactophenol cotton blue (LPCB) stain showing broad ribbon-like fungal hyphae with sporangium





a Axial T1 post-contrast image showing mucosal thickening and collection involving left maxillary sinus (black arrow) with pre-maxillary soft tissue swelling (white arrow). **b** Axial T1 post-contrast image showing inferior orbital wall with extension of soft tissue component into left inferomedial orbit (white arrow) and left phthisis bulbi (red arrow). **c** Coronal T1 post-contrast image showing left sphenoid sinusitis (black arrow) with an area of enhancement involving left medial temporal lobe (white arrow).





Reversed halo or bird next sign

THANK YOU

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