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RADIOLOGY EDUCATION

Imaging of COVID-19, Part 2

March 20, 2020

Benjamin W. Strong, MD

Disclosures -

Benjamin W. Strong, MD

- I have no relevant financial relationships to disclose or conflicts of interest to resolve.
- I will not be discussing any unapproved or off-label, experimental or investigational use of a drug or device.

Katie Lozano, MD

- I have no relevant financial relationships to disclose or conflicts of interest to resolve.
- I have not mentioned any unapproved or off-label, experimental or investigational use of a drug or device.

Brian Schmidt

- I have no relevant financial relationships to disclose or conflicts of interest to resolve.
- I will not be discussing any unapproved or off-label, experimental or investigational use of a drug or device.

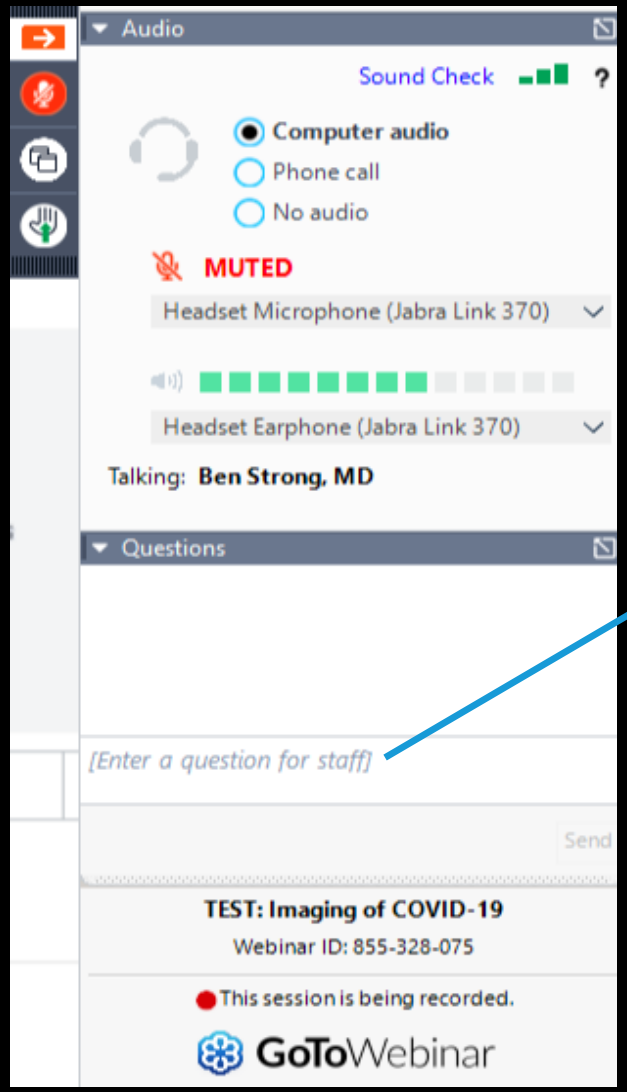
Scott Baginski, MD

- I have no relevant financial relationships to disclose or conflicts of interest to resolve.

Hilja Dodd Sousa Conceição, CHCP, CPHQ

- I have no relevant financial relationships to disclose or conflicts of interest to resolve.

Asking Questions



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Our Presenter

Benjamin W. Strong, MD
Chief Medical Officer, vRad

Clinical Work History

- Joined vRad as a teleradiologist in July 2004
- vRad medical director 2005 – 2012
- Has read 150,000+ studies on the vRad platform
- Licensed in all 50 states
- ACR Committee on Emergency Radiology
- AIRP International Lecturer
- Prior to joining vRad:
  - Emergency room physician
  - Private practice radiologist, Inland Imaging, Spokane, WA
  - Clinical Assistant Professor of Radiology, Arizona Health Sciences Center

Education and Certification

- Medical degree: The University of Arizona College of Medicine, Tucson
- Internal medicine residency: Dartmouth-Hitchcock Medical Center
- Radiology residency: University of Arizona, Arizona Health Sciences Center
- Fellowship in Musculoskeletal MRI: University of Arizona, Arizona Health Sciences Center
- Board certifications: American Board of Radiology, American Board of Internal Medicine (1996-2016)

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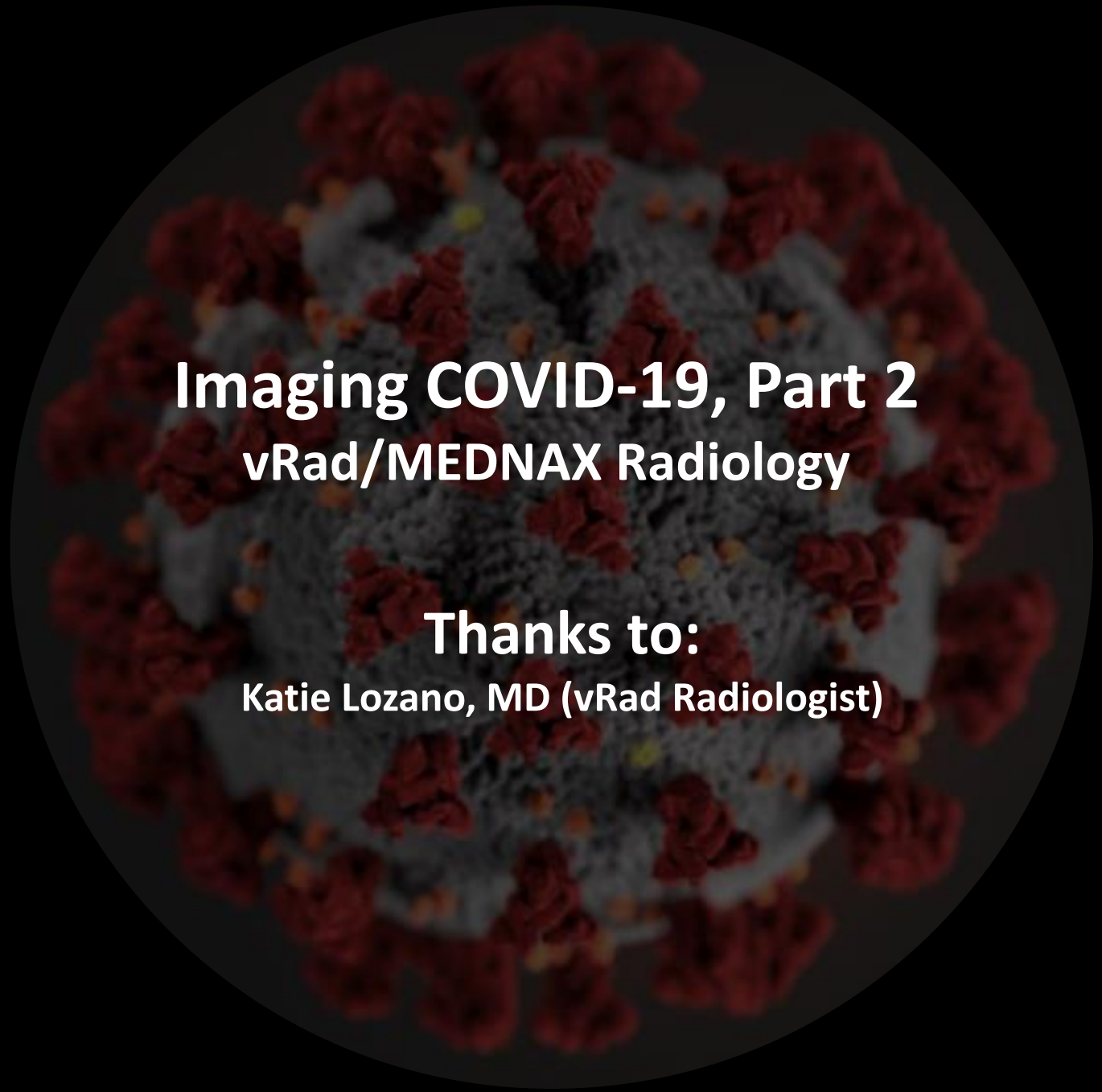


Imaging COVID-19, Part 2

vRad/MEDNAX Radiology

Thanks to:

Katie Lozano, MD (vRad Radiologist)

“Chest CT is a vital component in the diagnostic algorithm for patients with suspected COVID-19.” (2)

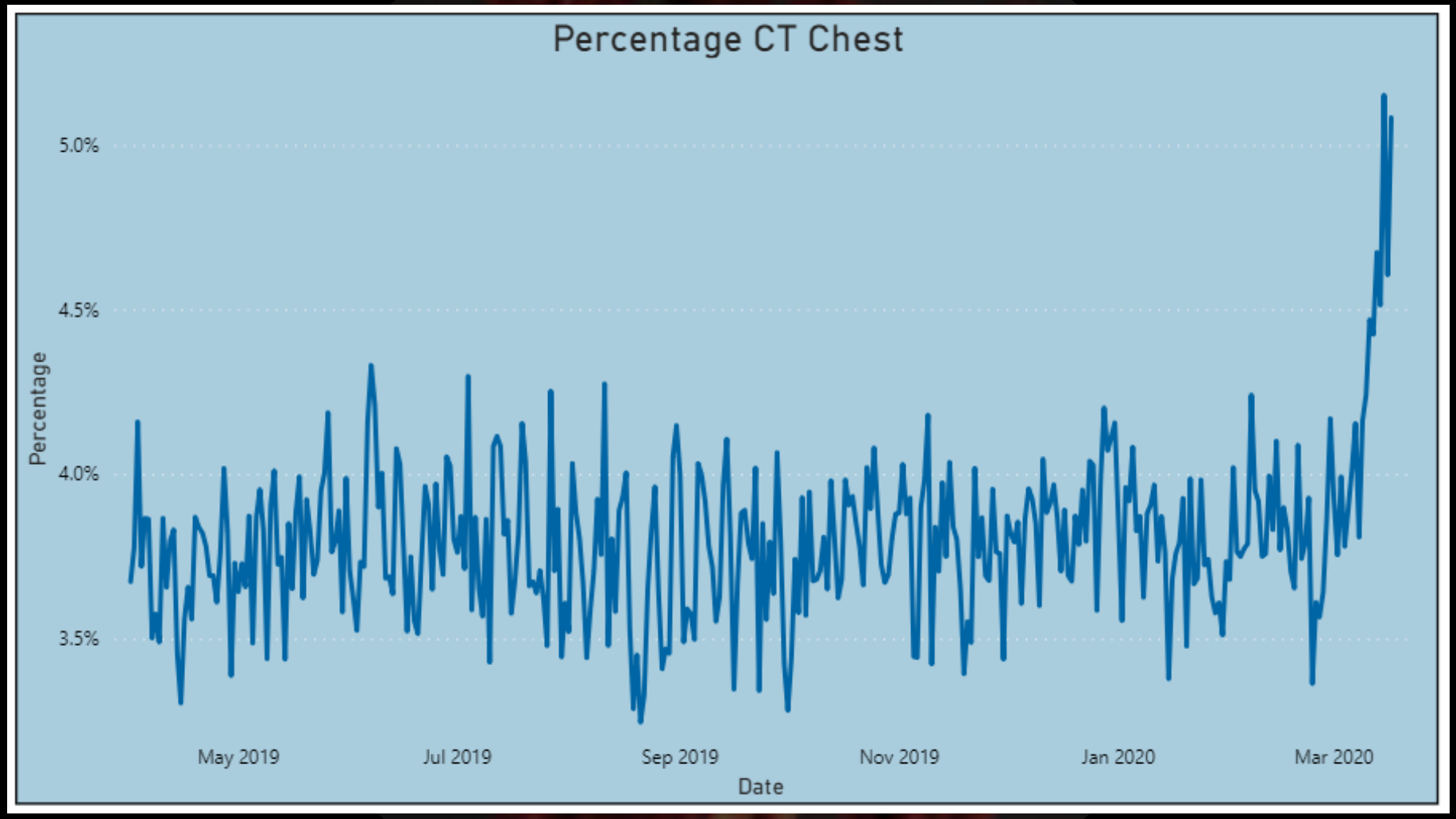
“Chest CT has a high sensitivity for diagnosis of COVID-19. Chest CT may be considered as a primary tool for the current COVID-19 detection in epidemic areas.” (3)

“In a series of 51 patients with chest CT and RT-PCR assay performed within 3 days, the sensitivity of CT for COVID-19 infection was 98% compared to RT-PCR sensitivity of 71% ($p<.001$).” (4)

“With analysis of serial RT-PCR assays and CT scans, 60% to 93% of patients had initial positive chest CT consistent with COVID-19 before the initial positive RT-PCR results.” (3)

“The National Health Commission of the People’s Republic of China has encouraged diagnosis based on clinical and chest CT findings alone.” (2)

“In China, the disease epicenter, imaging has been at the forefront of investigation for patients with suspected or confirmed COVID-19 infection. As a result, computed tomography (CT) of the chest has been utilized on an unprecedented scale.” (5)


Percentage CT Chest
5.0%
4.5%
4.0%
3.5%
Percentage
May 2019
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
Date

CT findings and stages:

Stage 1 (early, 0-4 days after onset of initial symptom): Ground glass opacity (GGO), usually peripheral, can be unilateral or bilateral). Lower lobe predominance (6). Often bilateral with rounded morphology (2).

Stage 2 (progressive, 5-8 days after onset of initial symptom): Crazy paving. Increased ground glass opacities, more diffuse, with some consolidation. Lower lobe predominance (6).

Stage 3 (peak, 9-13 days after onset of initial symptom, most severe at 10 days): Bilateral consolidative opacities, can be peripheral, rounded (6). Reverse halo sign may be seen (2).

Stage 4 (absorption, 14 or more days after onset of the initial symptom): Gradual resolution of consolidation, resolution of crazy paving (6). Improvement begins centrally (2). Of note, Stage 4 is when things go well.

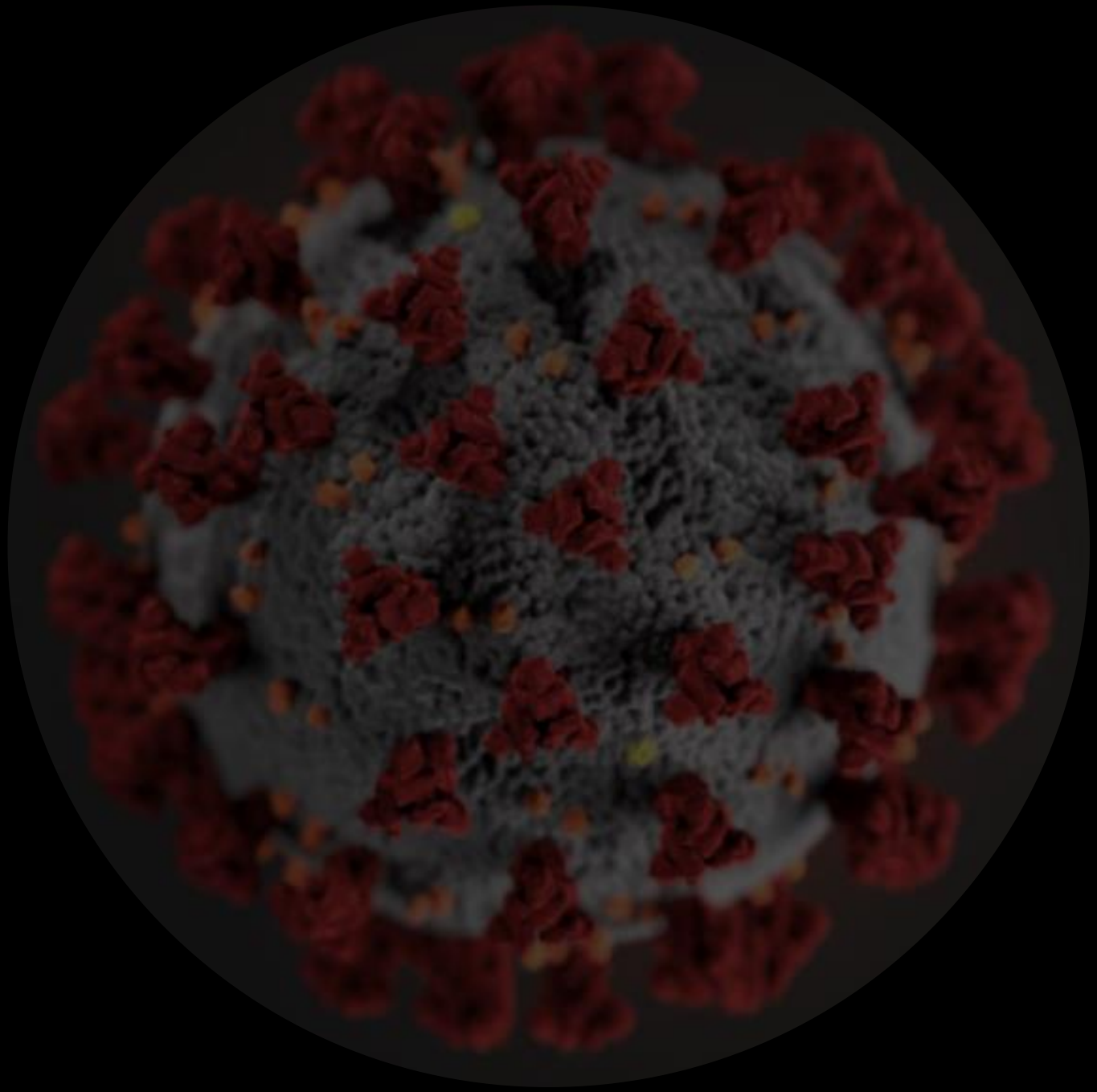
CT findings and stages:

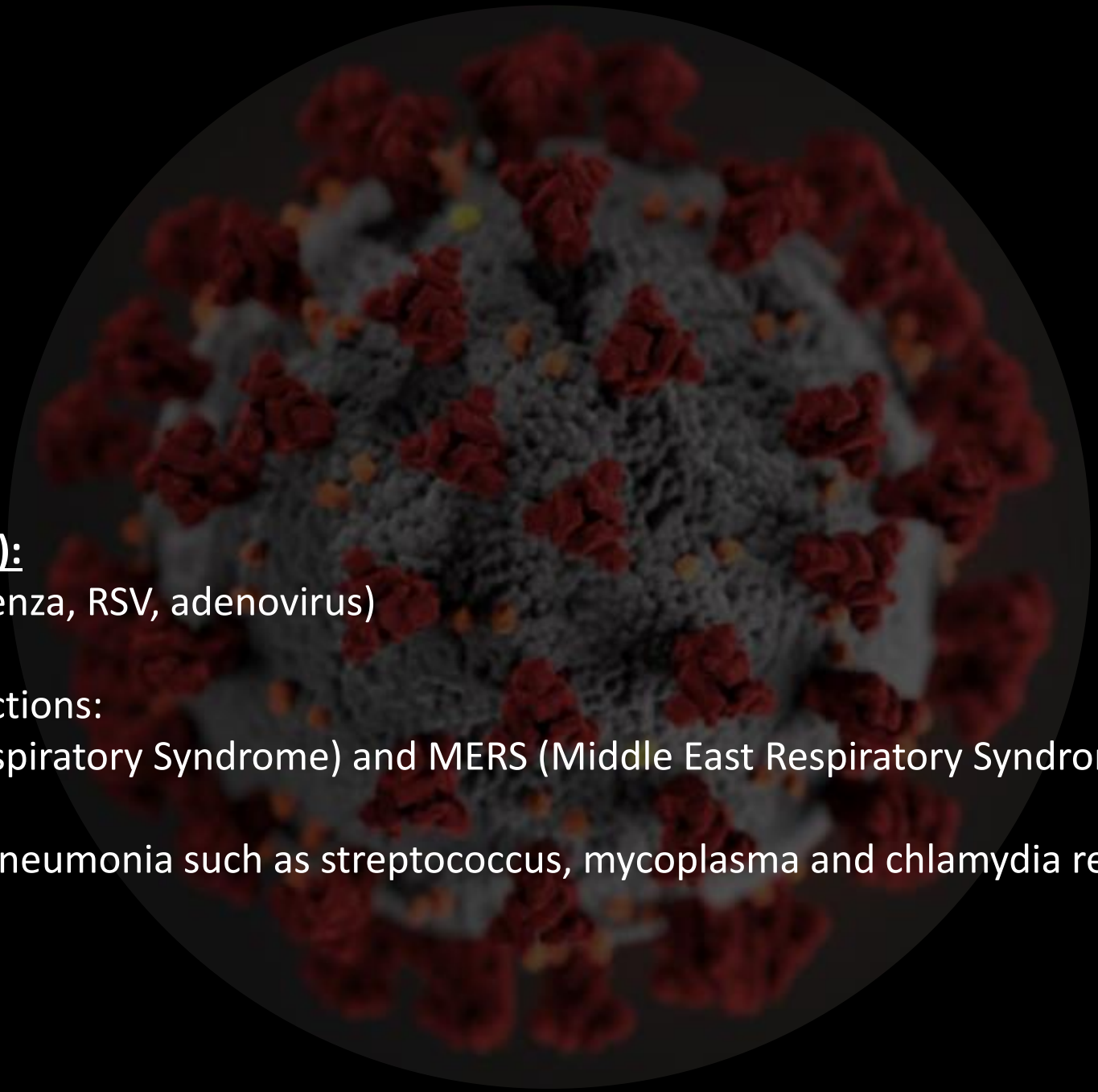
Ground Glass

Crazy Paving

Consolidation

Resolution





Notably absent:
Pulmonary nodules
Cavitation
Lymphadenopathy (2)
Pleural effusions (5)
Calcification (7)

Differential (infectious):
Viral pneumonia (influenza, RSV, adenovirus)

Other coronavirus infections:
SARS (Severe Acute Respiratory Syndrome) and MERS (Middle East Respiratory Syndrome)

Community-acquired pneumonia such as streptococcus, mycoplasma and chlamydia related pneumonia (7)

Ground Glass Opacity

Chronic interstitial diseases

eosinophilic pneumonias: ground-glass opacification can be seen in many of the eosinophilic pneumonias but is most commonly seen in:
- simple pulmonary eosinophilia (SPE): nodules with a GGO halo
- idiopathic hypereosinophilic syndrome (IHS): nodules with a GGO halo
- acute eosinophilic pneumonia (AEP): bilateral patchy areas of GGO with interlobular septal thickening
- eosinophilic drug reactions: peripheral airspace consolidation and GGO

idiopathic interstitial pneumonias
- non-specific interstitial pneumonia: GGO with linear or reticular markings, micronodules, consolidation, and microcystic honeycombing
- usual interstitial pneumonia (UIP): focal GGO with macrocystic honeycombing, reticular opacities, traction bronchiectasis, and architectural distortion
- cryptogenic organizing pneumonia (COP): formerly bronchiolitis obliterans with organizing pneumonia (BOOP); GGO with airspace consolidation and mild bronchial dilatation
- exudative phase of acute interstitial pneumonia (AIP): diffuse lung consolidation with GGO
- respiratory bronchiolitis-associated interstitial lung disease (RB-ILD): patchy GGO centrilobular nodules and bronchial wall thickening
- desquamative interstitial pneumonia (DIP): GGO with linear or reticular opacities
- lymphoid interstitial pneumonia (LIP): GGO often in association with perivascular cystic lesions, septal thickening, and centrilobular nodules

sarcoidosis (pulmonary manifestations of sarcoidosis)

Acute alveolar disease

alveolar edema or pulmonary edema
- cardiogenic pulmonary edema
- adult respiratory distress syndrome (ARDS)
- other causes of non-cardiogenic pulmonary edema

hypersensitivity pneumonitis: especially acute and subacute forms

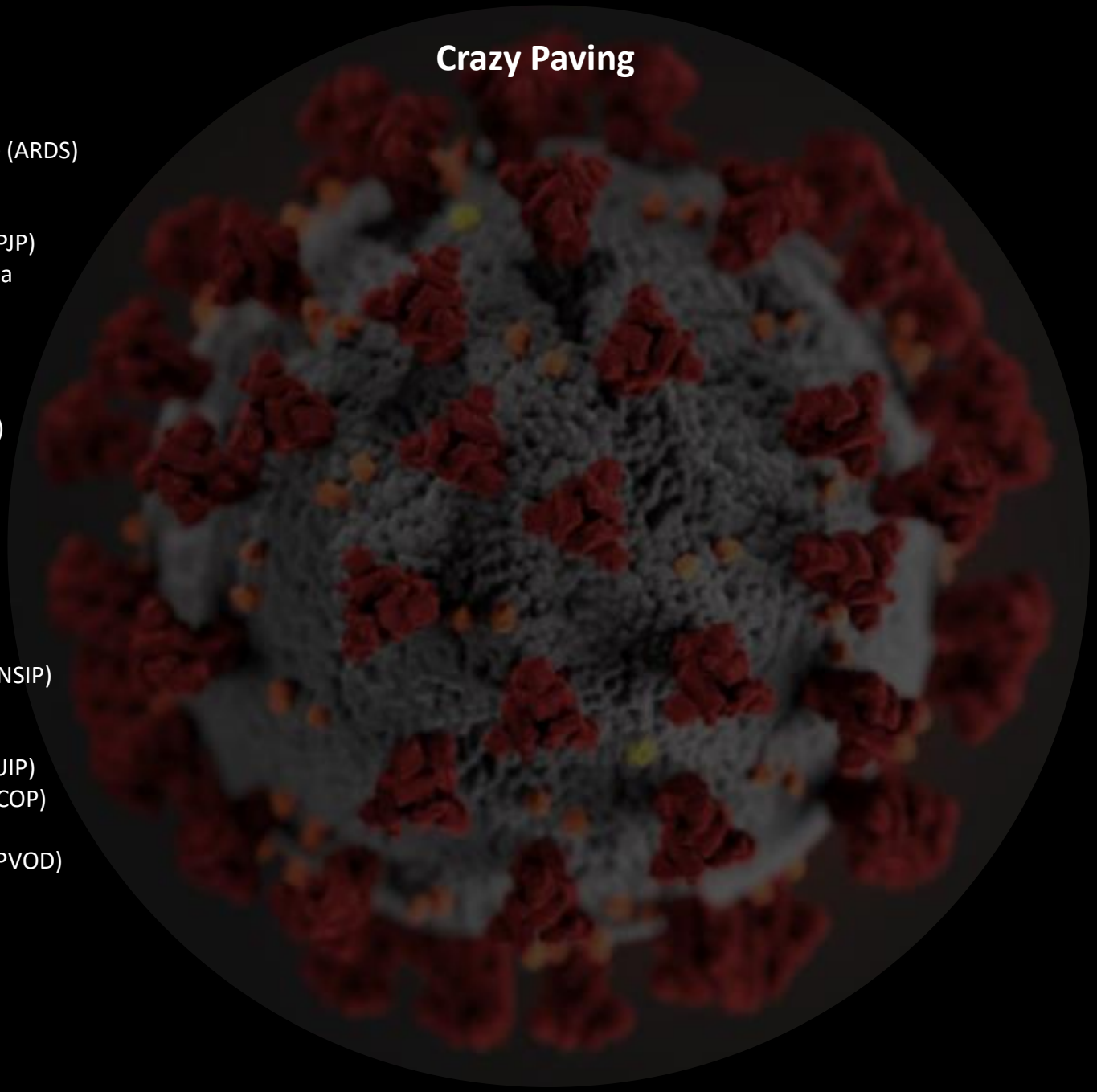
Other causes

neoplastic processes with a lepidic proliferation pattern
- atypical adenomatous hyperplasia
- localized adenocarcinoma
- adenocarcinoma in situ or minimally invasive (formerly bronchoalveolar cell carcinoma)

drug toxicity

Crazy Paving

- Acute Respiratory Distress Syndrome (ARDS)
- Bacterial Pneumonia
- Acute Interstitial Pneumonia (AIP)
- Pneumocystis Jerovecii pneumonia (PJP)
- Mucinous Bronchoalveolar Carcinoma
- Chronic Aspiration
- Lipoid Pneumonia
- Viral Pneumonia
- Fungal Pneumonia
- Pulmonary Alveolar Proteinosis (PAP)
- Granulomatosis with Polyangiitis
- Microscopic Polyangiitis
- Churg-Strauss Syndrome
- Goodpasture Disease
- Collagen vascular diseases
- Idiopathic hemorrhage
- Mycoplasma pneumonia
- Non-specific Interstitial Pneumonia (NSIP)
- Alveolar Sarcoidosis
- Chronic Eosinophilic Pneumonia
- Acute Usual Interstitial Pneumonia (UIP)
- Cryptogenic Organizing Pneumonia (COP)
- Drug induced pneumonitis
- Pulmonary Veno-Occlusive Disease (PVOD)
- Pulmonary edema
- Radiation Pneumonitis
- Graft-vs Host Disease
- Lymphangitic Carcinomatosis
- Hypersensitivity Pneumonitis

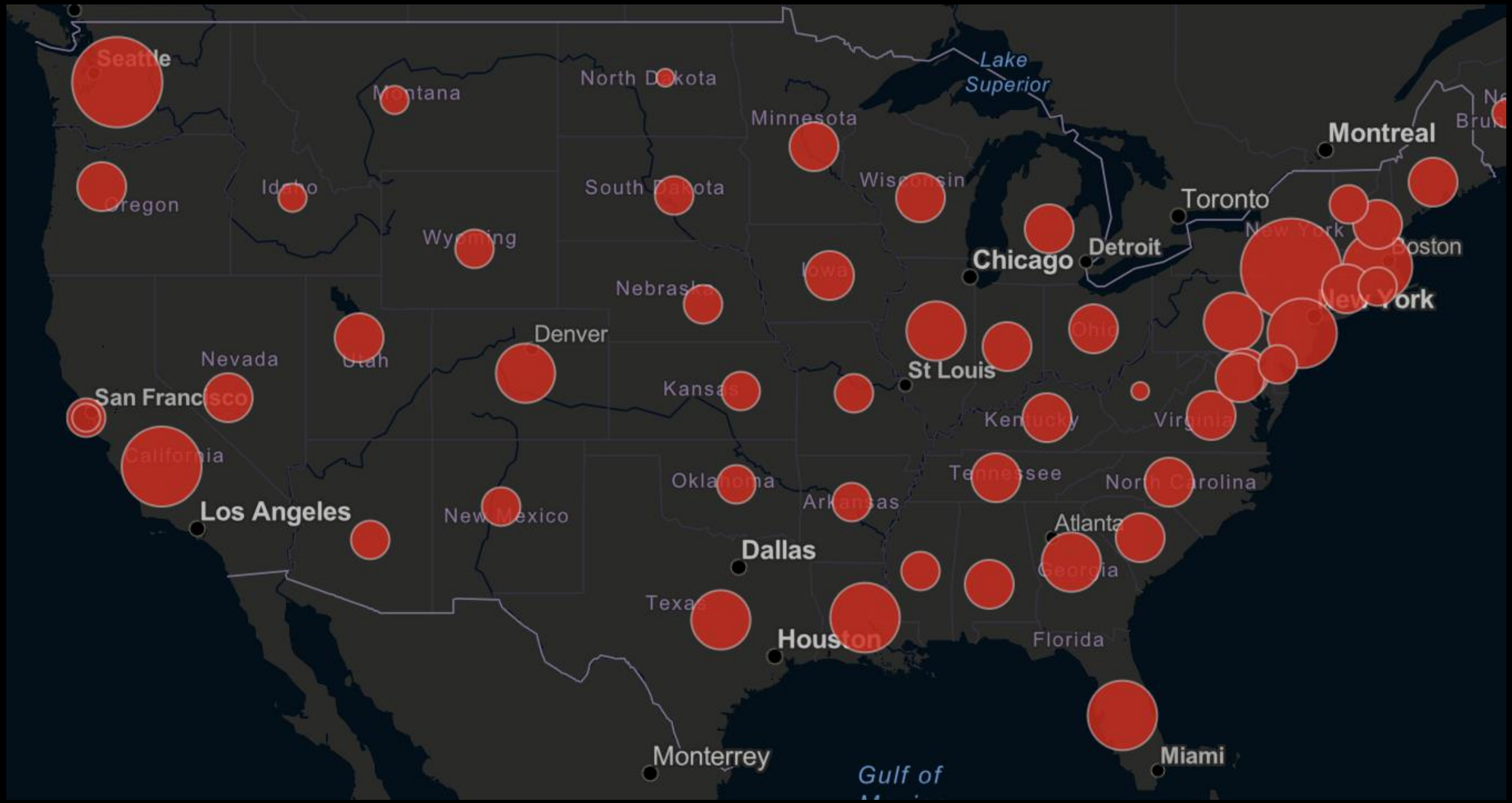


Reporting recommendations :

1) If the **requesting clinician does not indicate a suspicion for COVID-19** (coronavirus) in the clinical history, you should report the relevant findings on the Chest CT and **provide a general differential diagnosis** such as infection, organizing pneumonia, and hemorrhage, but specifically avoid mentioning the possibility of COVID-19. If your suspicion of COVID-19 is heightened based on the combination of imaging, demographic, and clinical information available to you, you should call the ordering clinician to discuss the findings and addend your report accordingly.

2) **If the clinical history specifically indicates a concern for COVID-19**, you should provide an opinion as to the likelihood that the CT findings are **consistent with COVID-19, while** also including a statement that the CT findings are **nonspecific overall**. In these cases, if your suspicion of COVID-19 is high based on the imaging findings, you should place a critical finding call to the requesting clinician. We're also now seeing sites starting to use euphemisms like "influenza-like illness (ILI)" to avoid mentioning "COVID" or "coronavirus." Please use your judgement in these cases and do not hesitate to call the clinician to obtain clinical context and convey the exam results.

Note: Be aware that a negative Chest CT does not rule out the possibility that the patient will subsequently develop pulmonary findings of COVID-19, and you should not state that the virus has been excluded based on a negative Chest CT scan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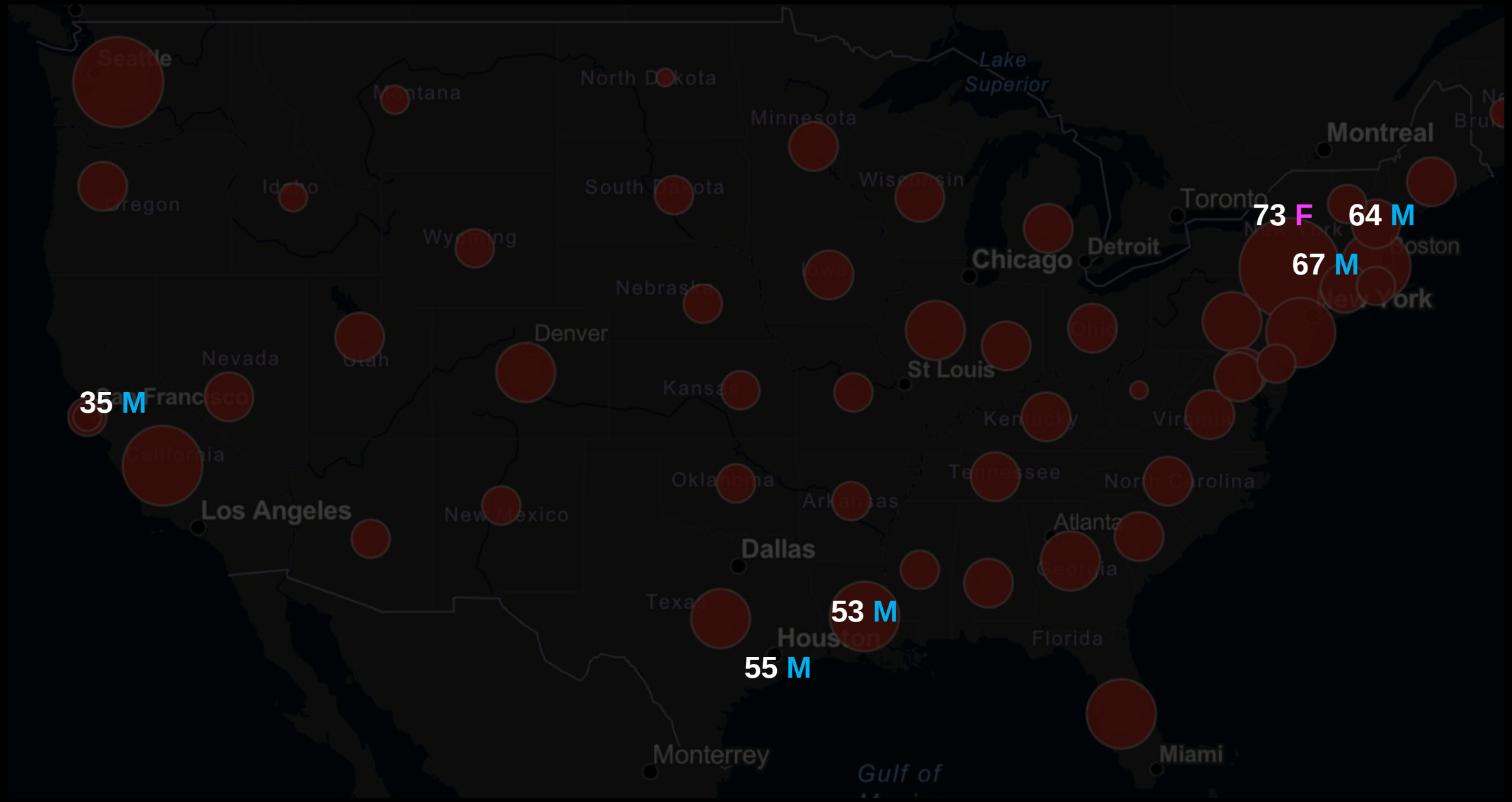
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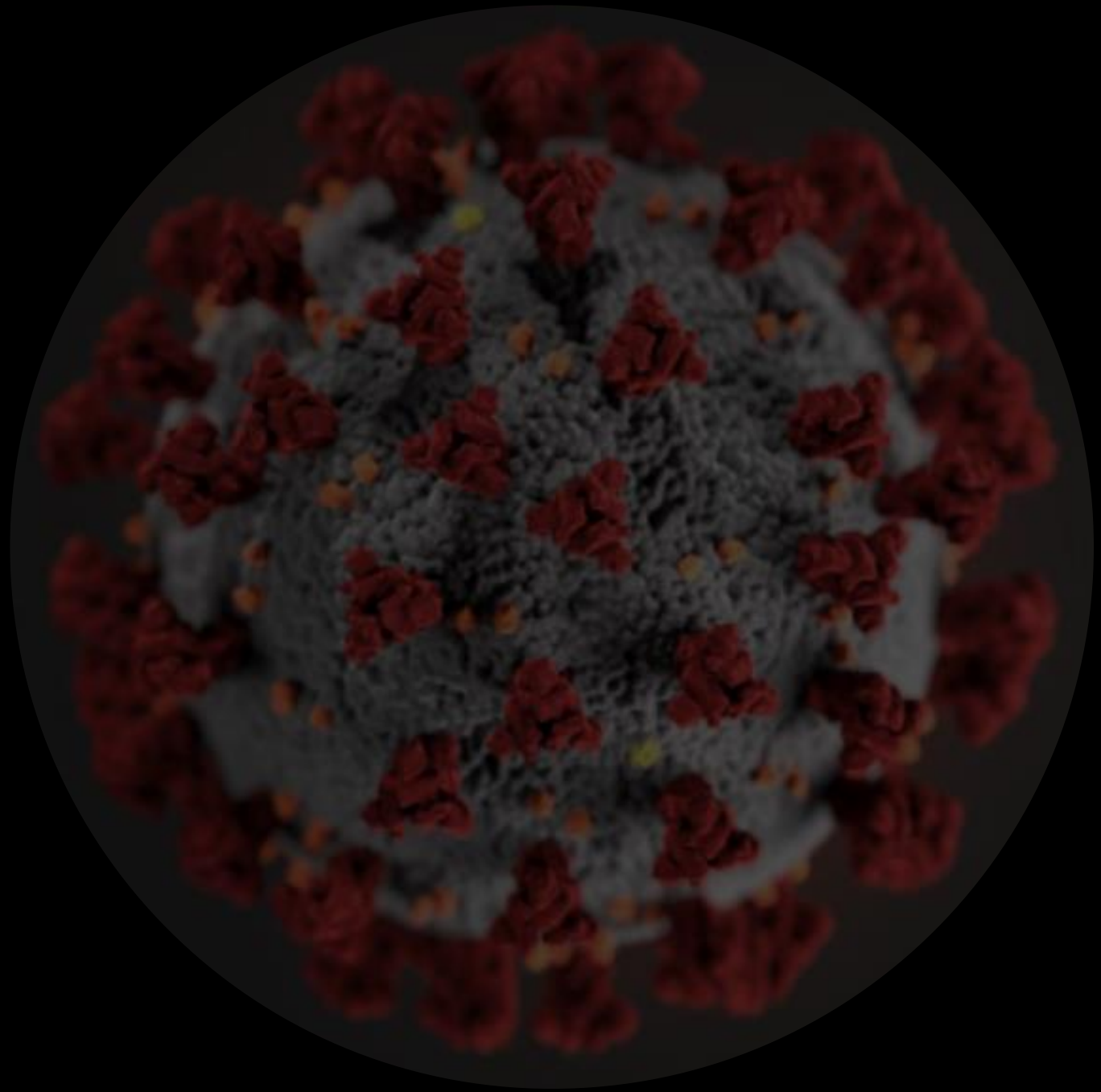
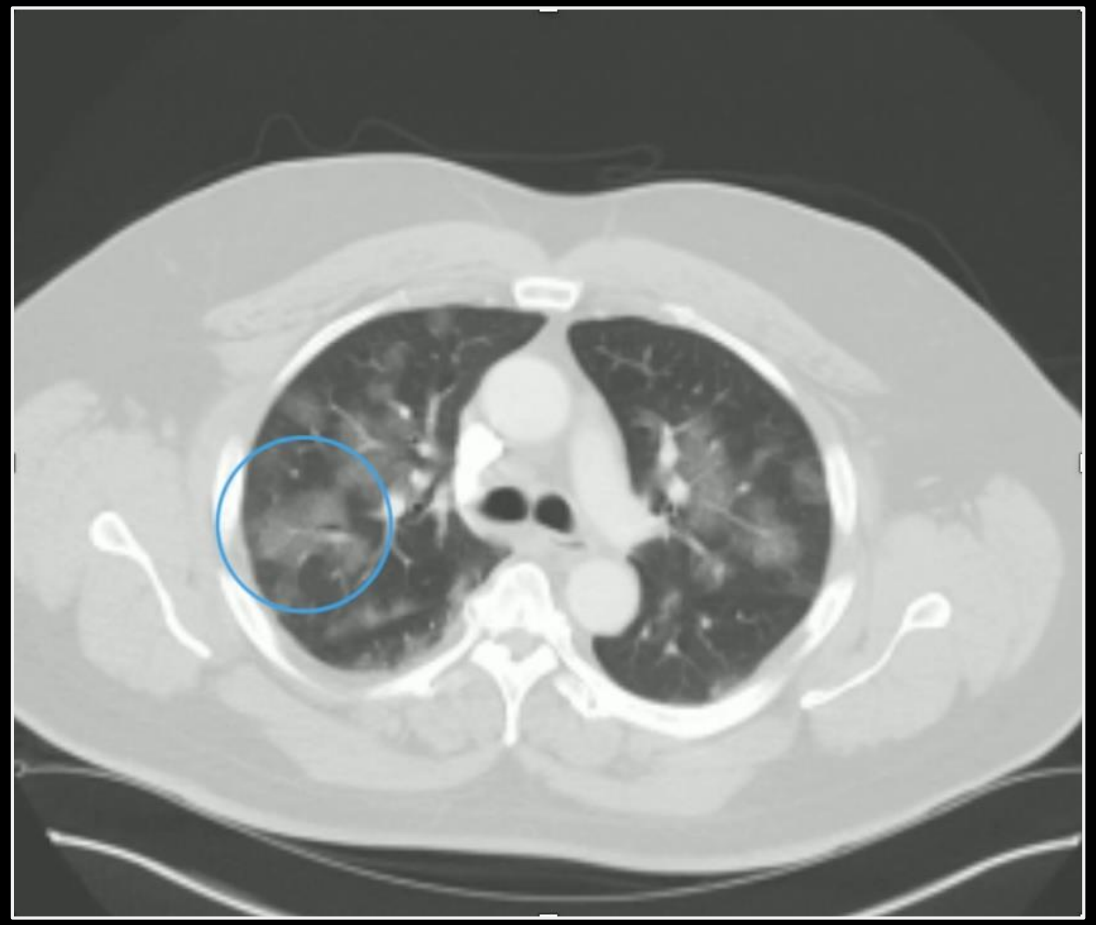


Ground glass opacities

COVID-19 pneumonia



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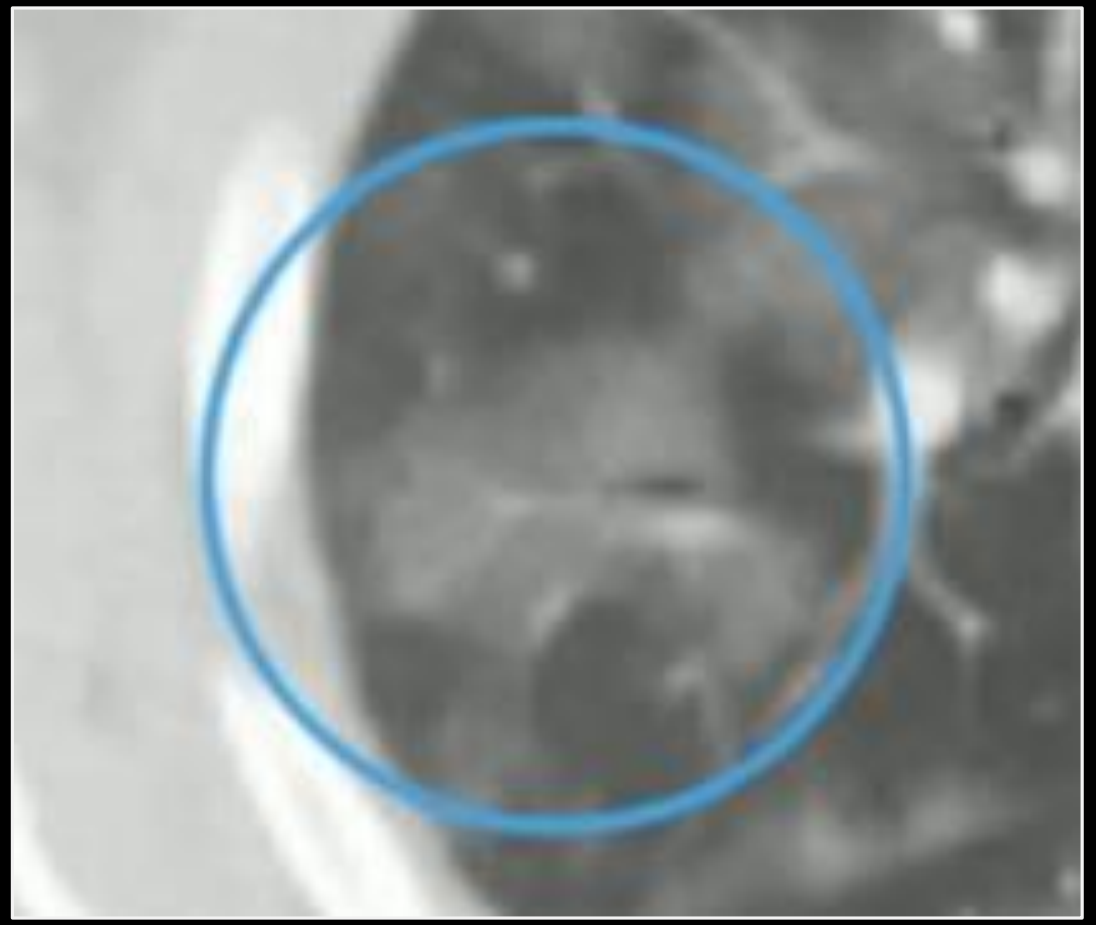
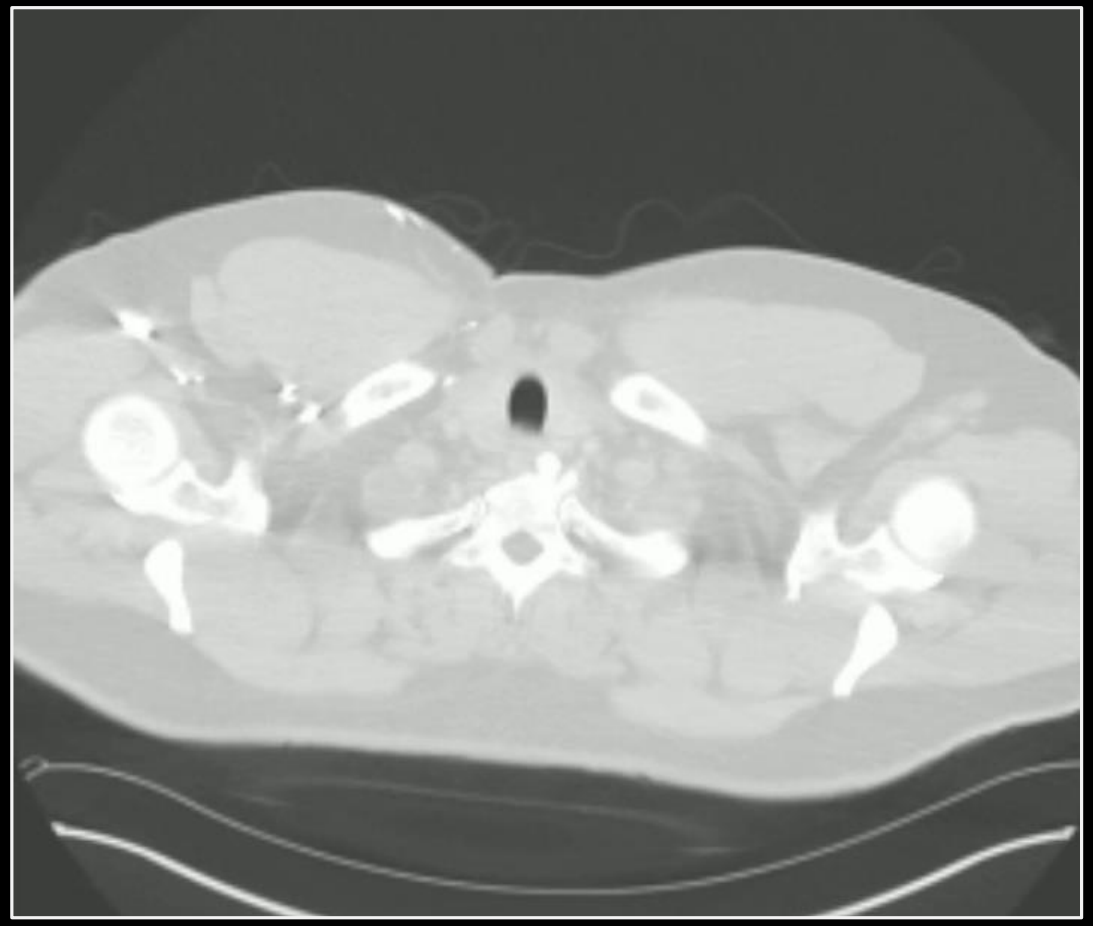
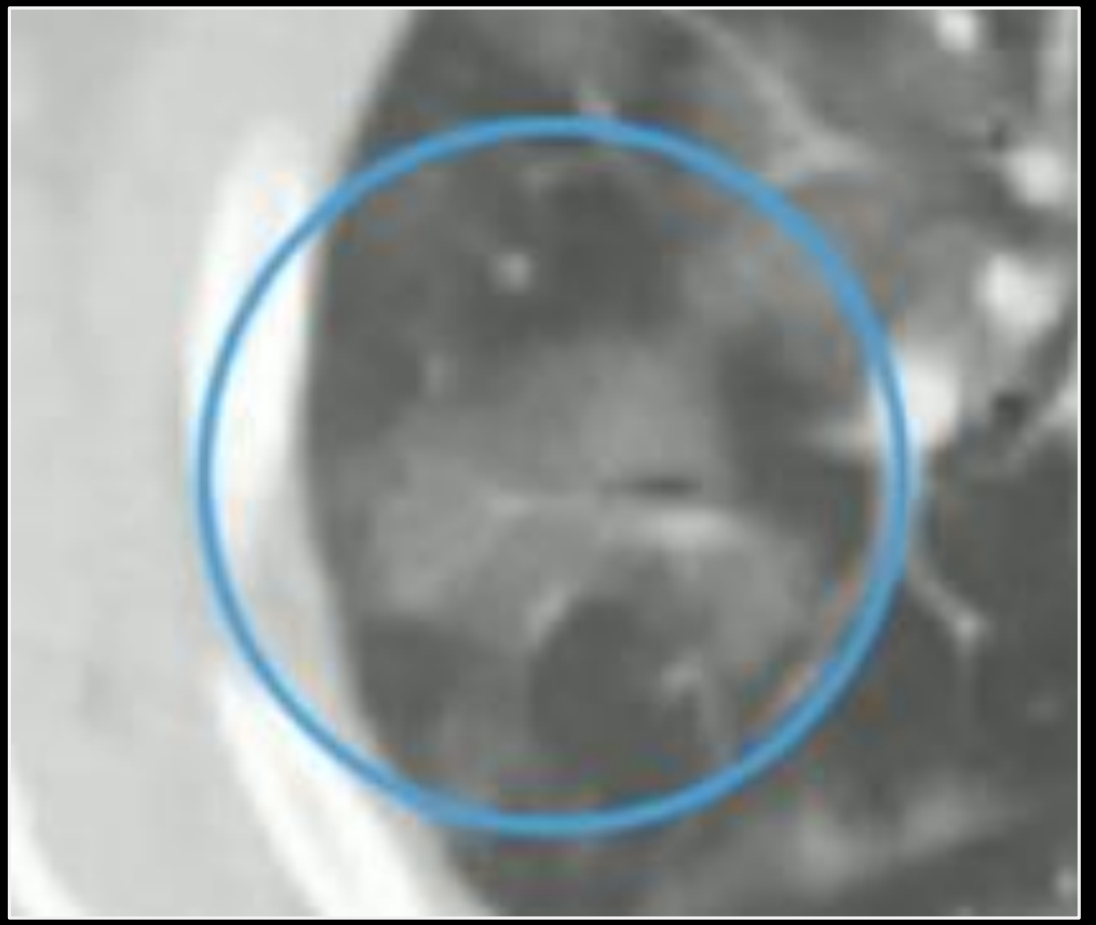
Ground glass opacities

COVID-19 pneumonia

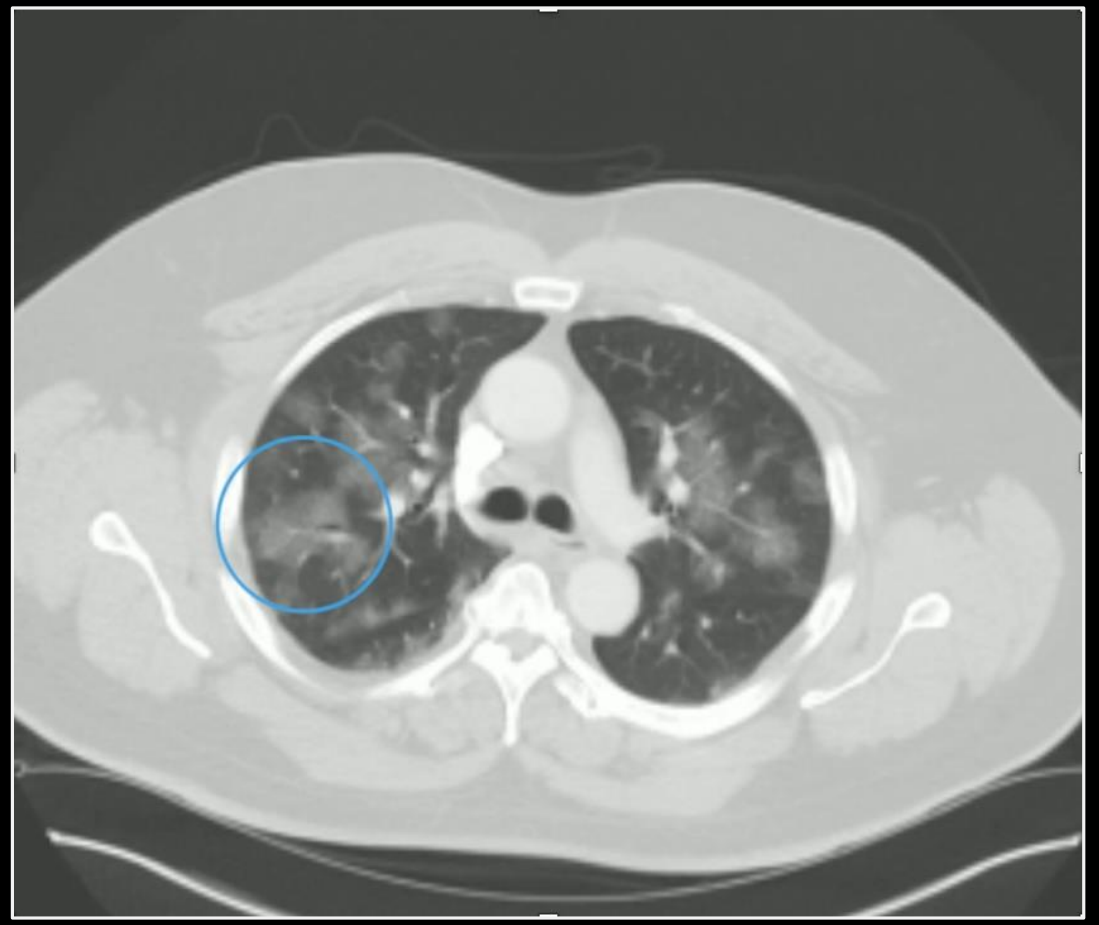






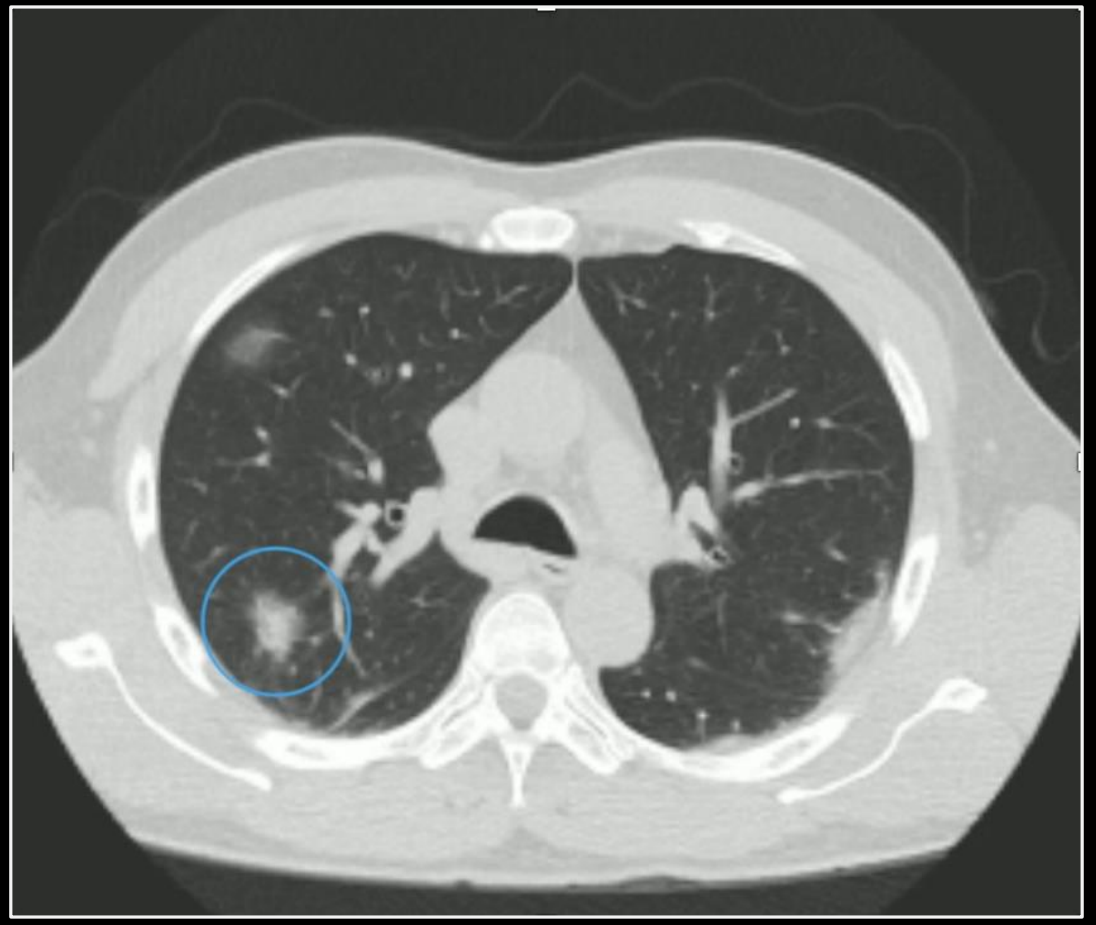
Ground glass opacities

COVID-19 pneumonia



Dense peripheral opacities

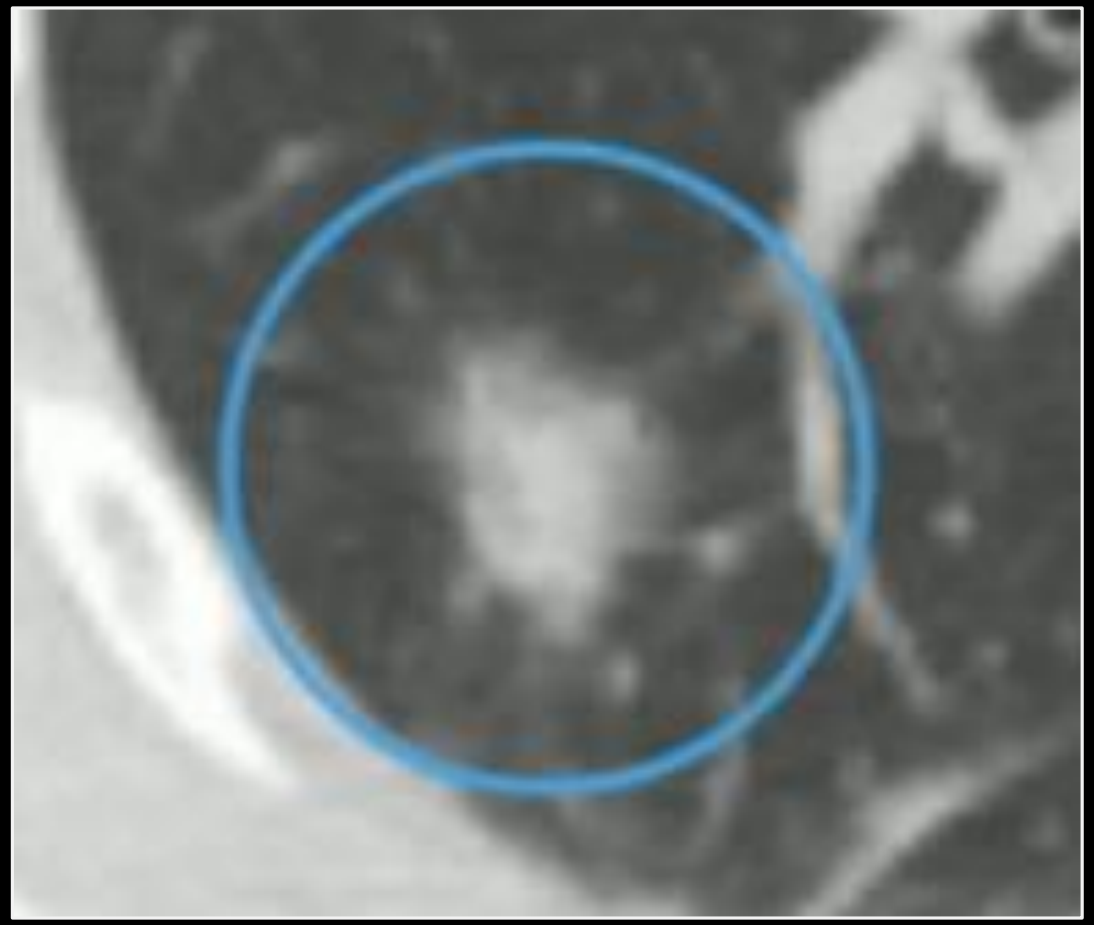
COVID-19 pneumonia

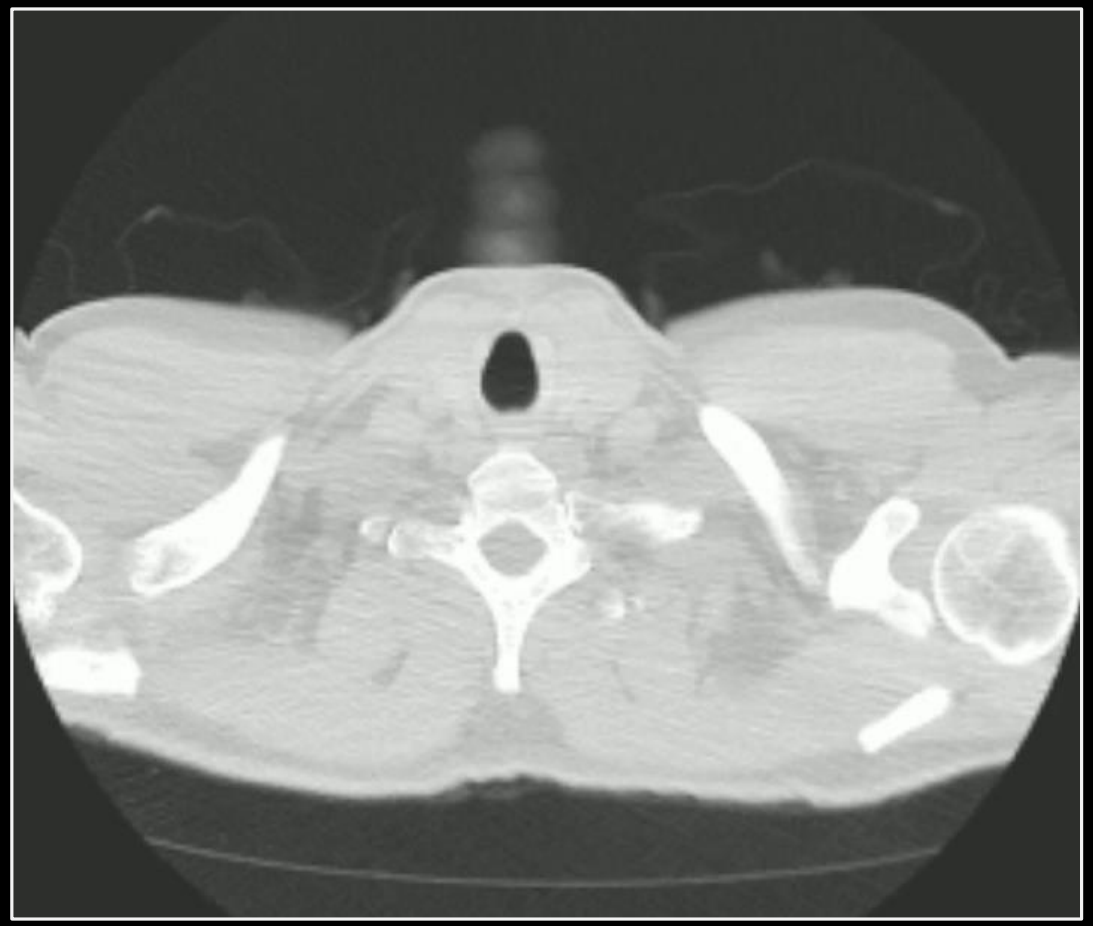


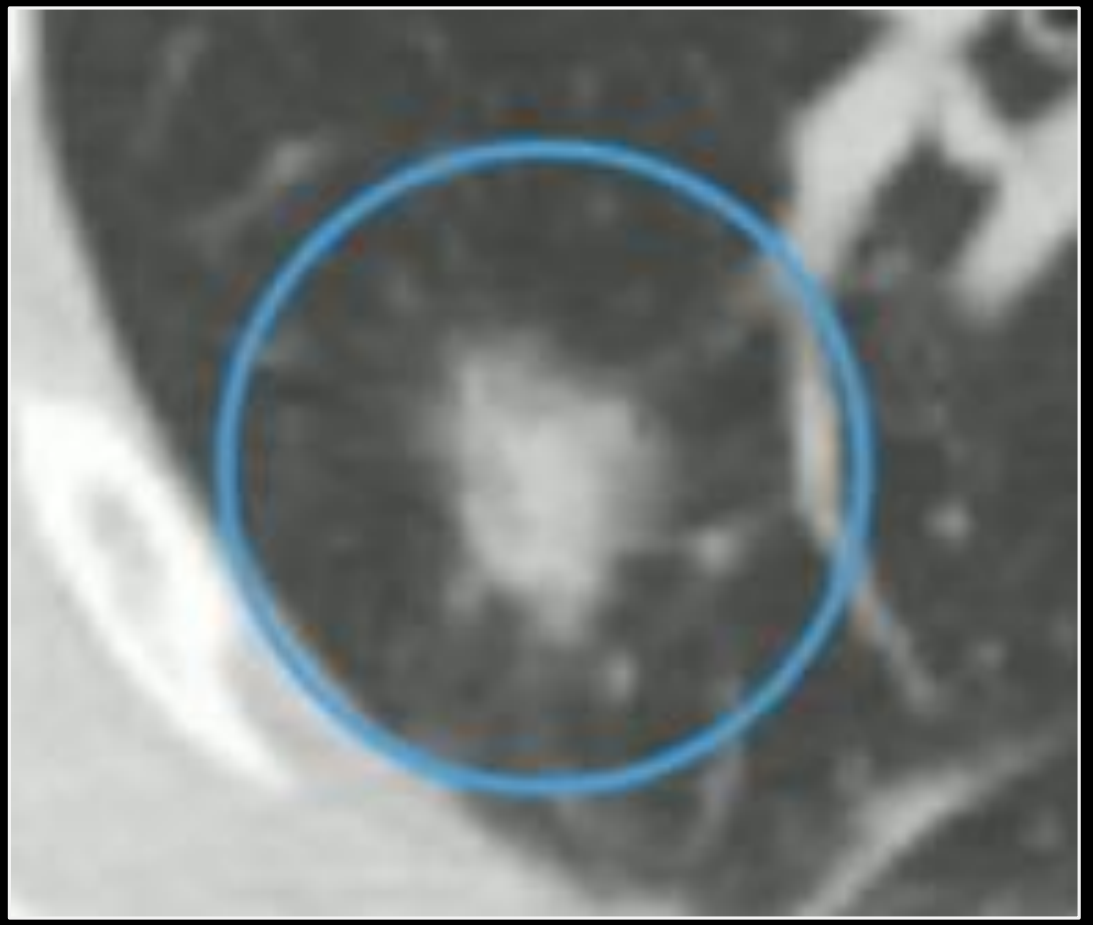
55 M

Dense peripheral opacities

COVID-19 pneumonia

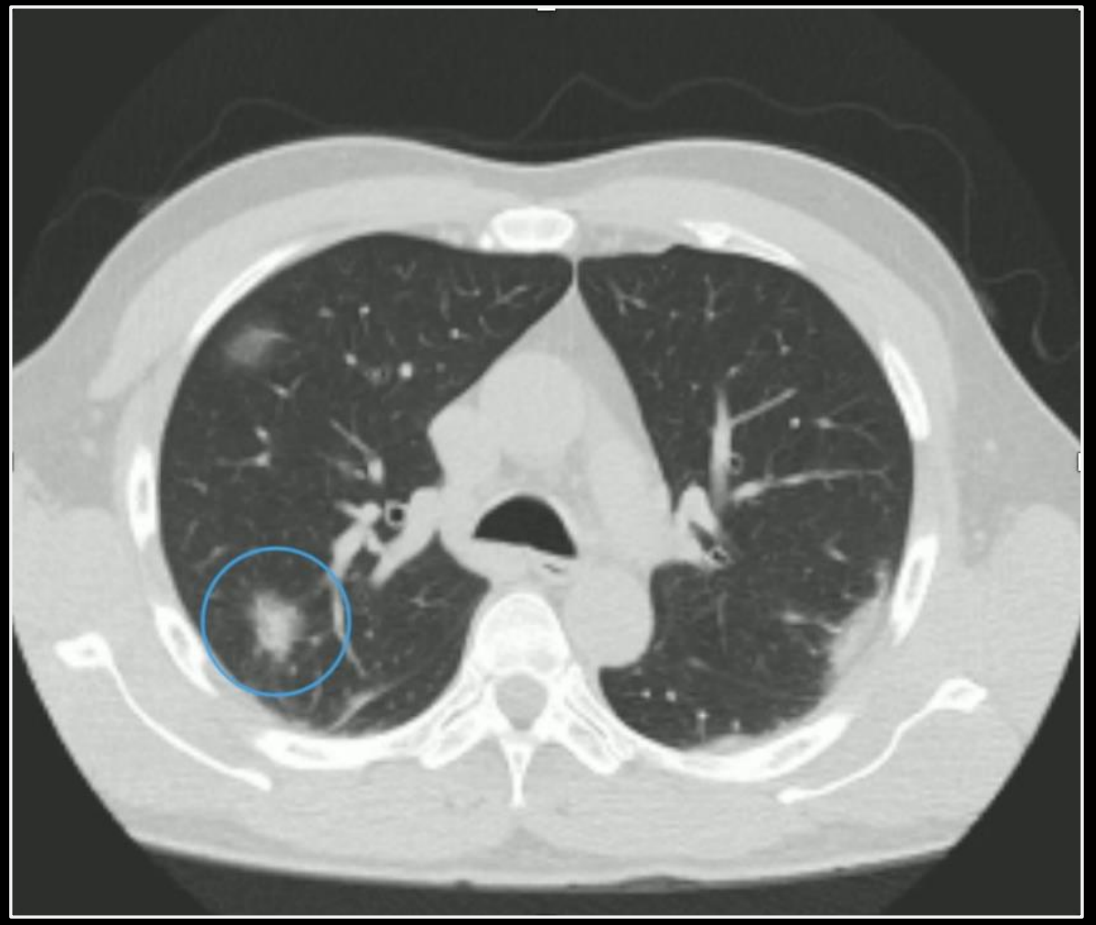






Dense peripheral opacities

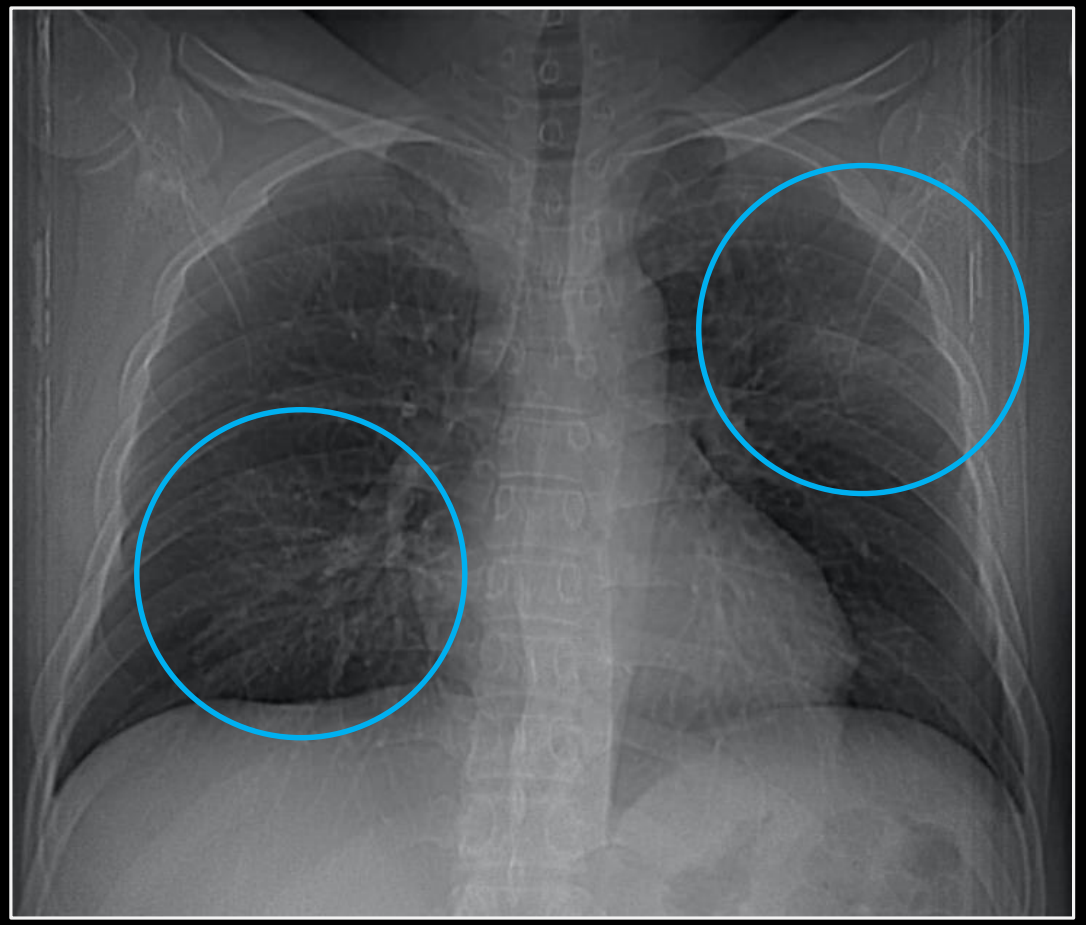
COVID-19 pneumonia



Ground glass opacity

Crazy paving

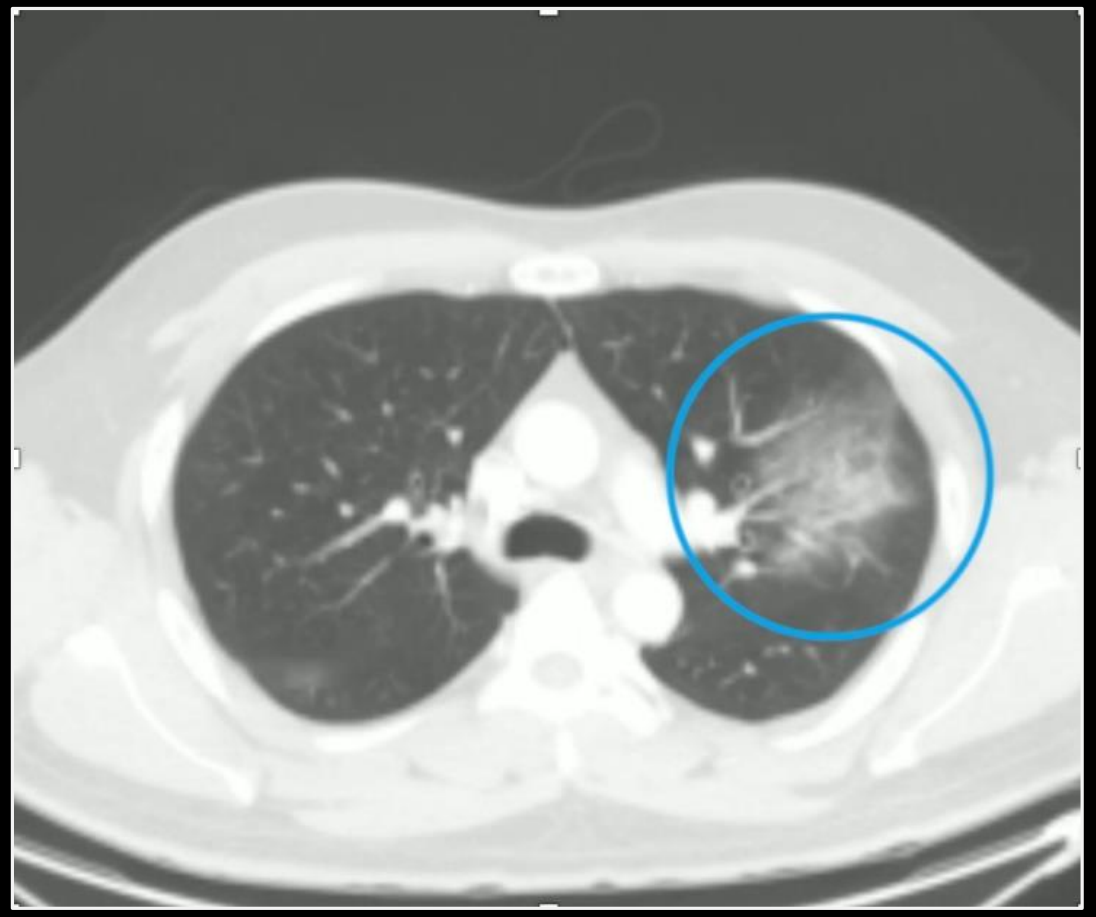
COVID-19 pneumonia



35 M

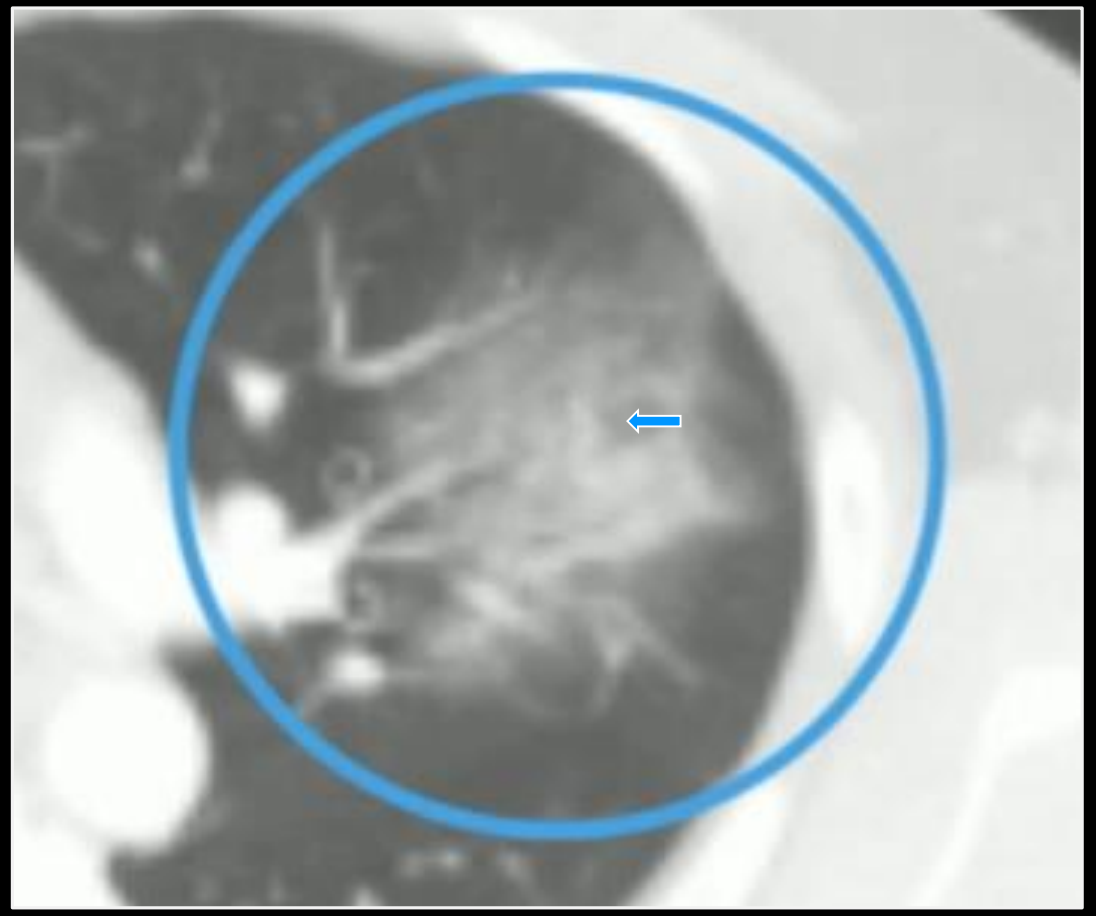
Ground glass opacity
Crazy paving

COVID-19 pneumonia



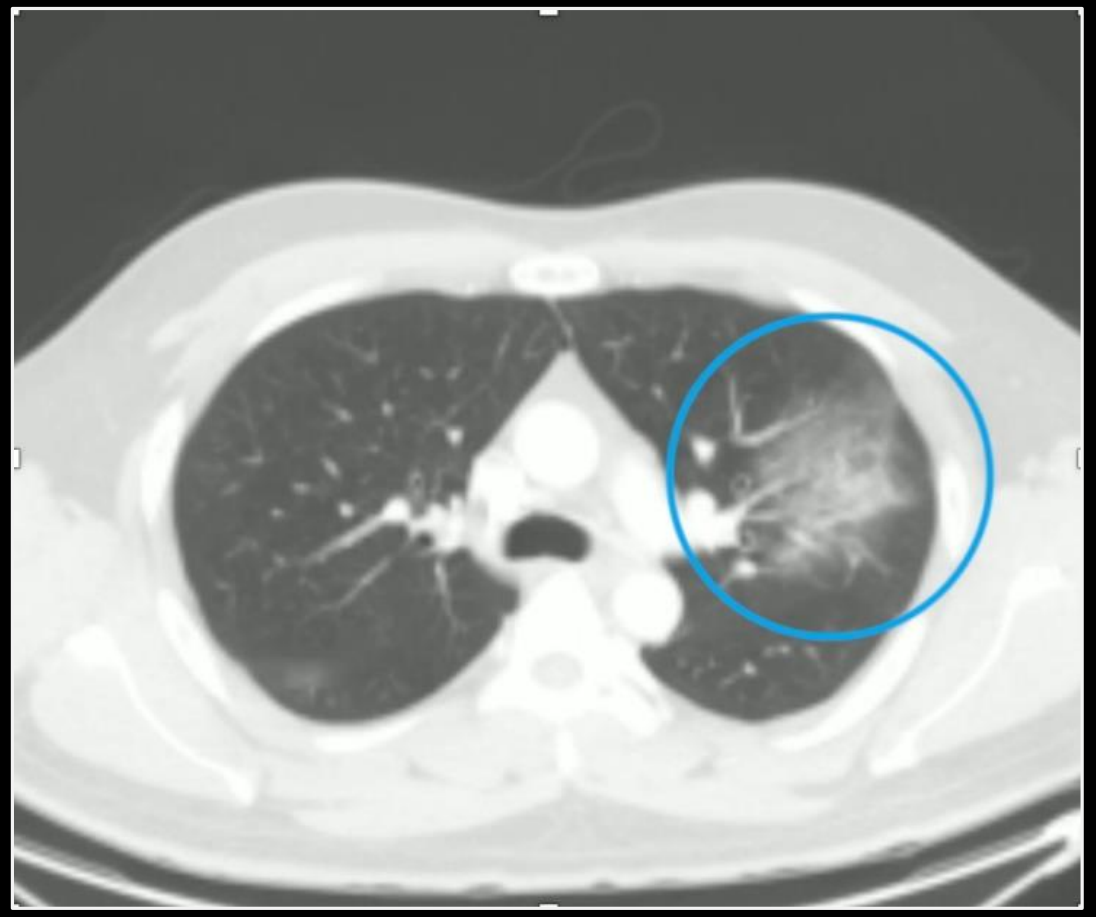
Ground glass opacity
Crazy paving

COVID-19 pneumonia



Ground glass opacity
Crazy paving

COVID-19 pneumonia



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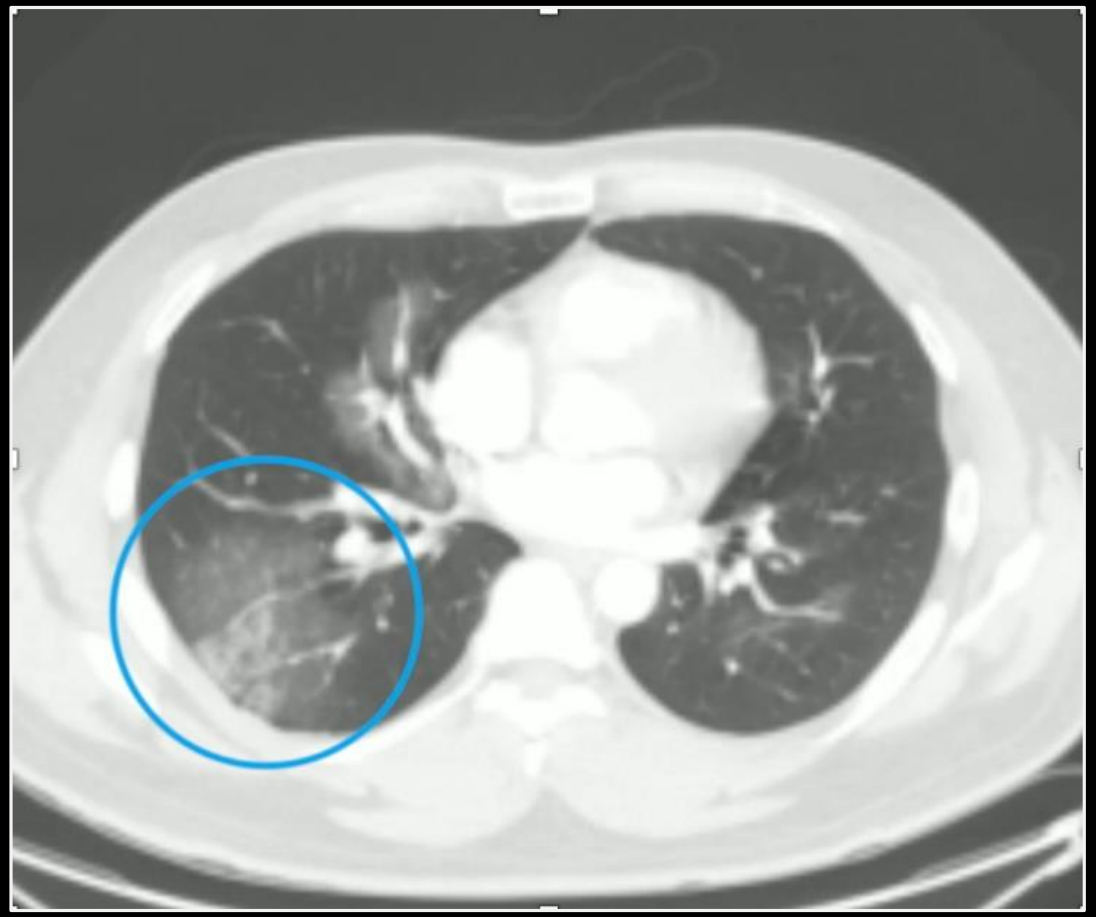
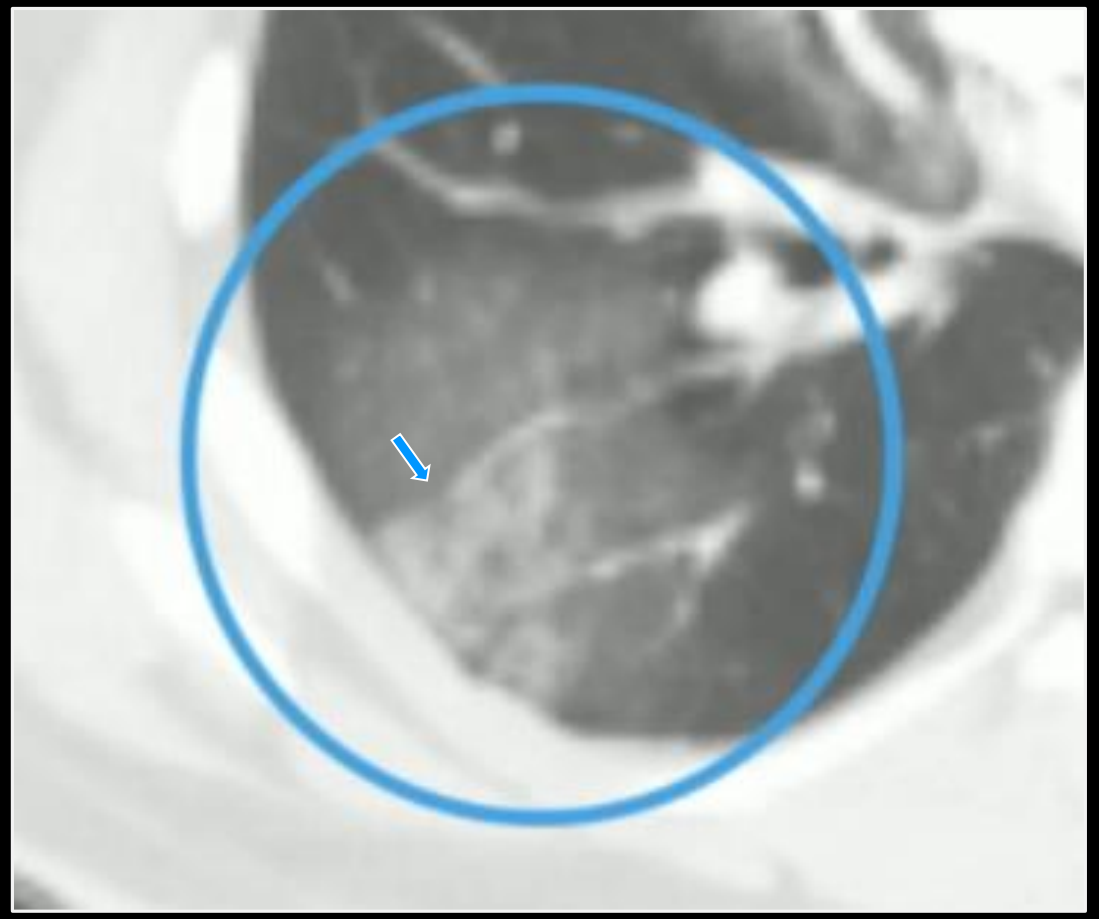
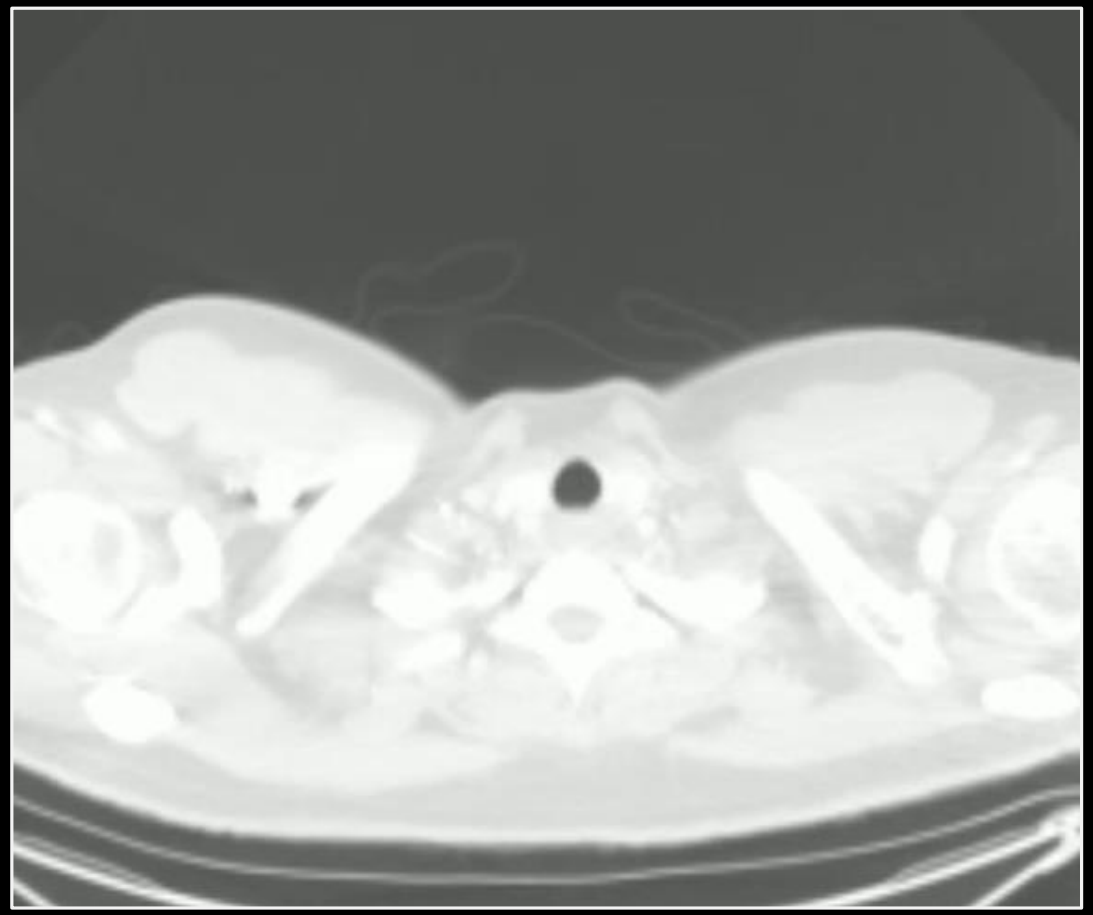
COVID-19 pneumonia

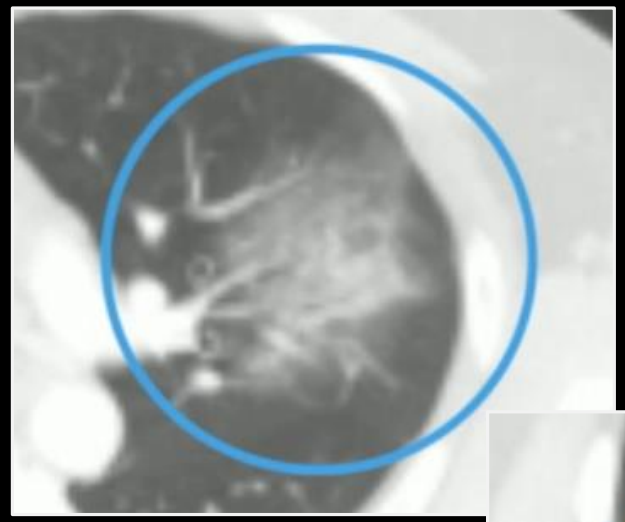


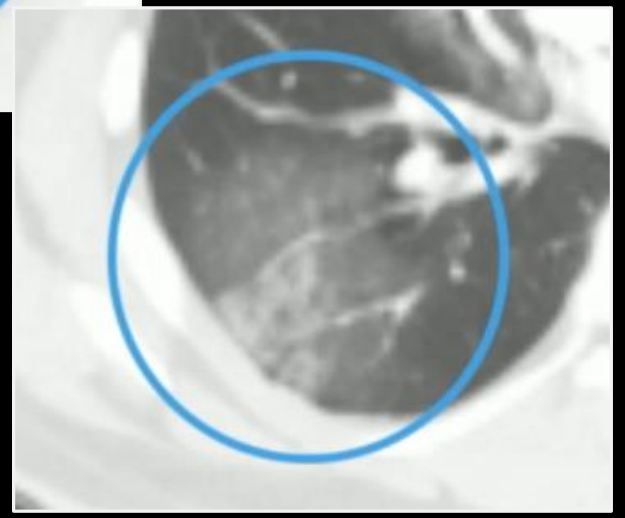
Ground glass opacity
Crazy paving

COVID-19 pneumonia









Ground glass opacity
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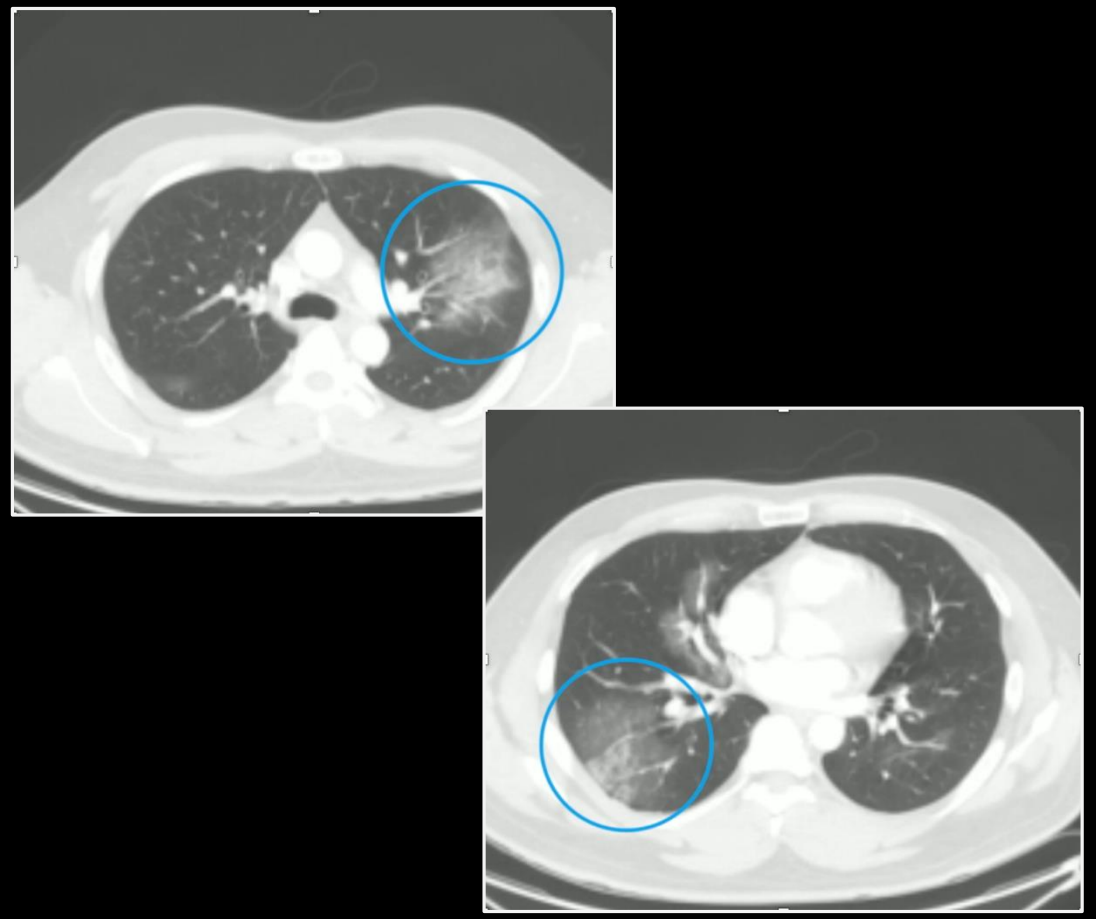
COVID-19 pneumonia



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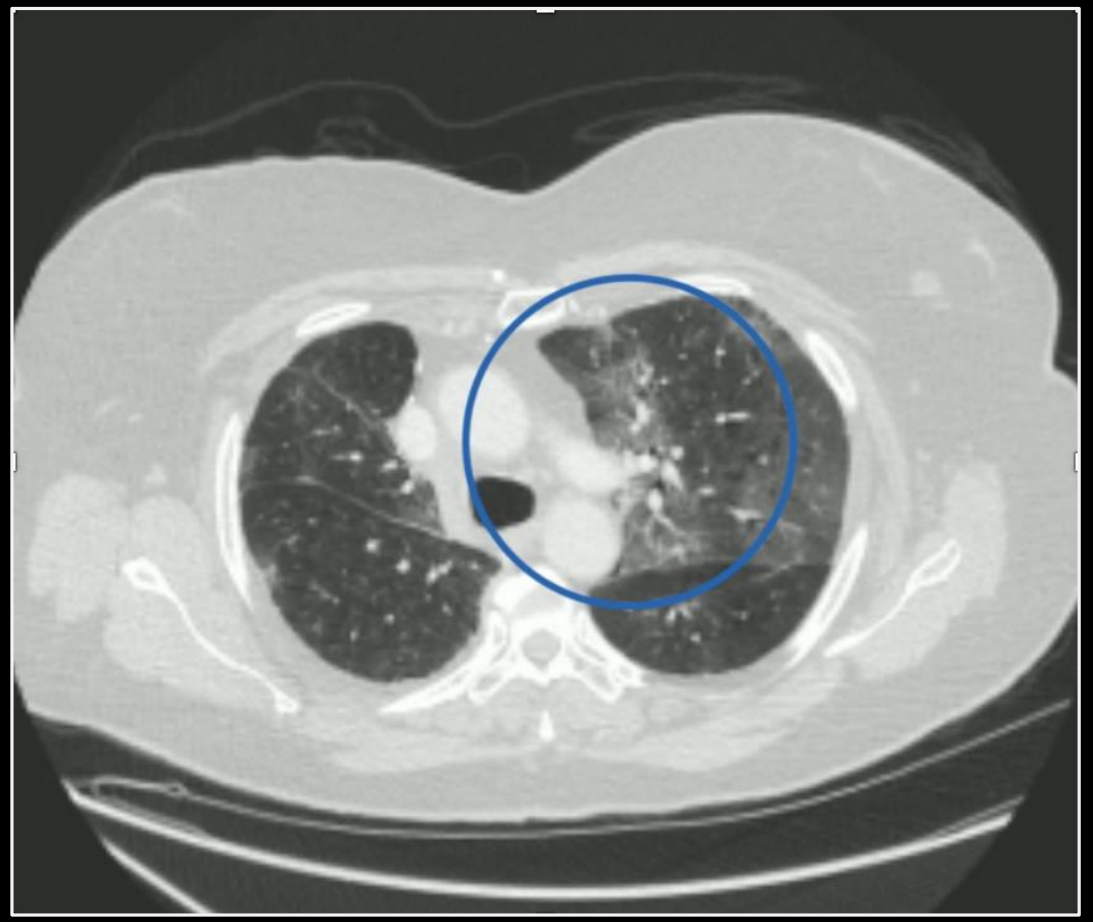
Crazy paving

COVID-19 pneumonia



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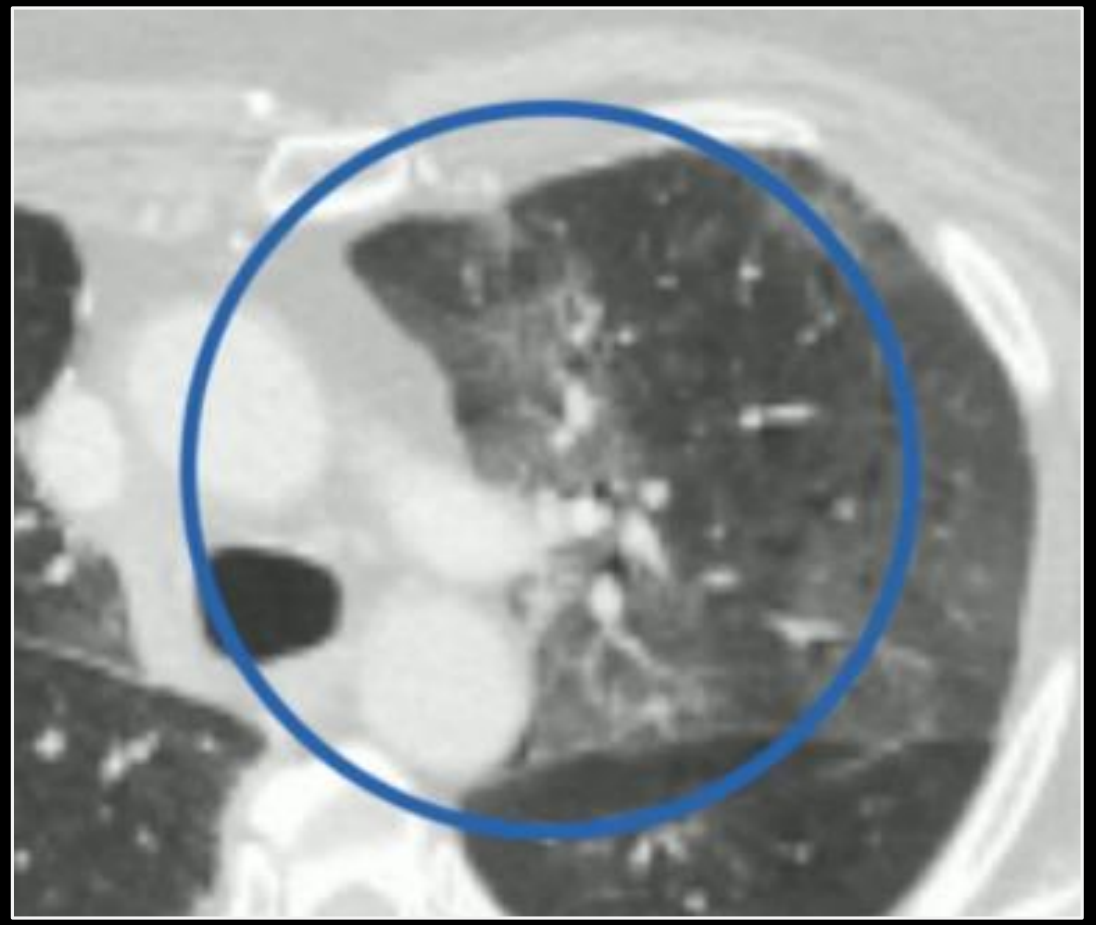
Ground glass opacity

Crazy paving

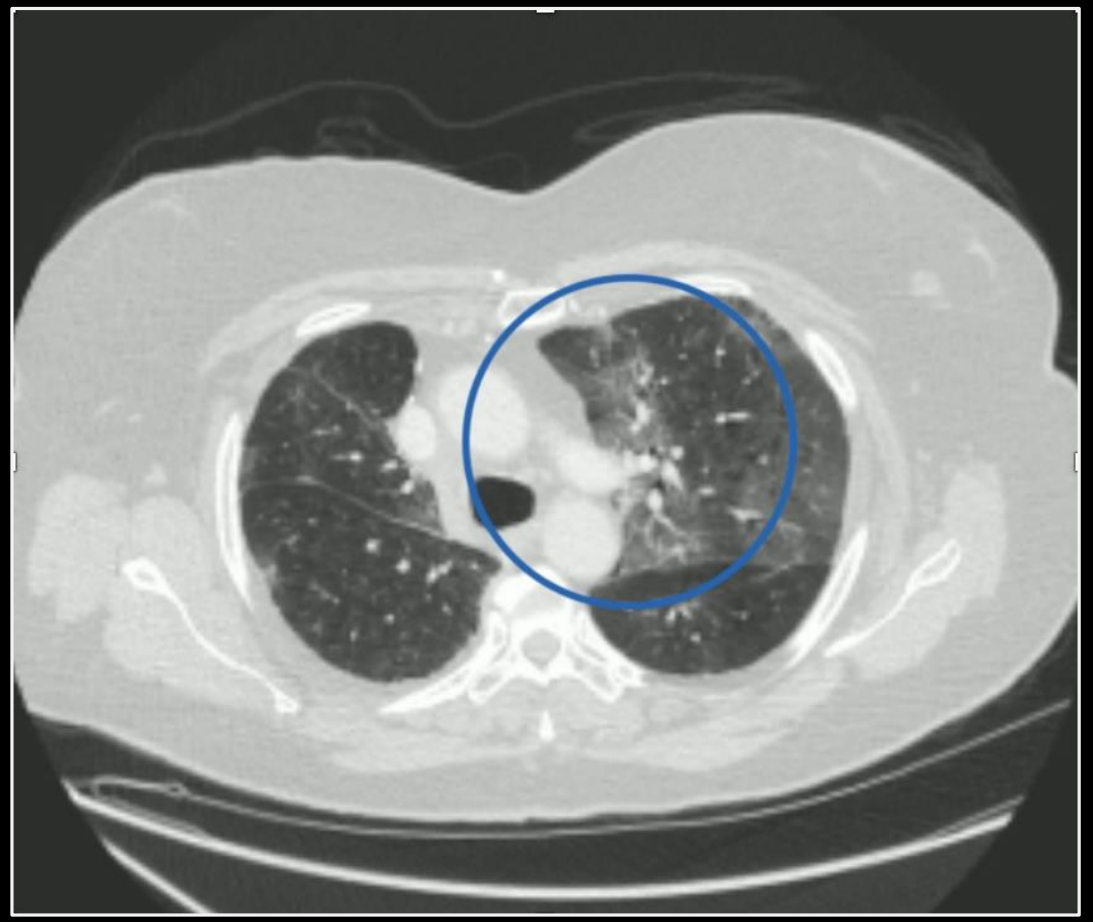
COVID-19 pneumonia



Ground glass opacity

Crazy paving

COVID-19 pneumonia



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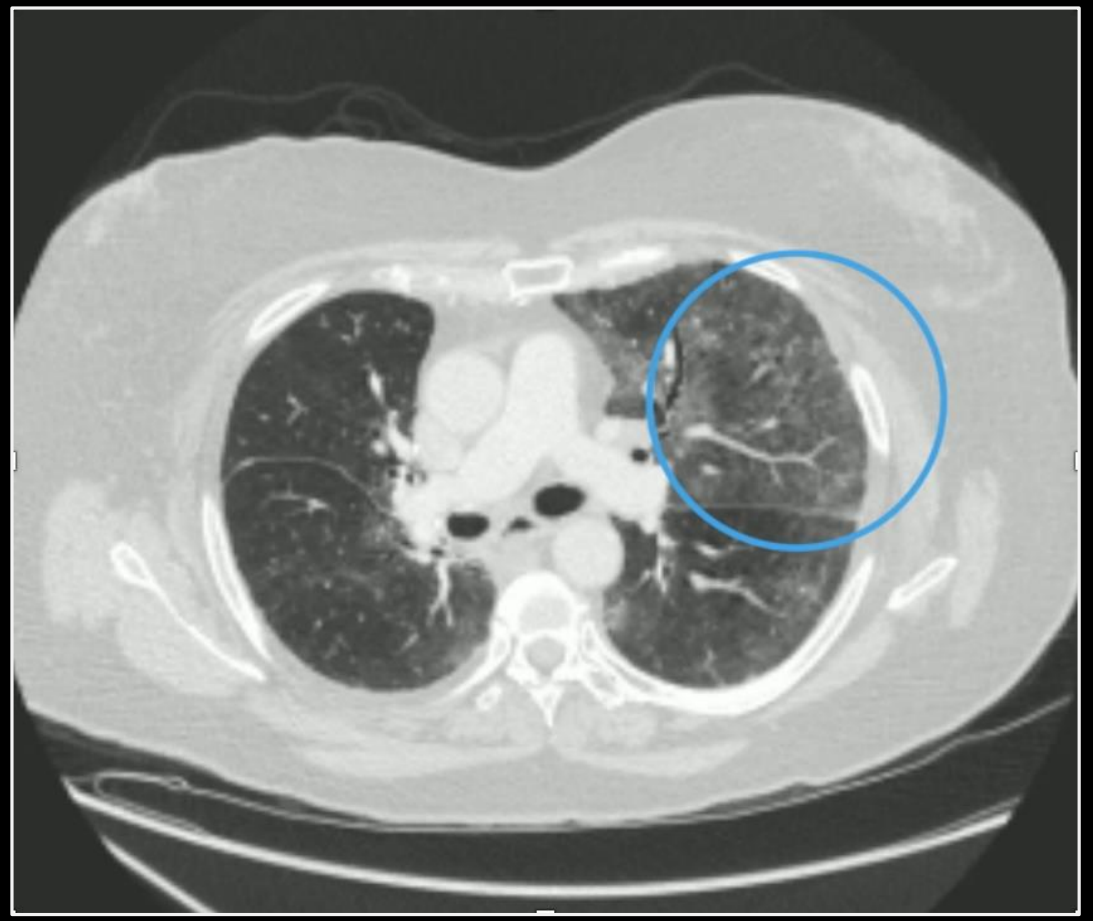
COVID-19 pneumonia



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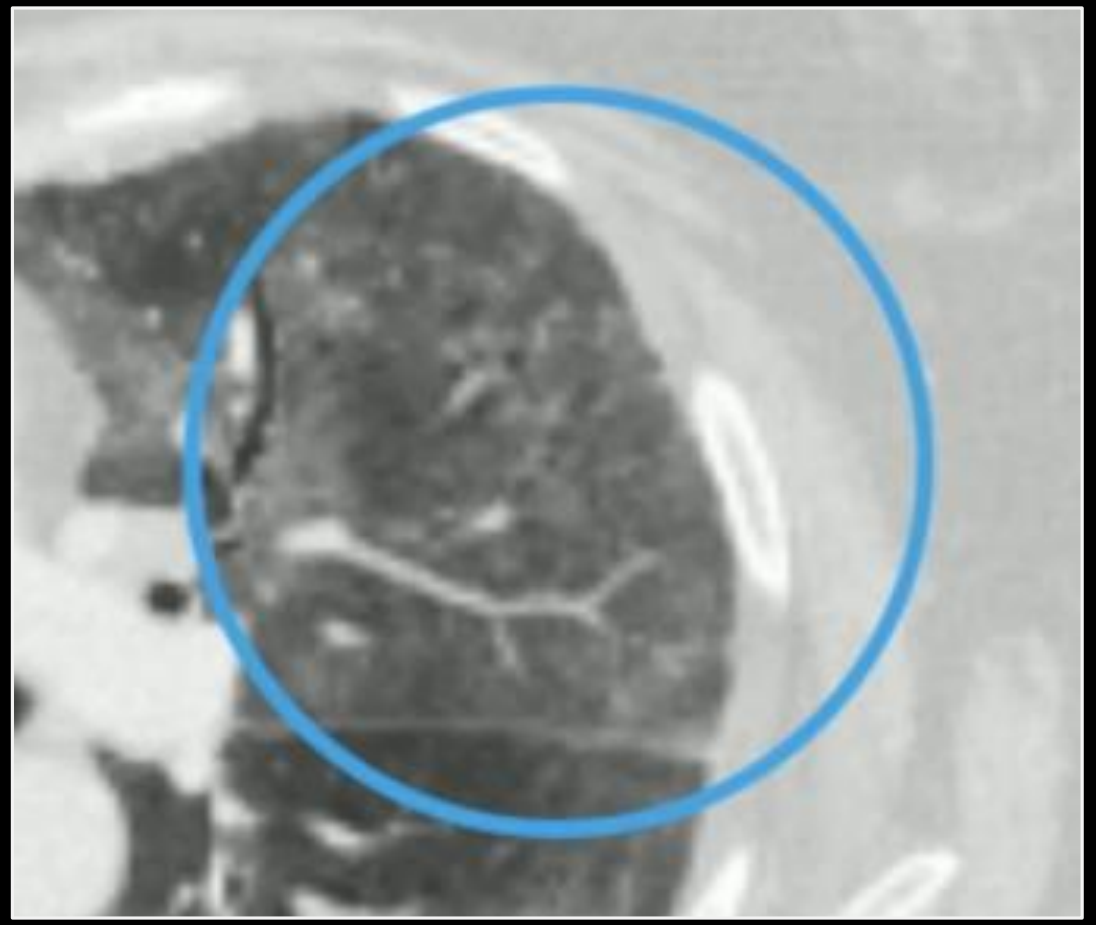
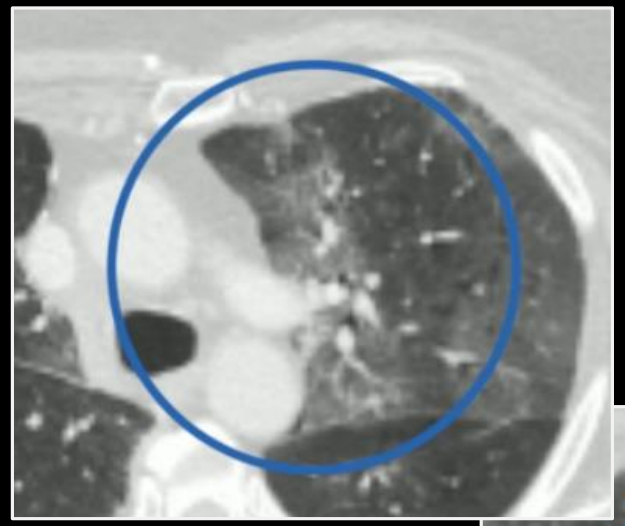
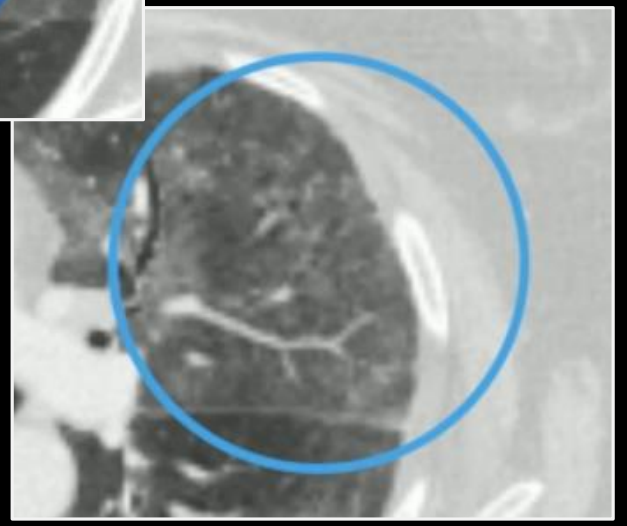
COVID-19 pneumonia

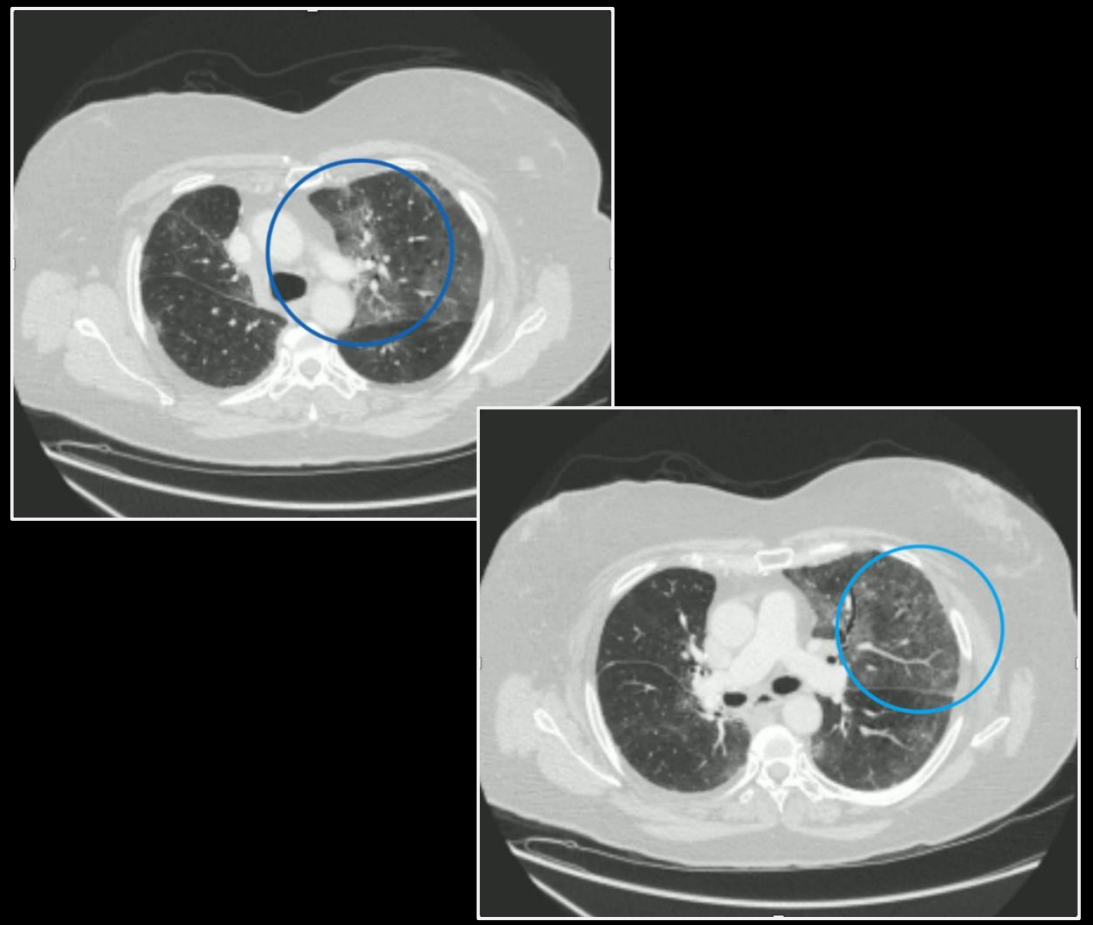






Ground glass opacity
Crazy paving

COVID-19 pneumonia



Ground glass opacity

Crazy paving

COVID-19 pneumonia

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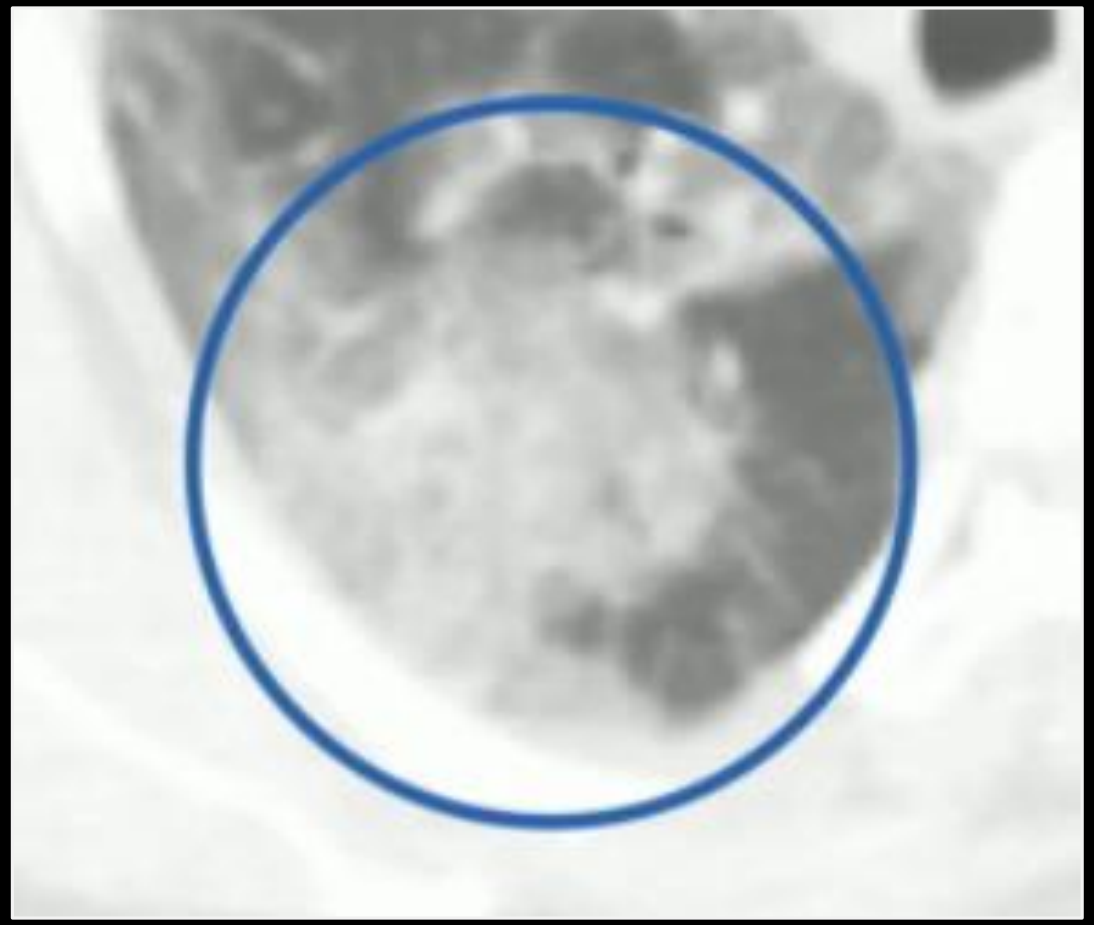
Ground glass opacity

Crazy paving

COVID-19 pneumonia



Ground glass opacity

Crazy paving

COVID-19 pneumonia

Ground glass opacity

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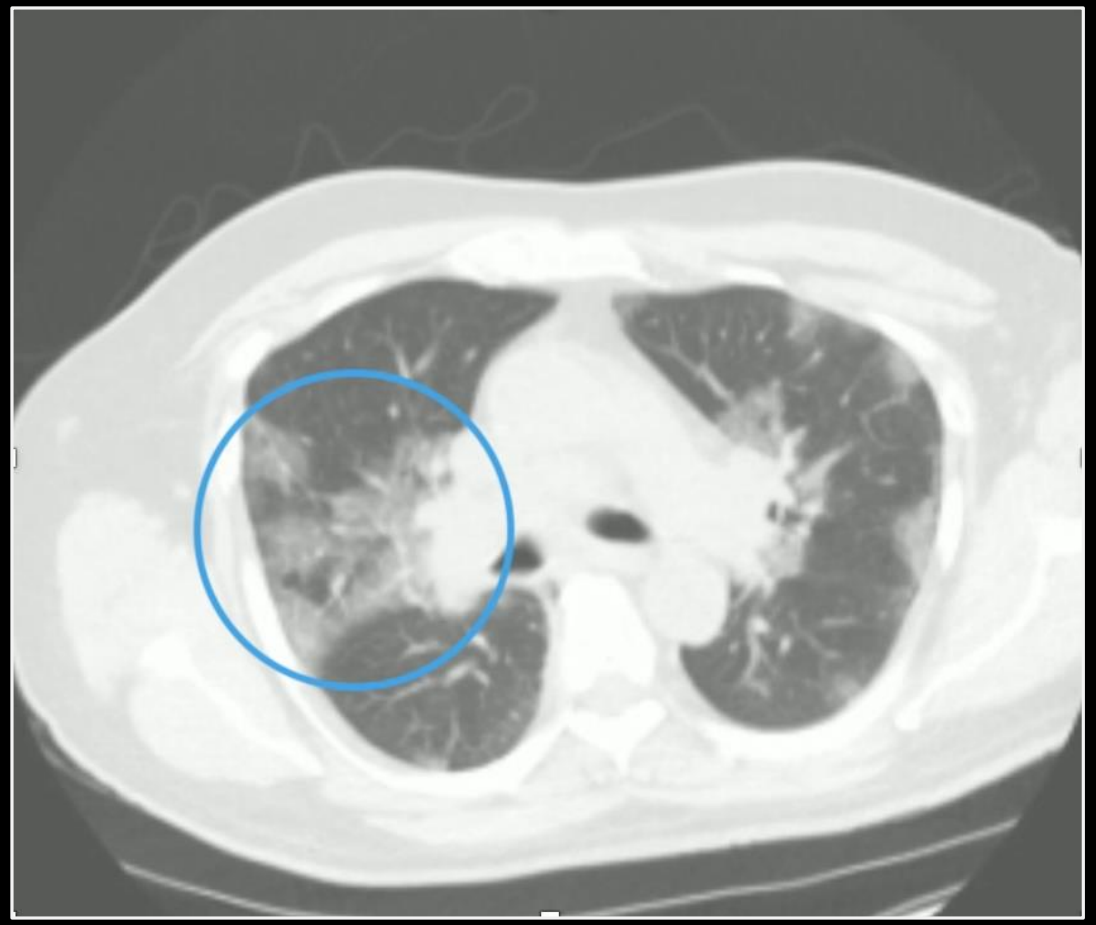
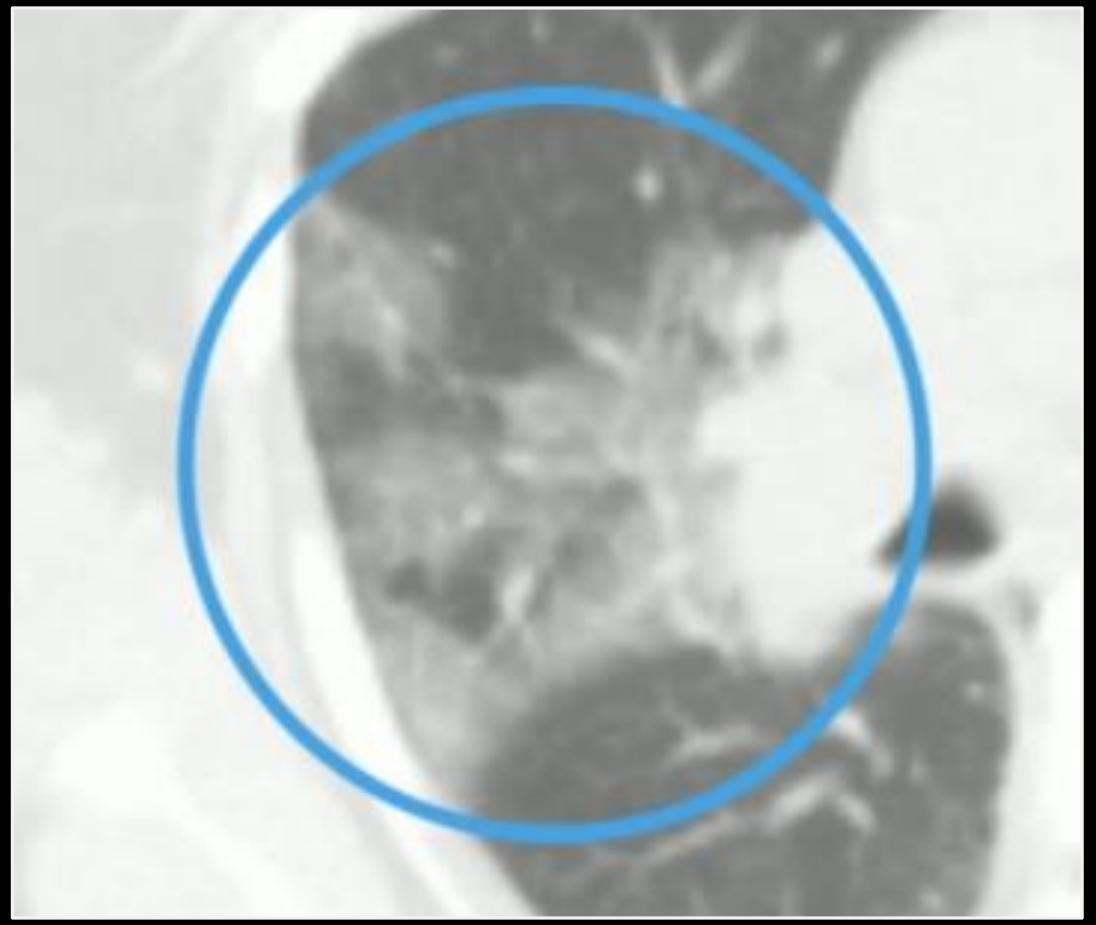
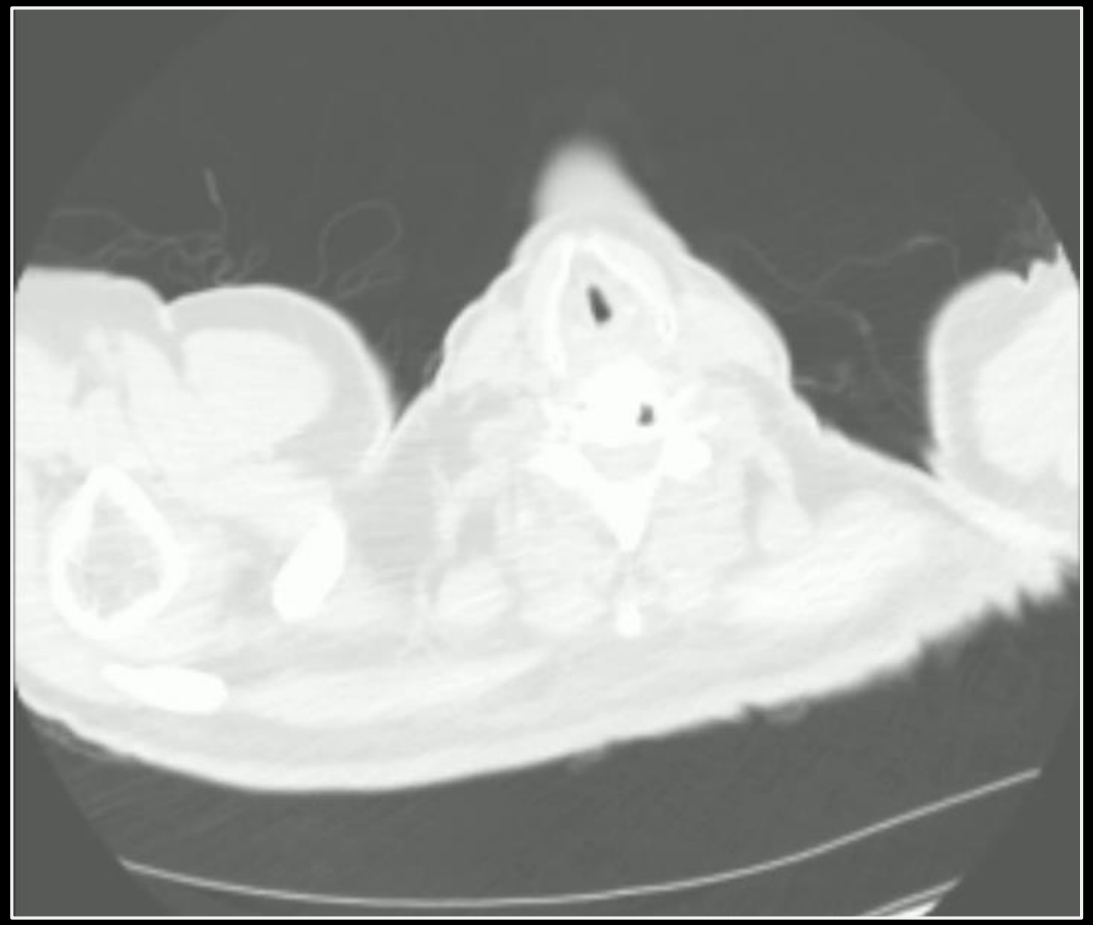


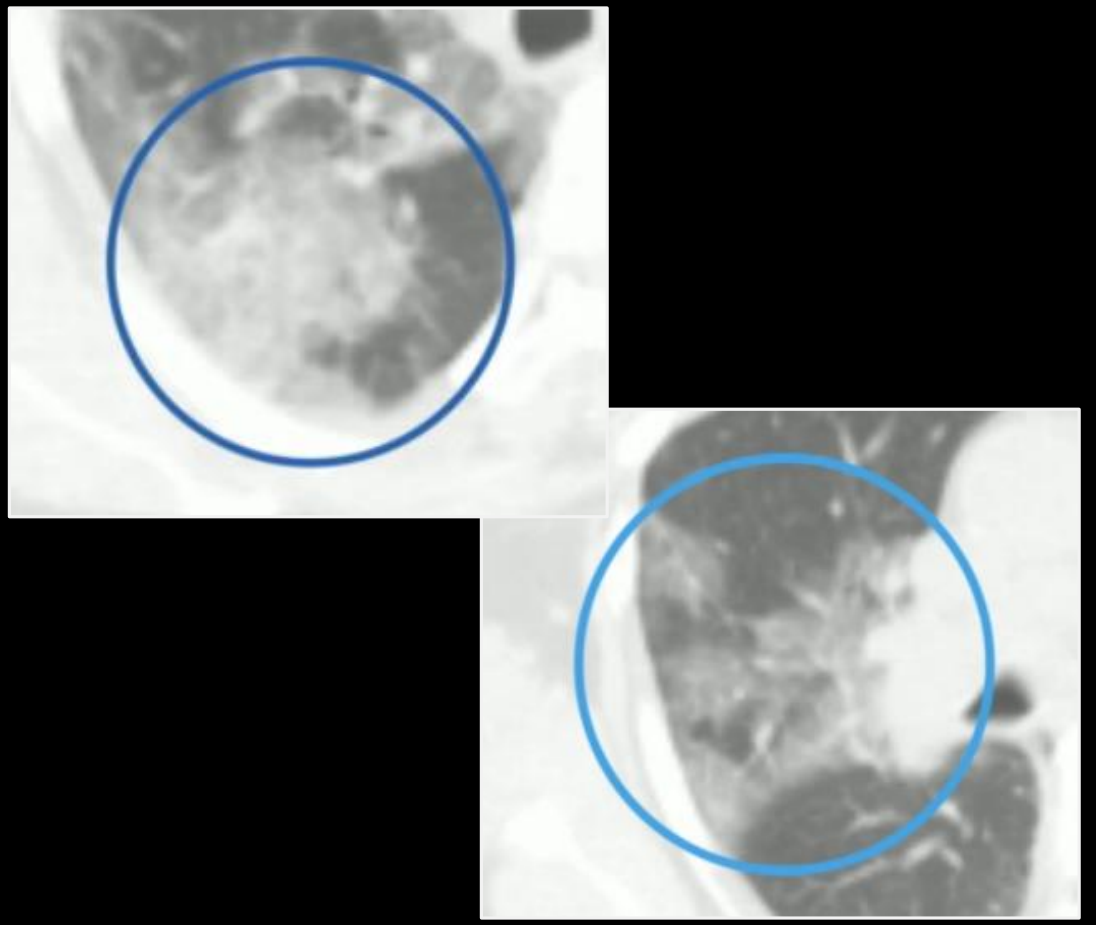
Ground glass opacity

Crazy paving

COVID-19 pneumonia

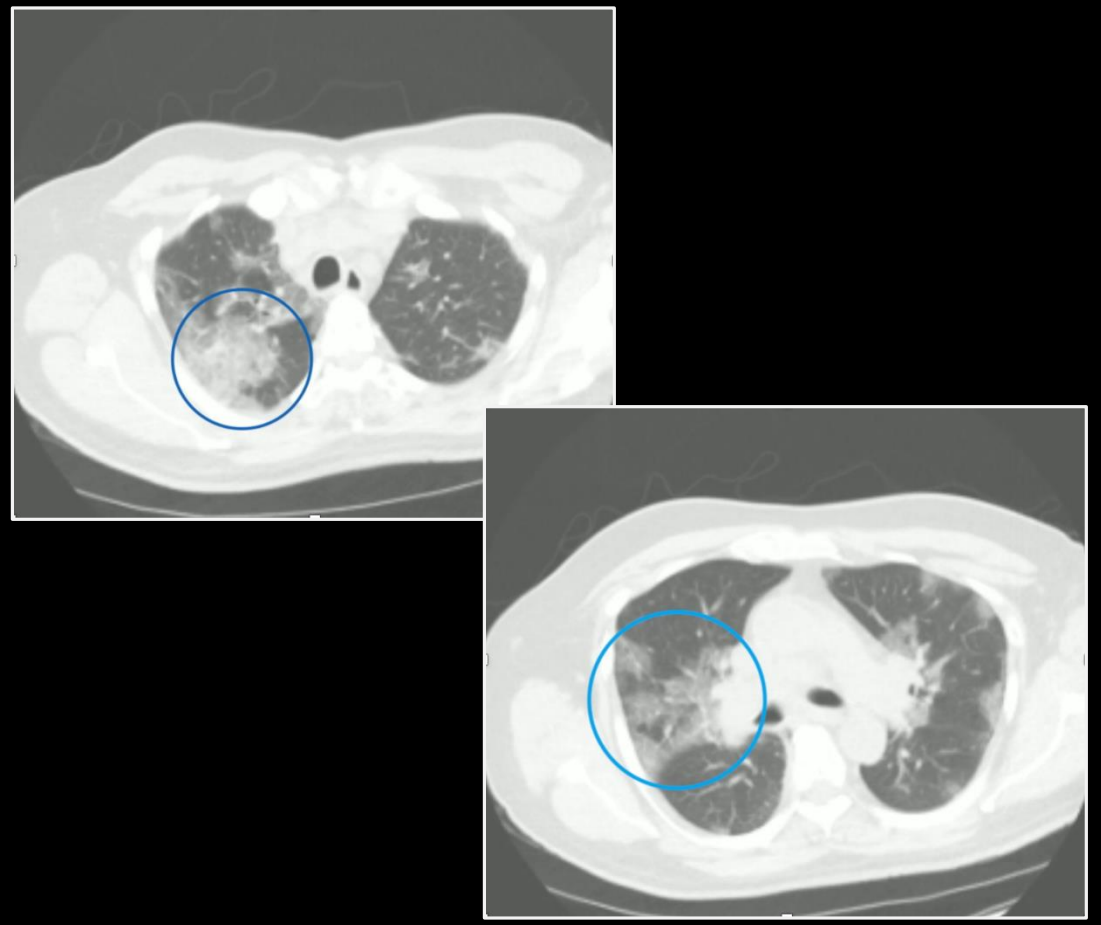






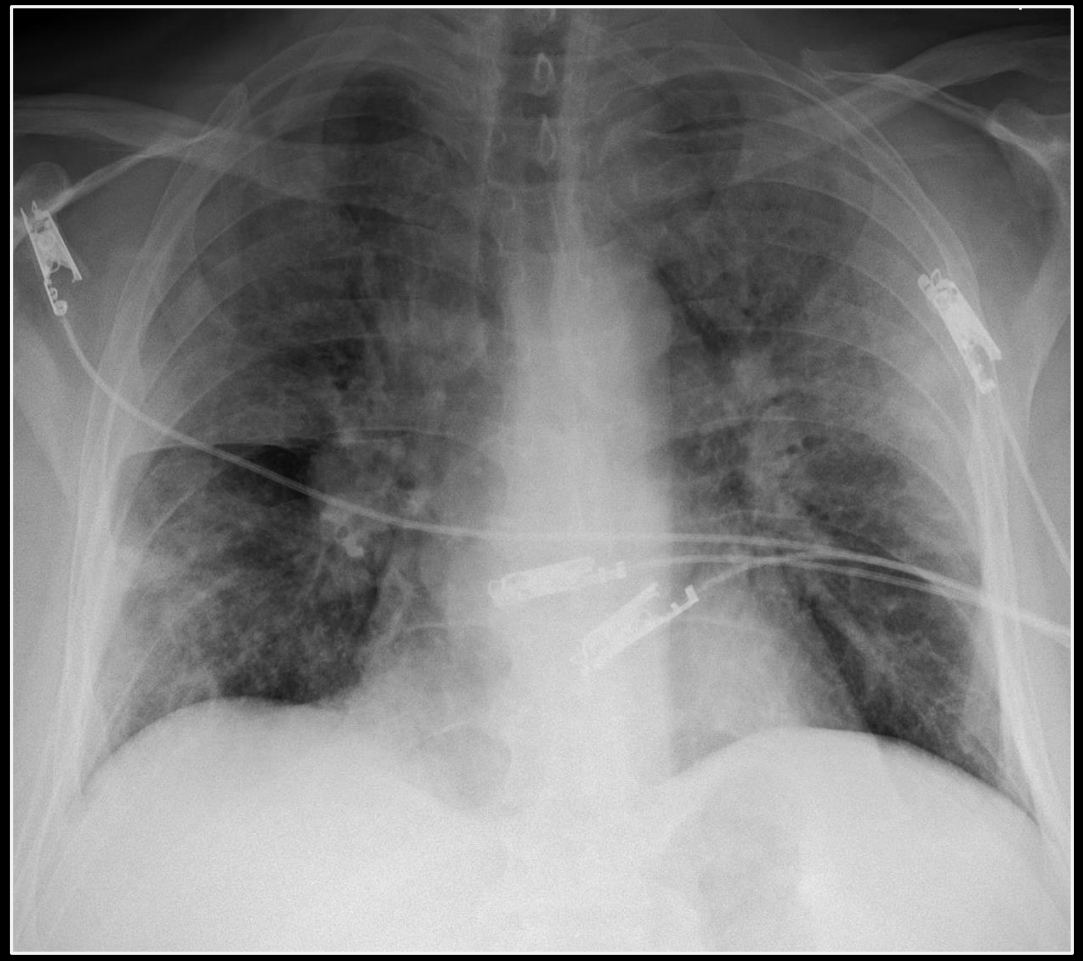
Ground glass opacity
Crazy paving

COVID-19 pneumonia



Ground glass opacity
Crazy paving
Consolidation

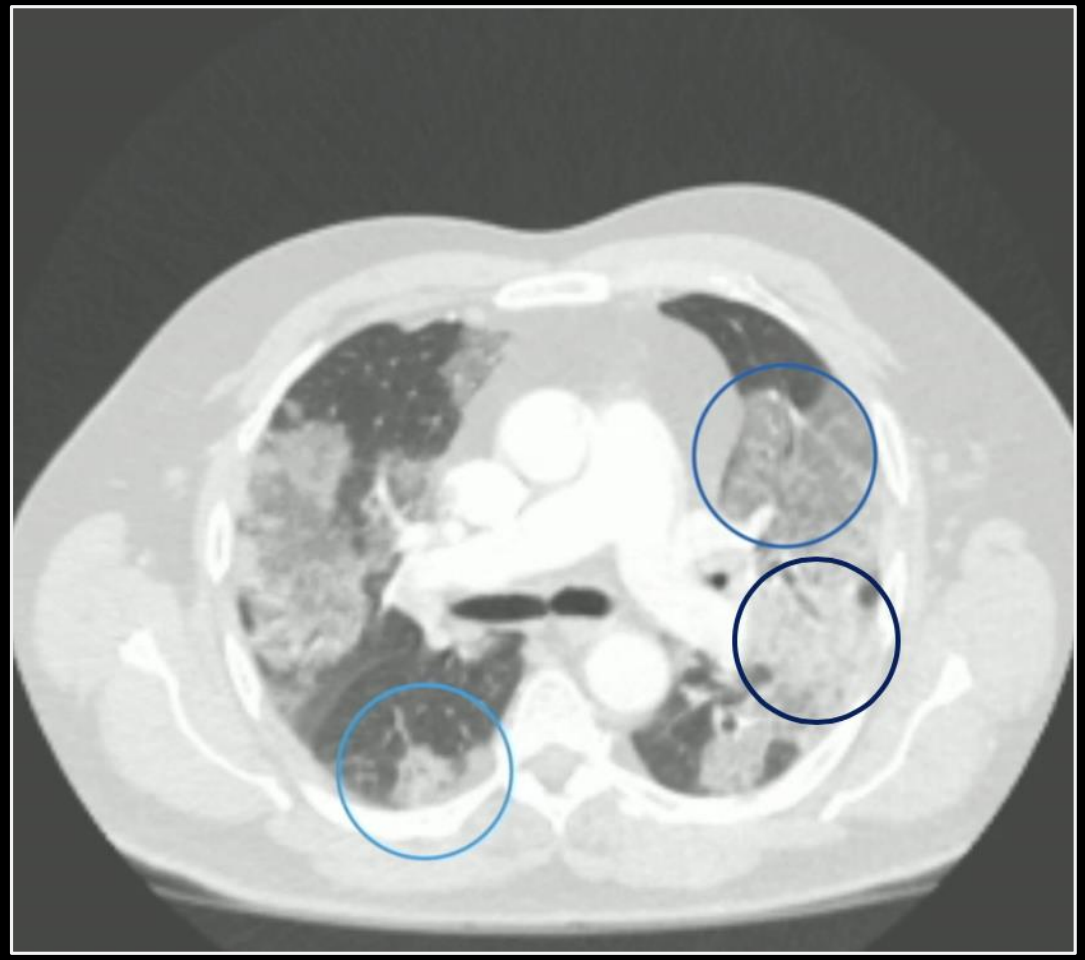
COVID-19 pneumonia



64 M

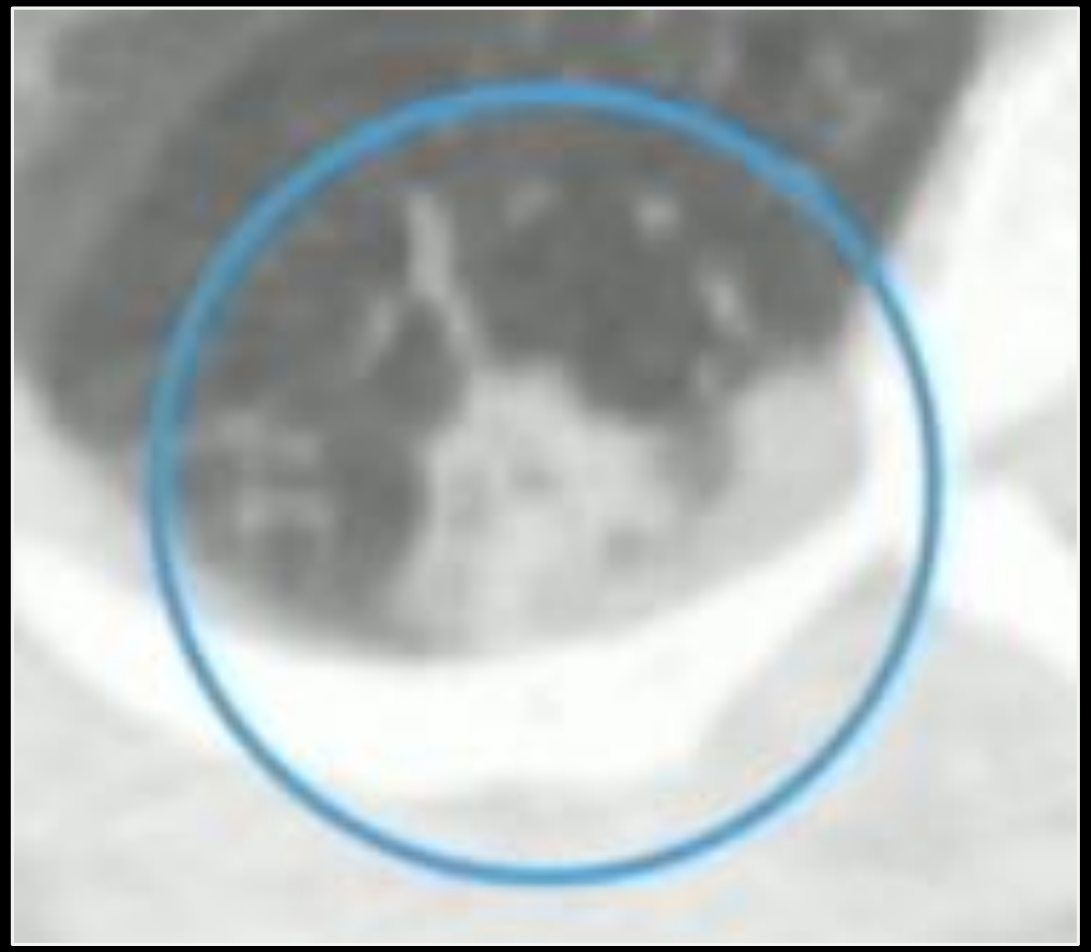
Ground glass opacity
Crazy paving
Consolidation

COVID-19 pneumonia



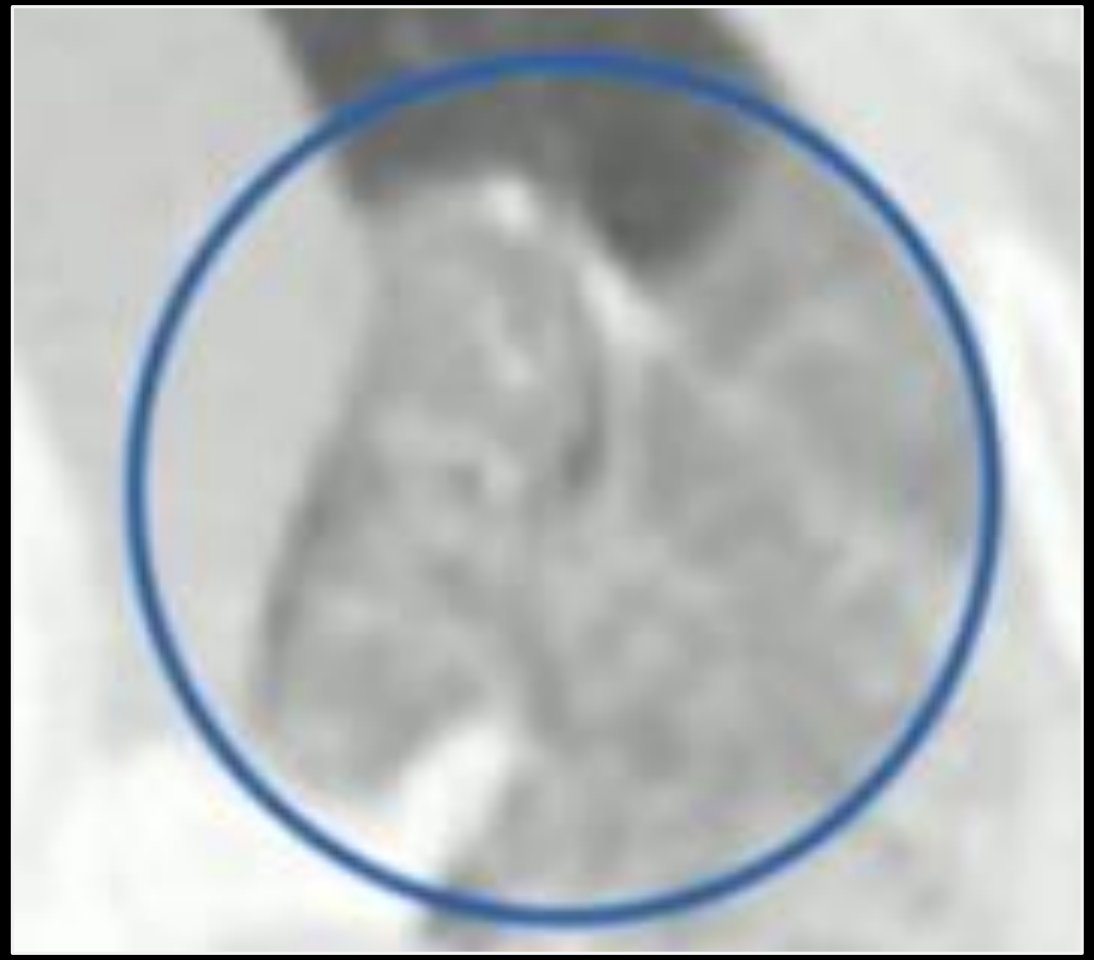
Ground glass opacity
Crazy paving
Consolidation

COVID-19 pneumonia



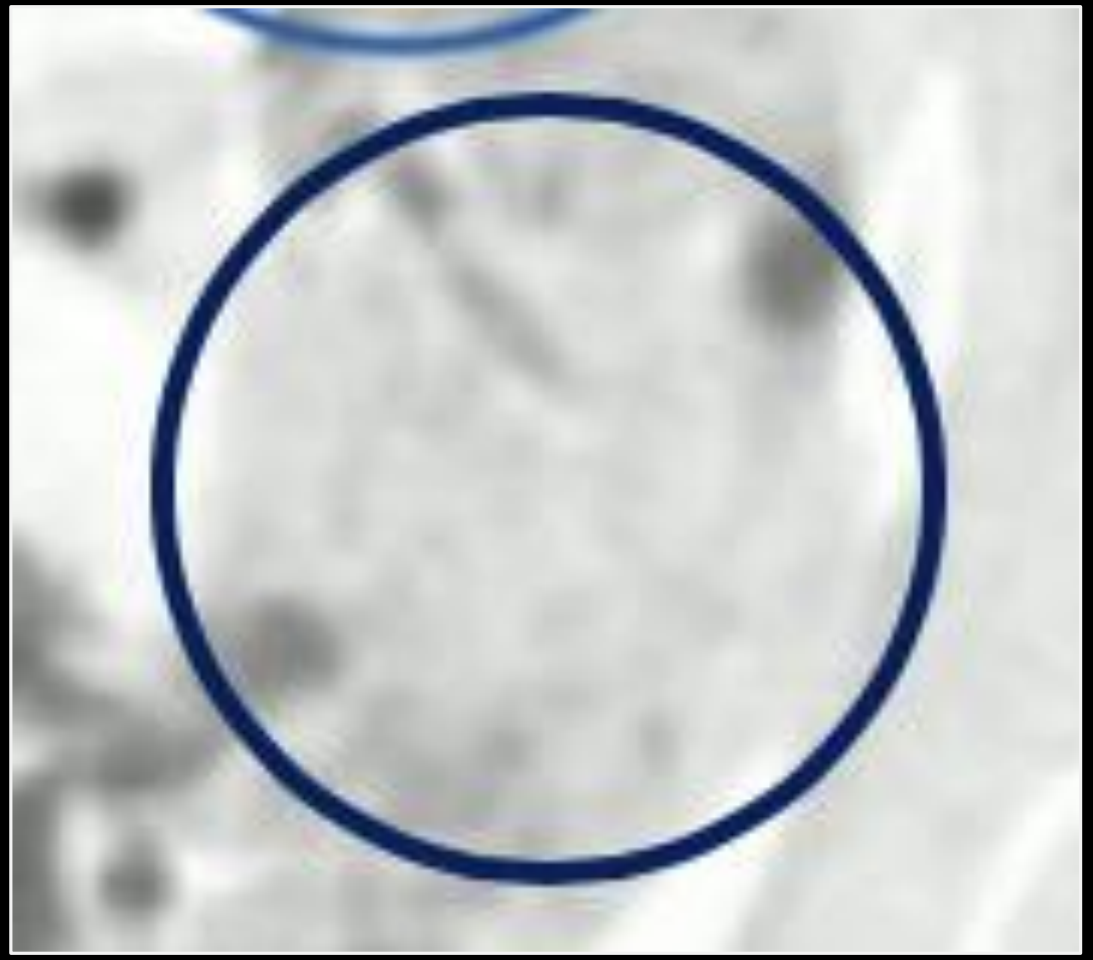
Ground glass opacity
Crazy paving
Consolidation

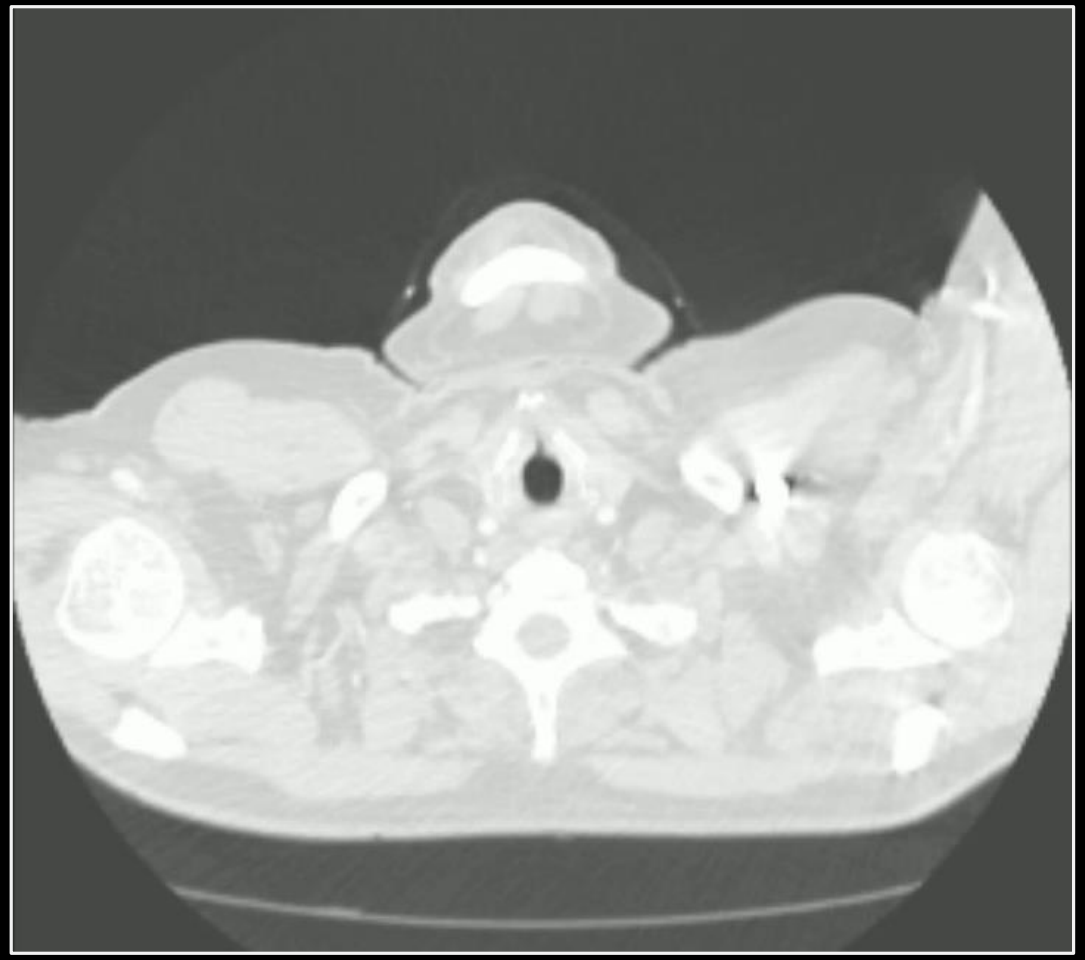
COVID-19 pneumonia

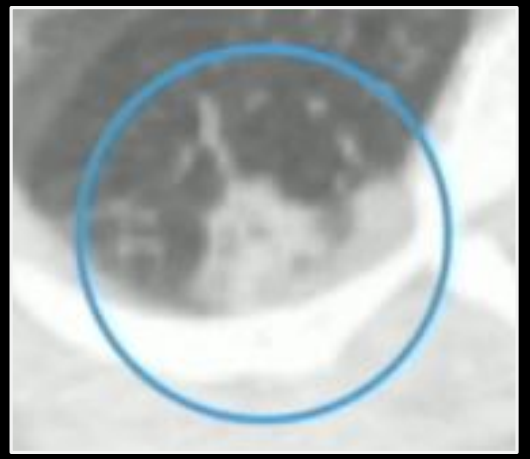


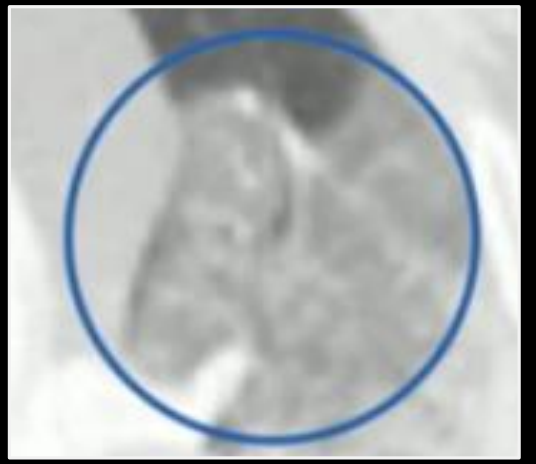
Ground glass opacity
Crazy paving
Consolidation

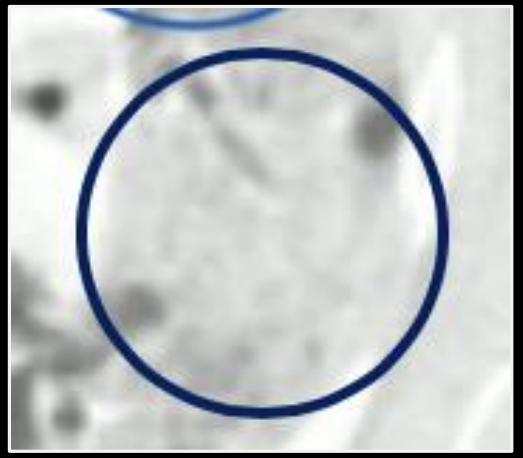
COVID-19 pneumonia





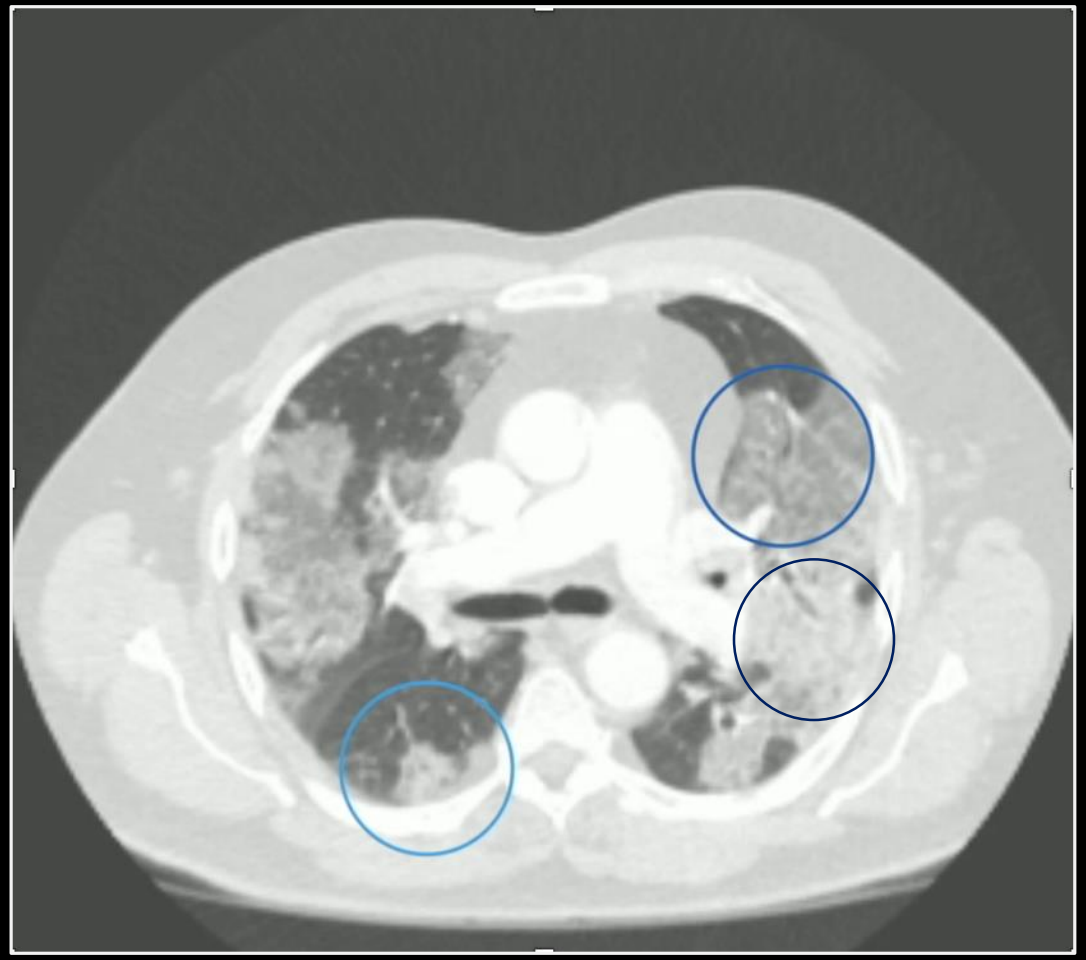






Ground glass opacity
Crazy paving
Consolidation

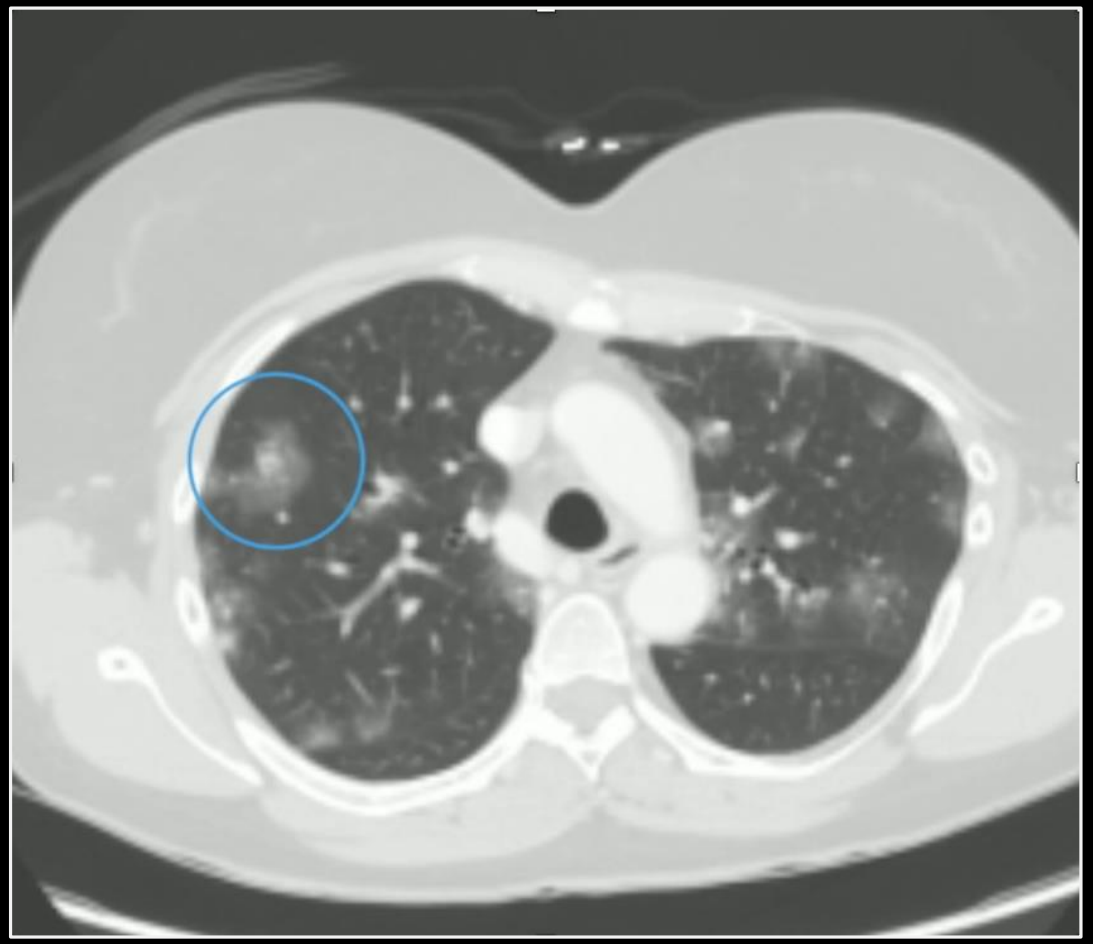
COVID-19 pneumonia



Ground glass opacity

Crazy paving

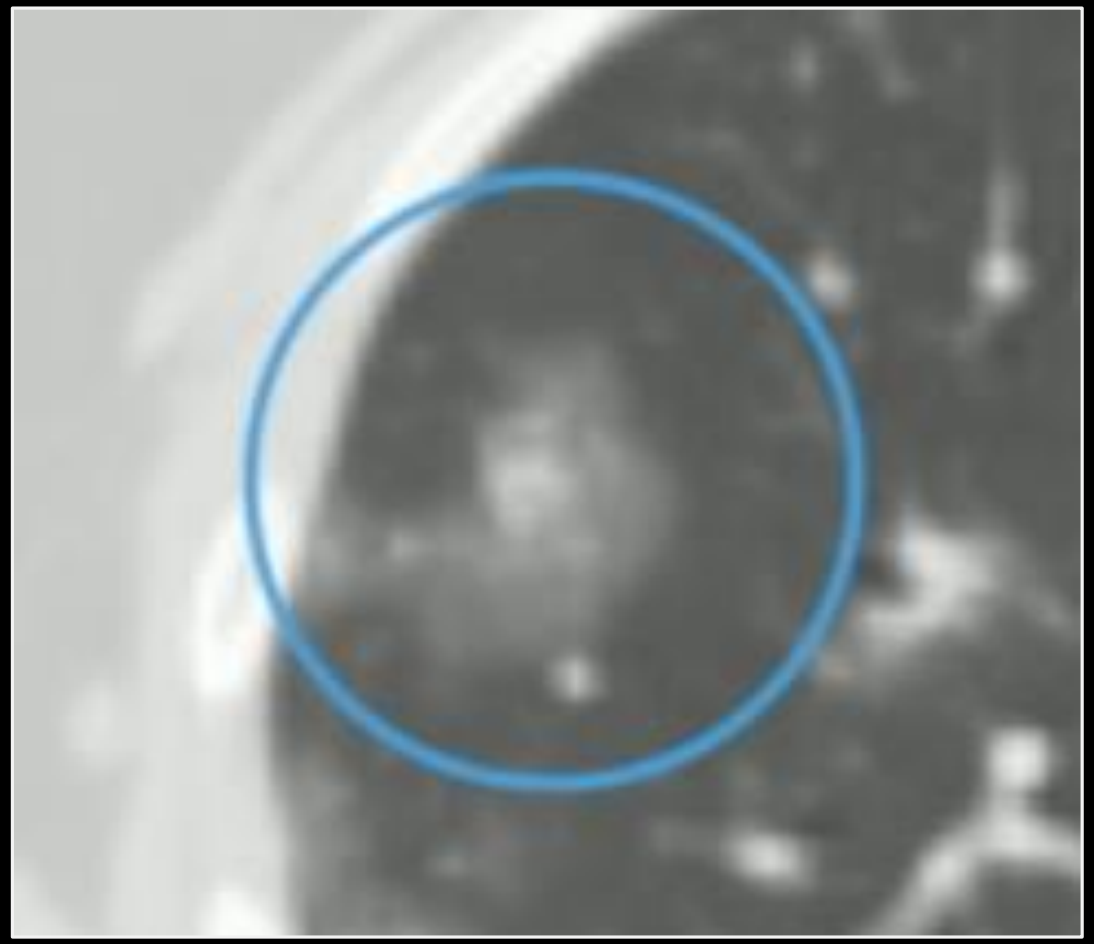
Influenza A pneumonia



Ground glass opacity

Crazy paving

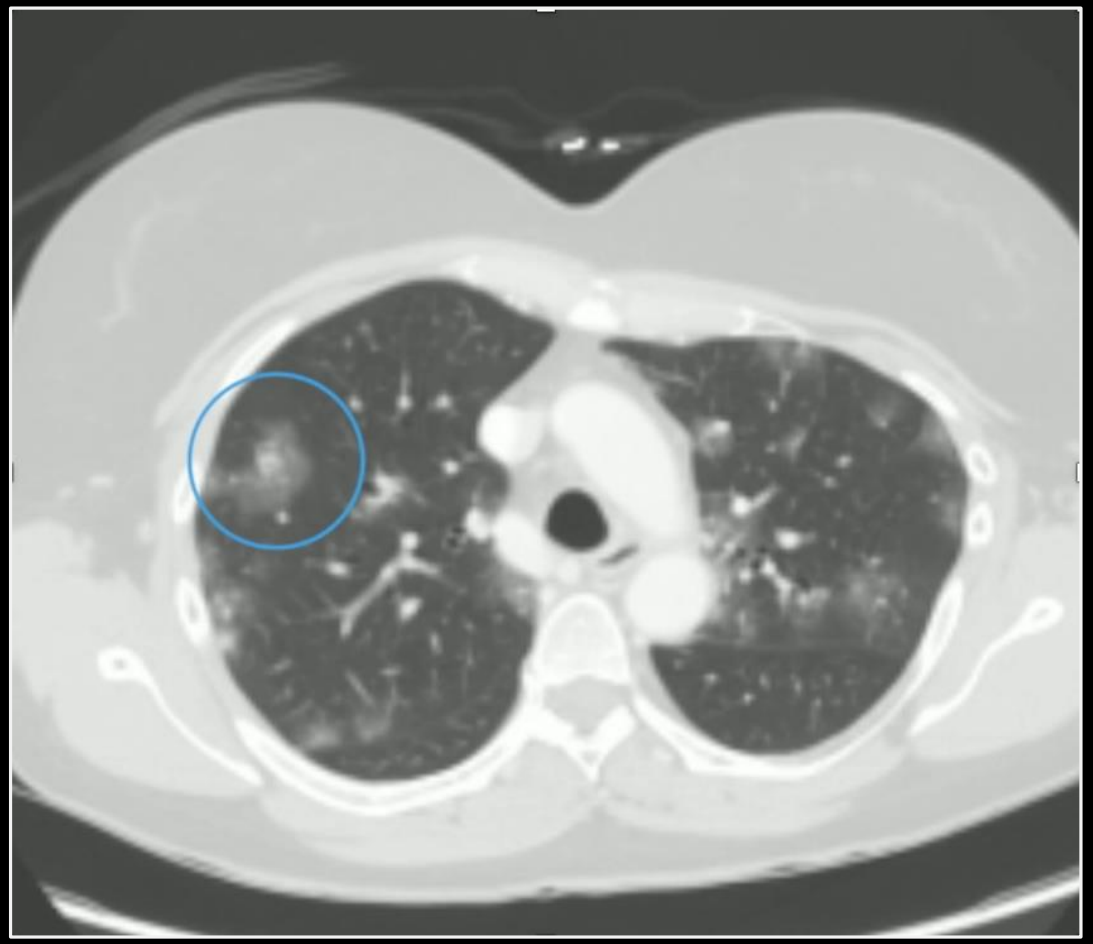
Influenza A pneumonia



Ground glass opacity

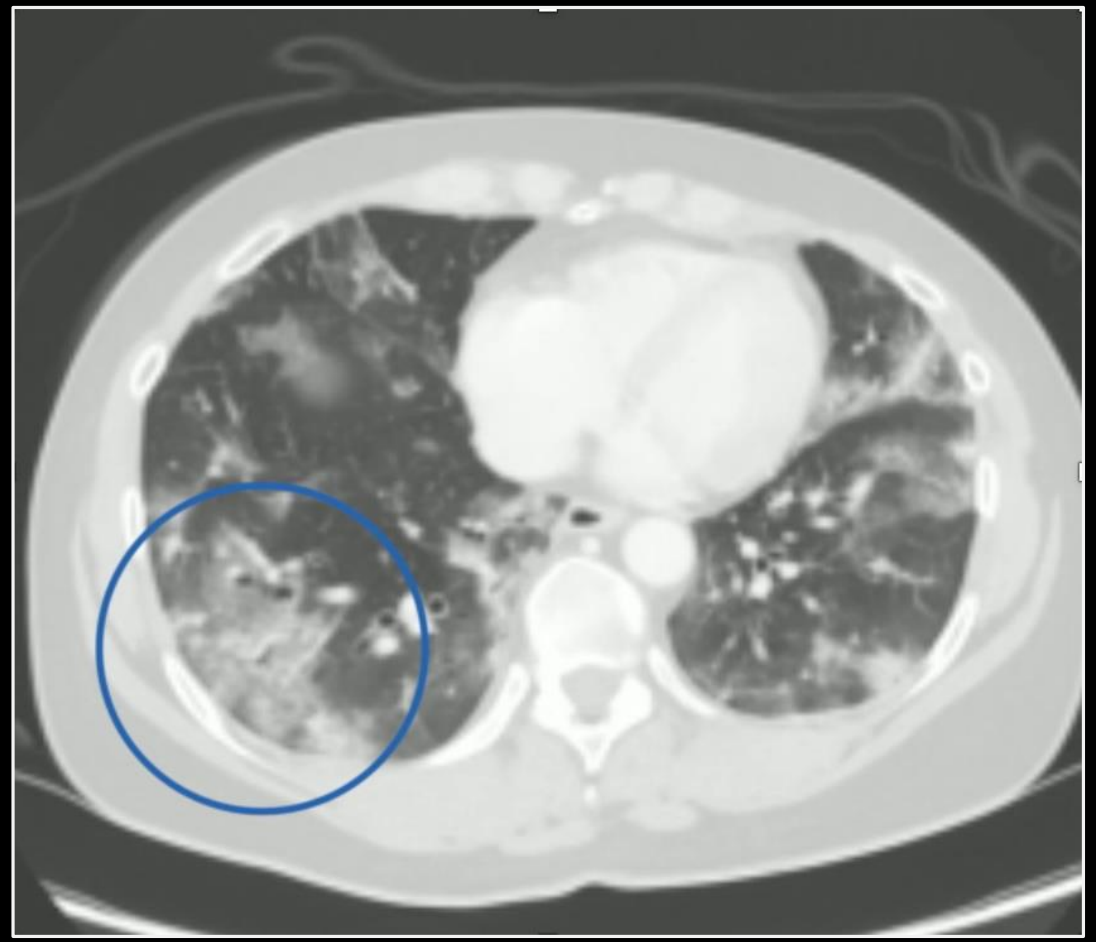
Crazy paving

Influenza A pneumonia



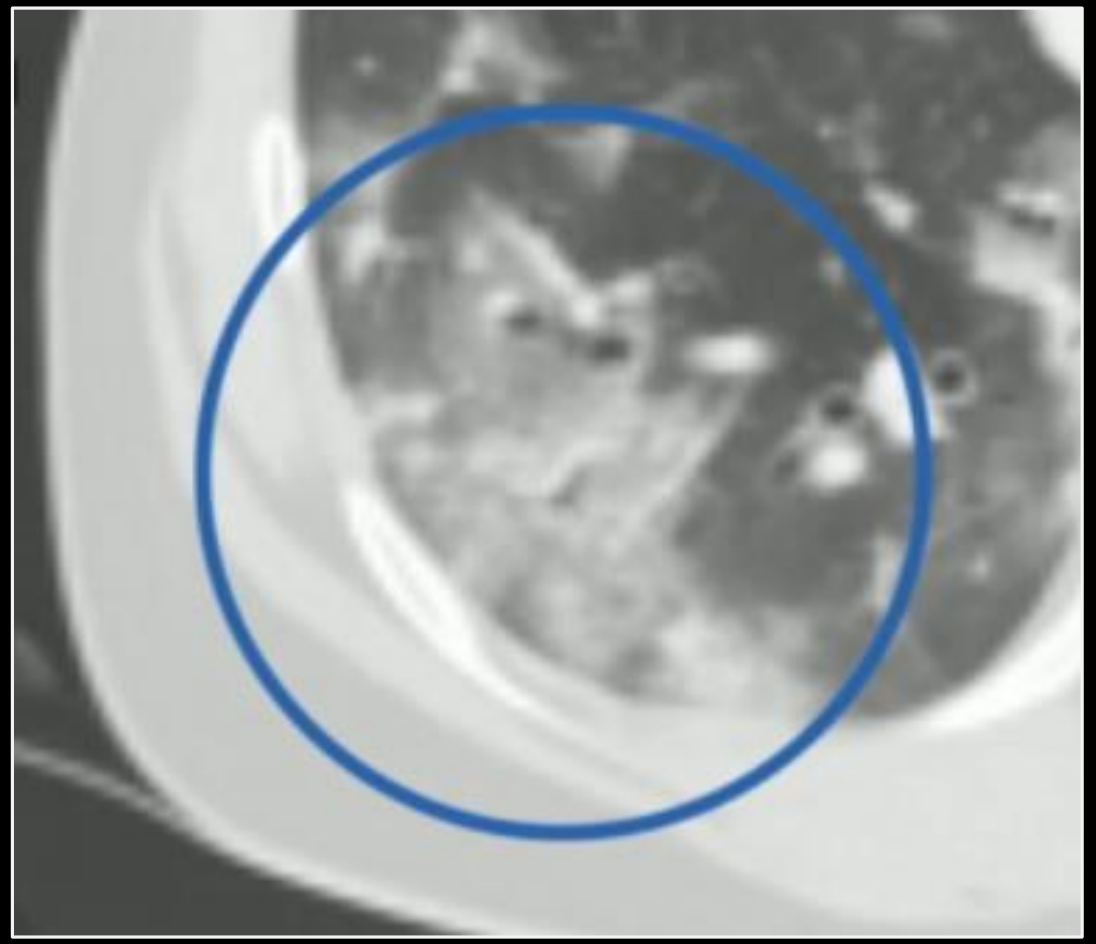
Ground glass opacity
Crazy paving

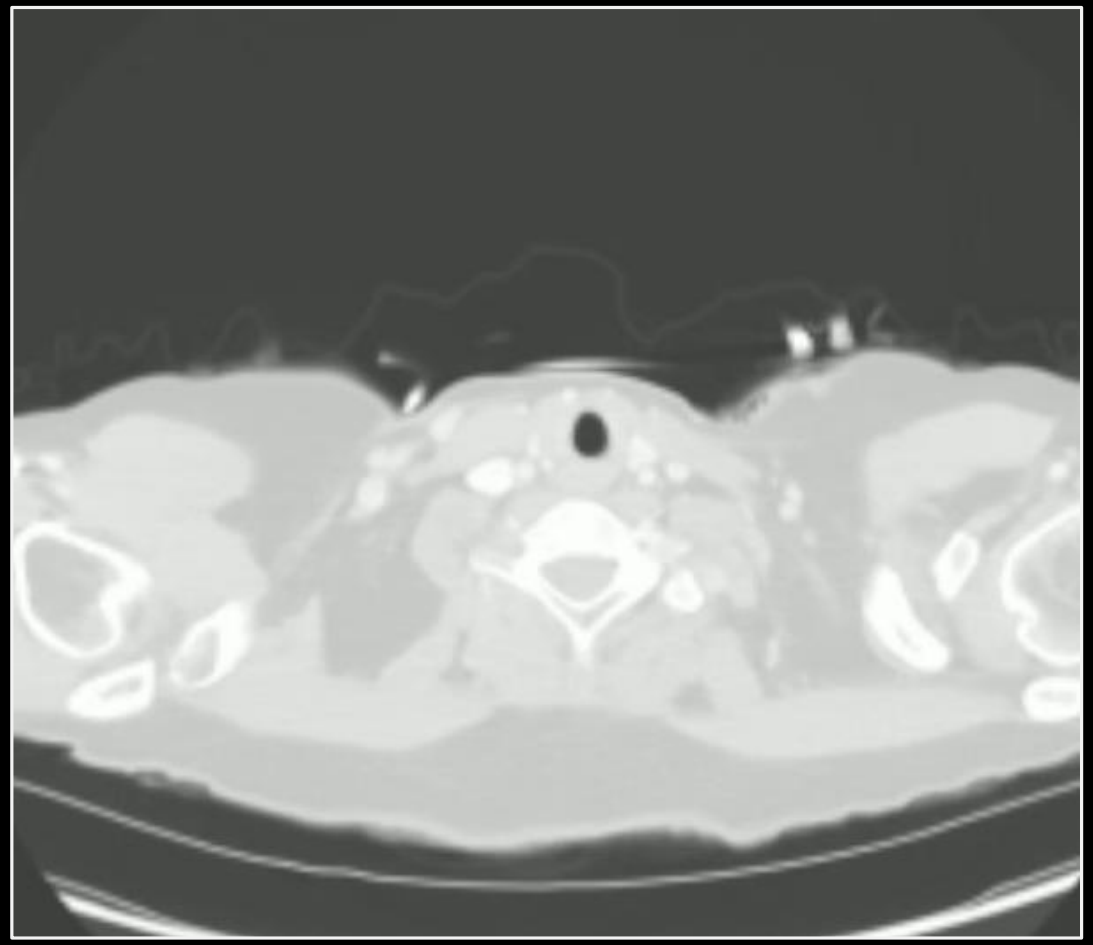
Influenza A pneumonia

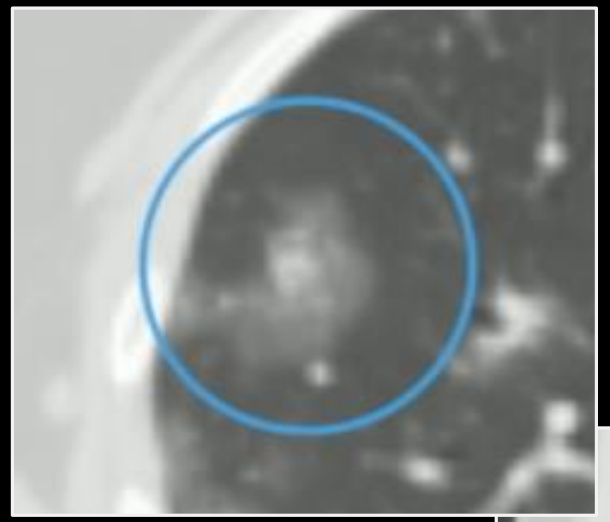


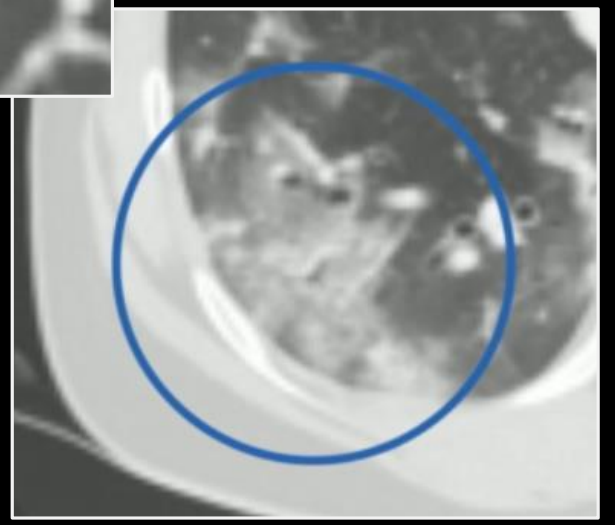
Ground glass opacity
Crazy paving

Influenza A pneumonia





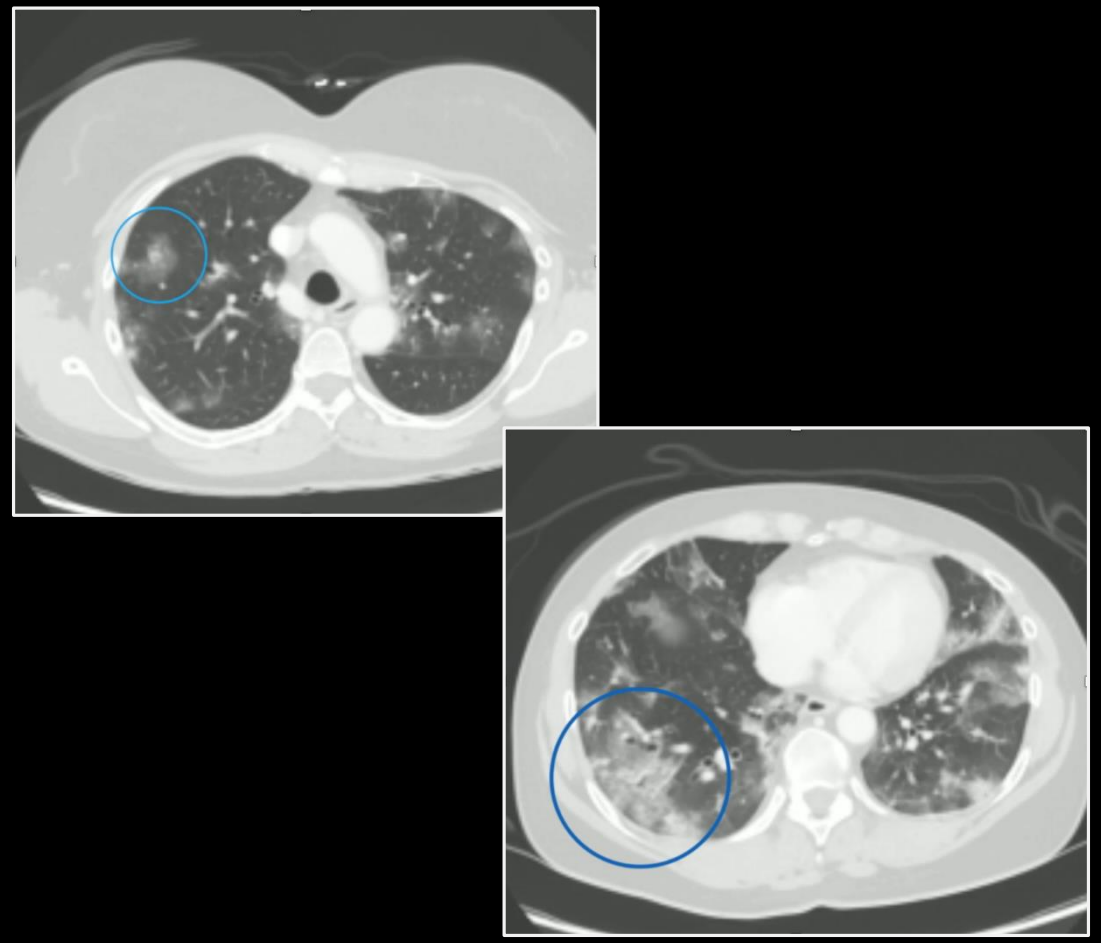




Ground glass opacity

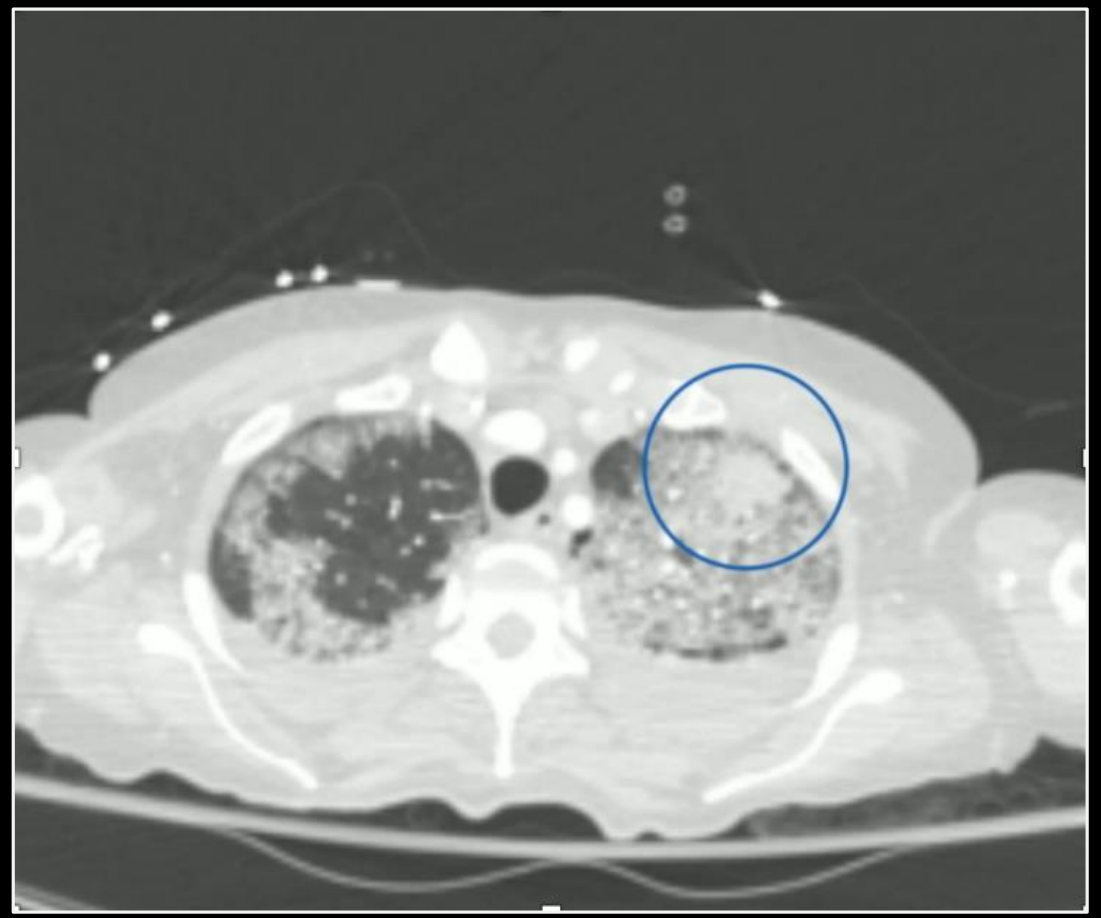
Crazy paving

Influenza A pneumonia



Crazy paving
Consolidation

Influenza B pneumonia

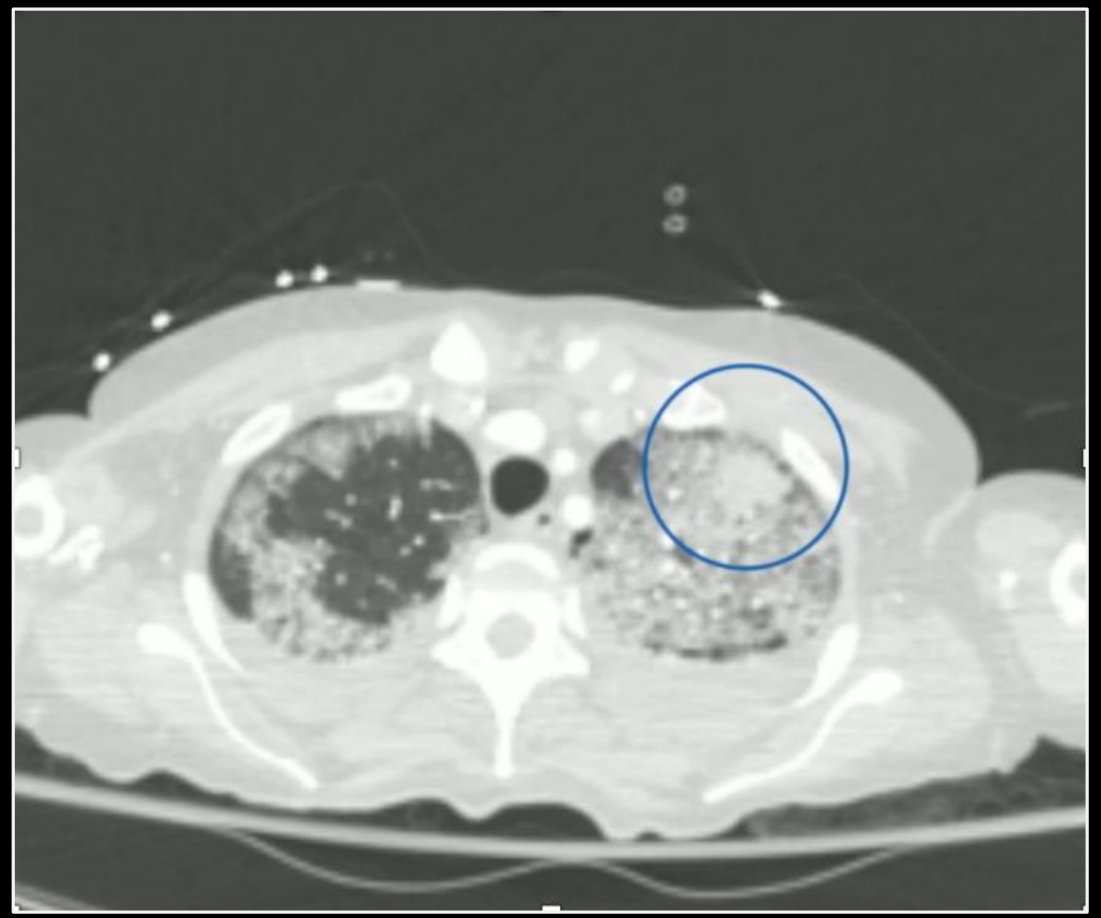


Crazy paving
Consolidation

Influenza B pneumonia

Crazy paving
Consolidation

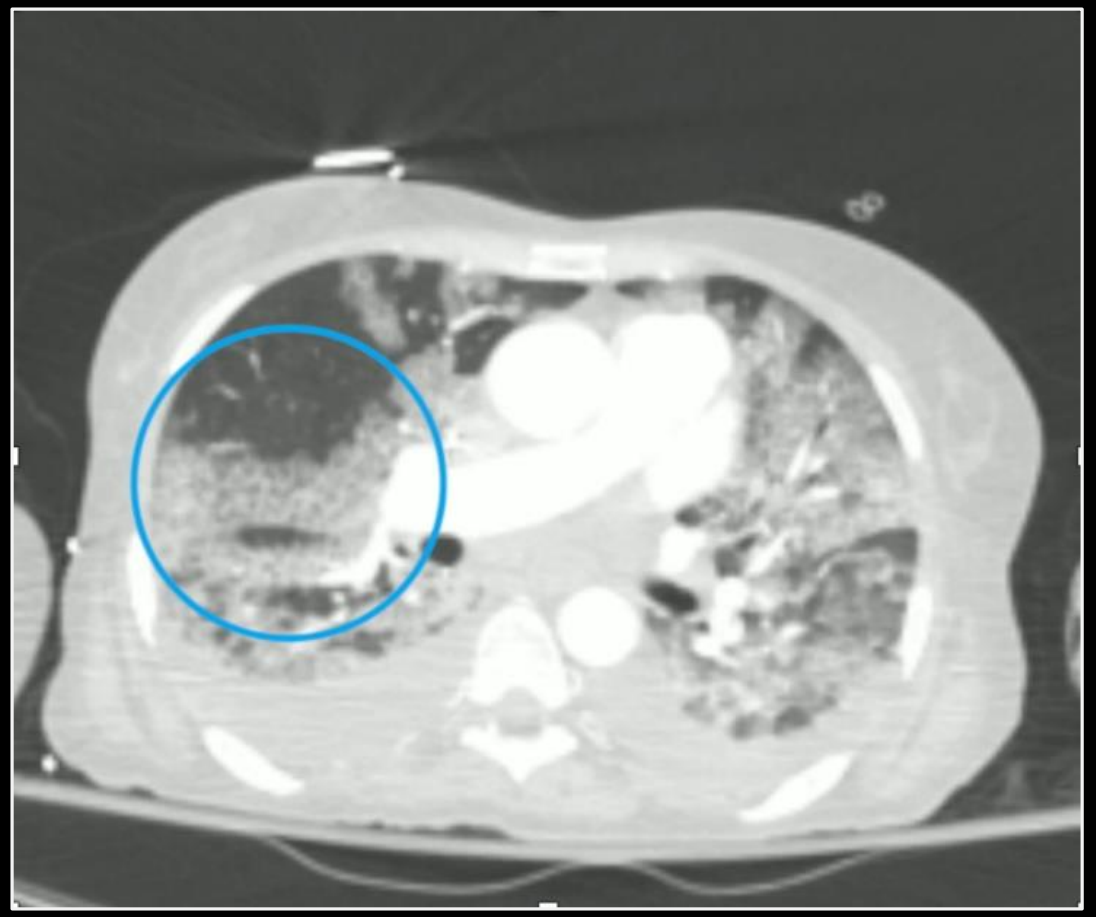
Influenza B pneumonia



Crazy paving

Consolidation

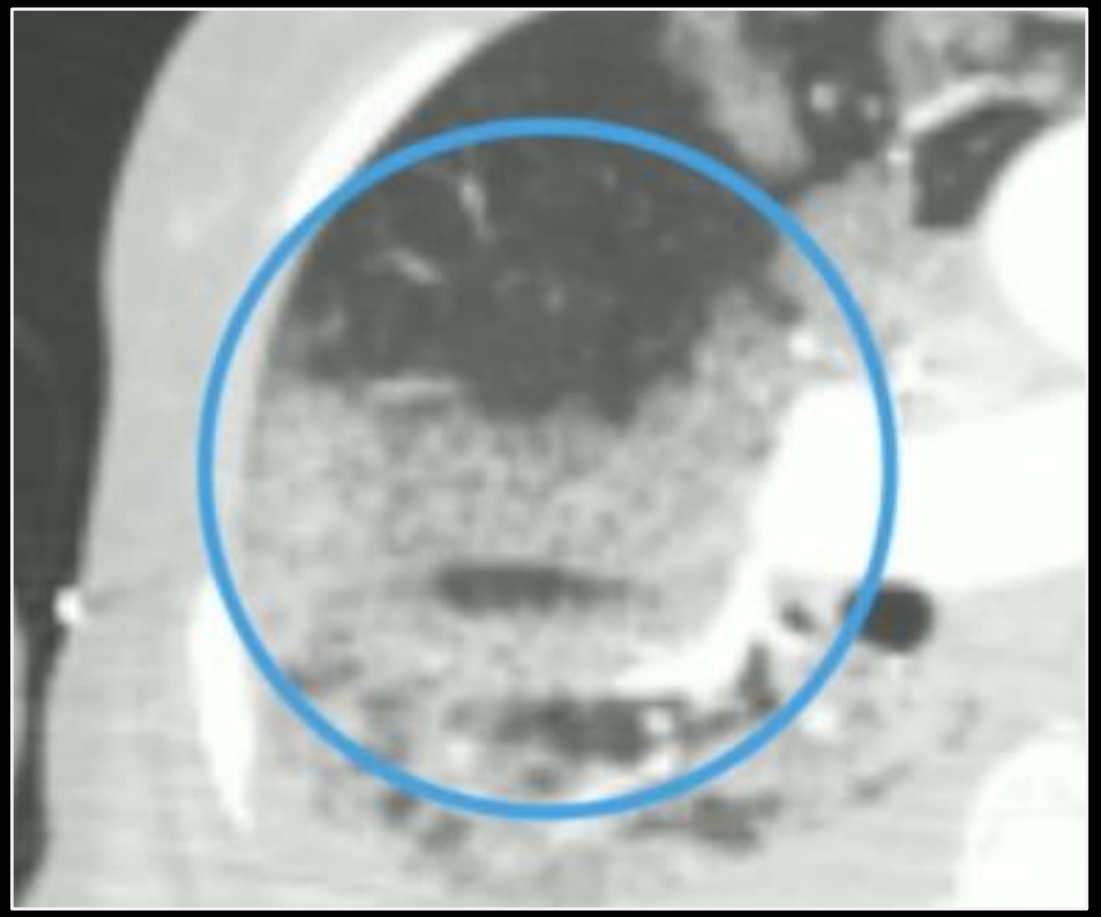
Influenza B pneumonia



Crazy paving

Consolidation

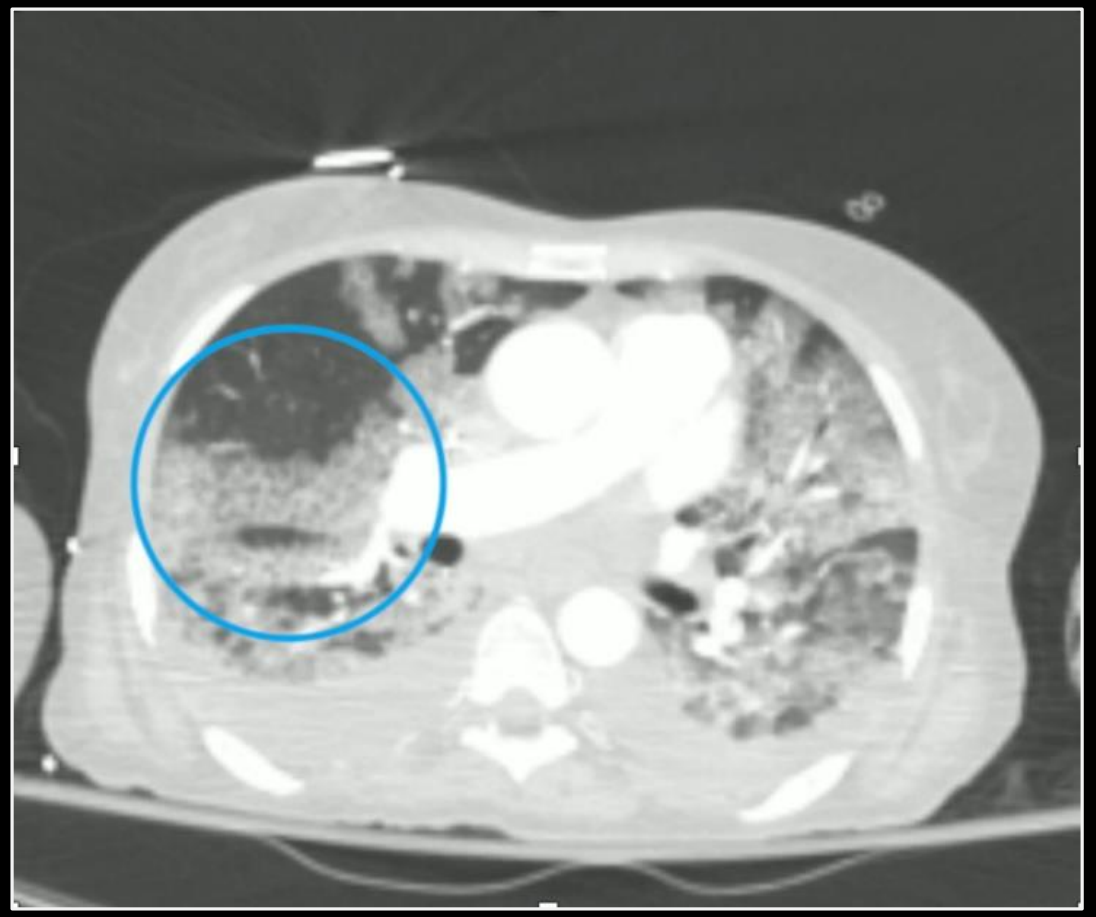
Influenza B pneumonia



Crazy paving

Consolidation

Influenza B pneumonia

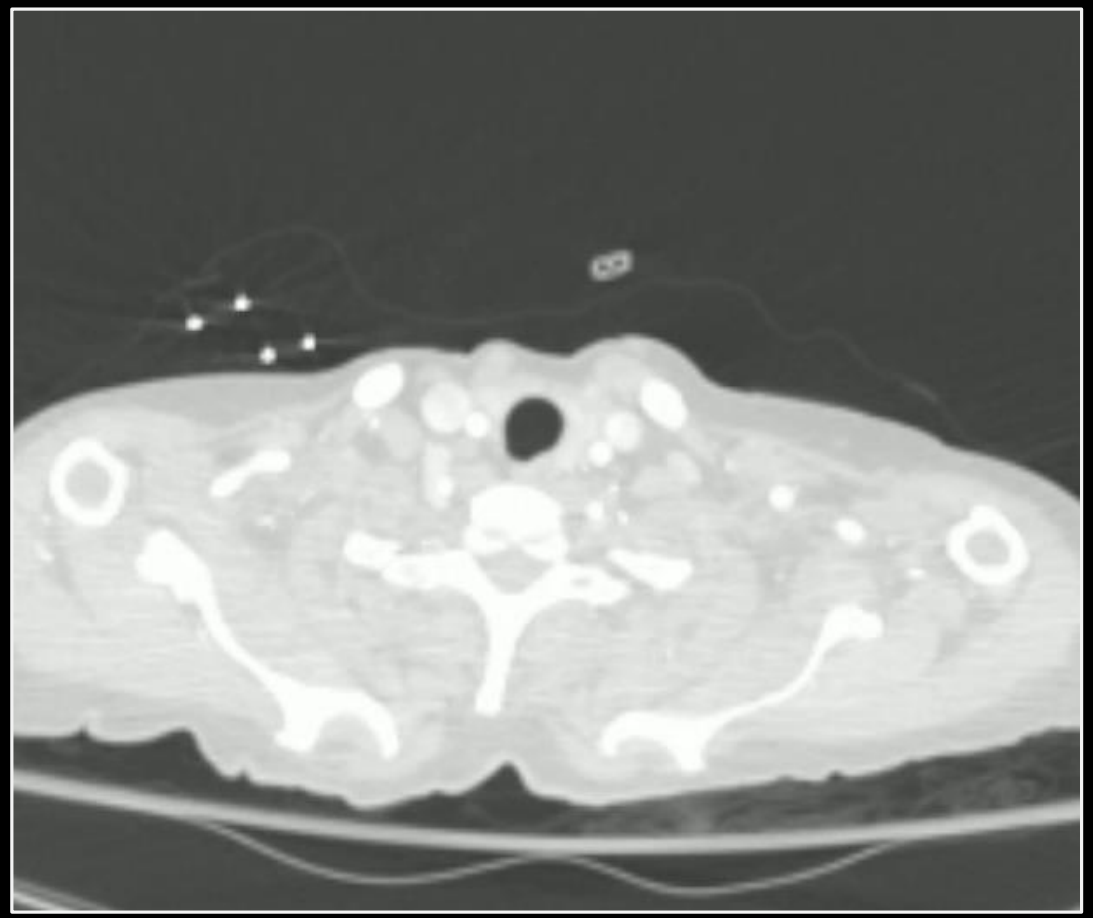


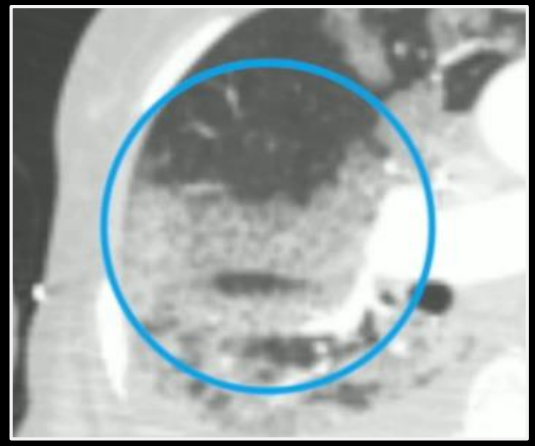
Crazy paving
Consolidation

Influenza B pneumonia

Crazy paving
Consolidation

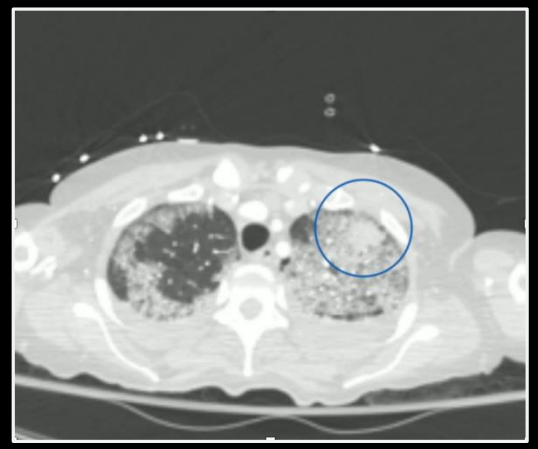
Influenza B pneumonia

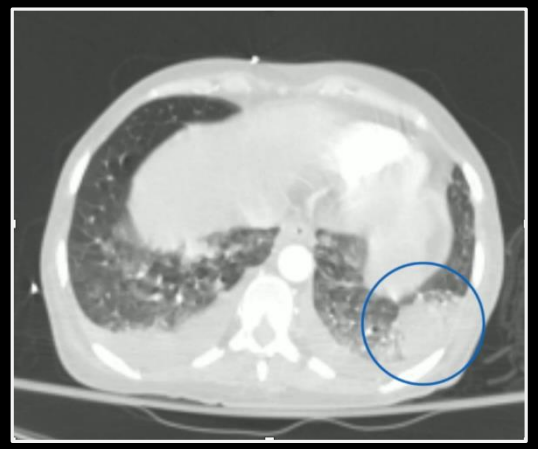


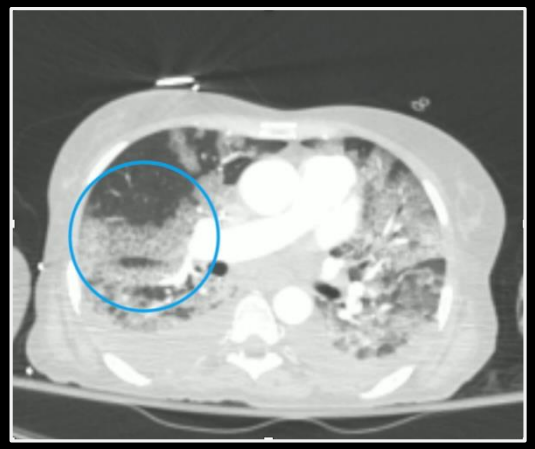


Crazy paving
Consolidation

Influenza B pneumonia

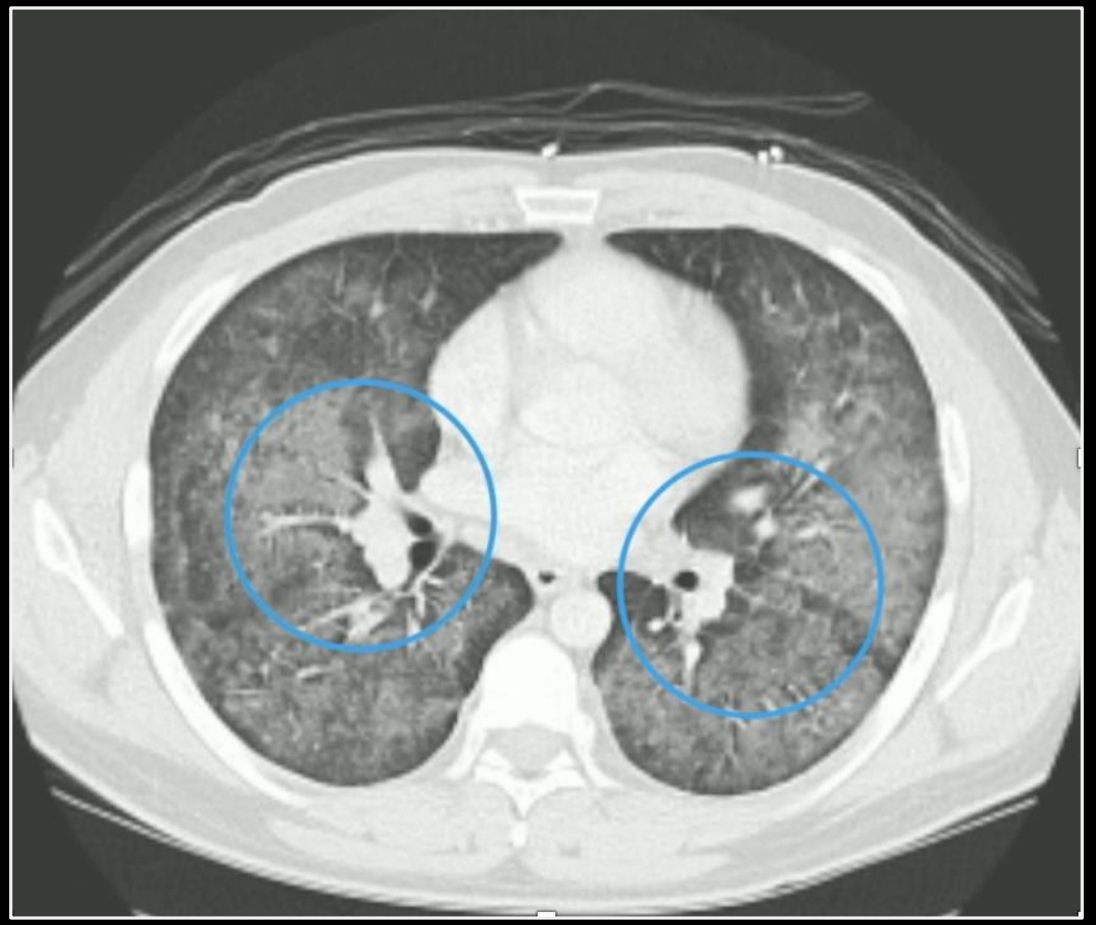






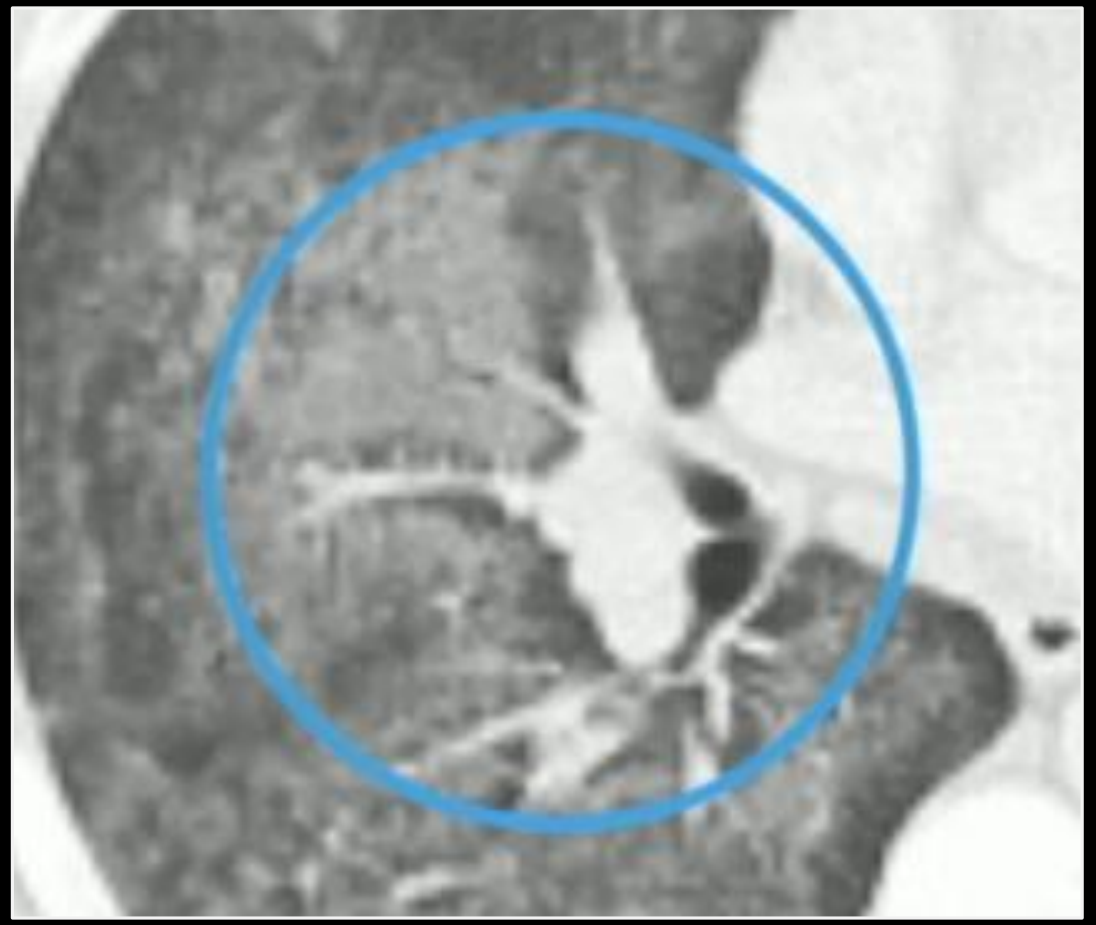
Ground glass opacity

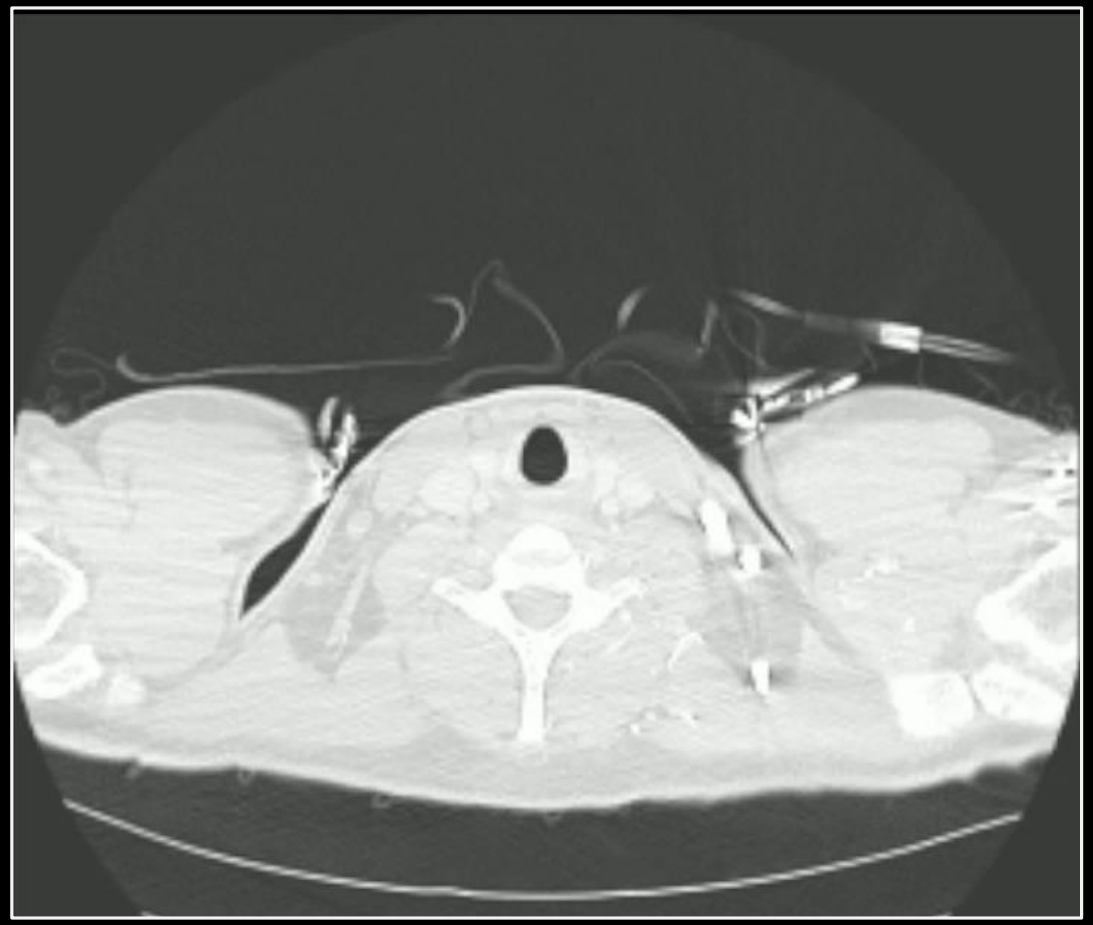
Adenovirus pneumonia



Ground glass opacity

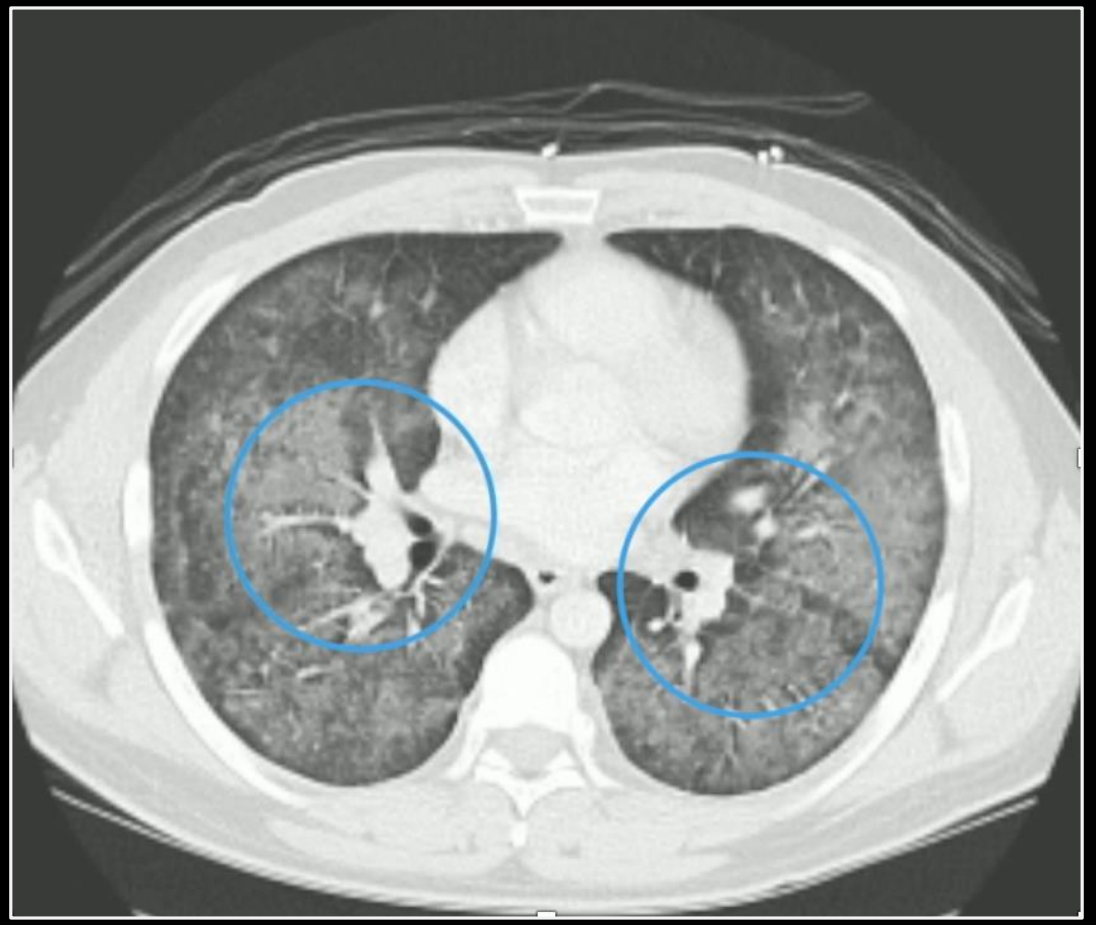
Adenovirus pneumonia





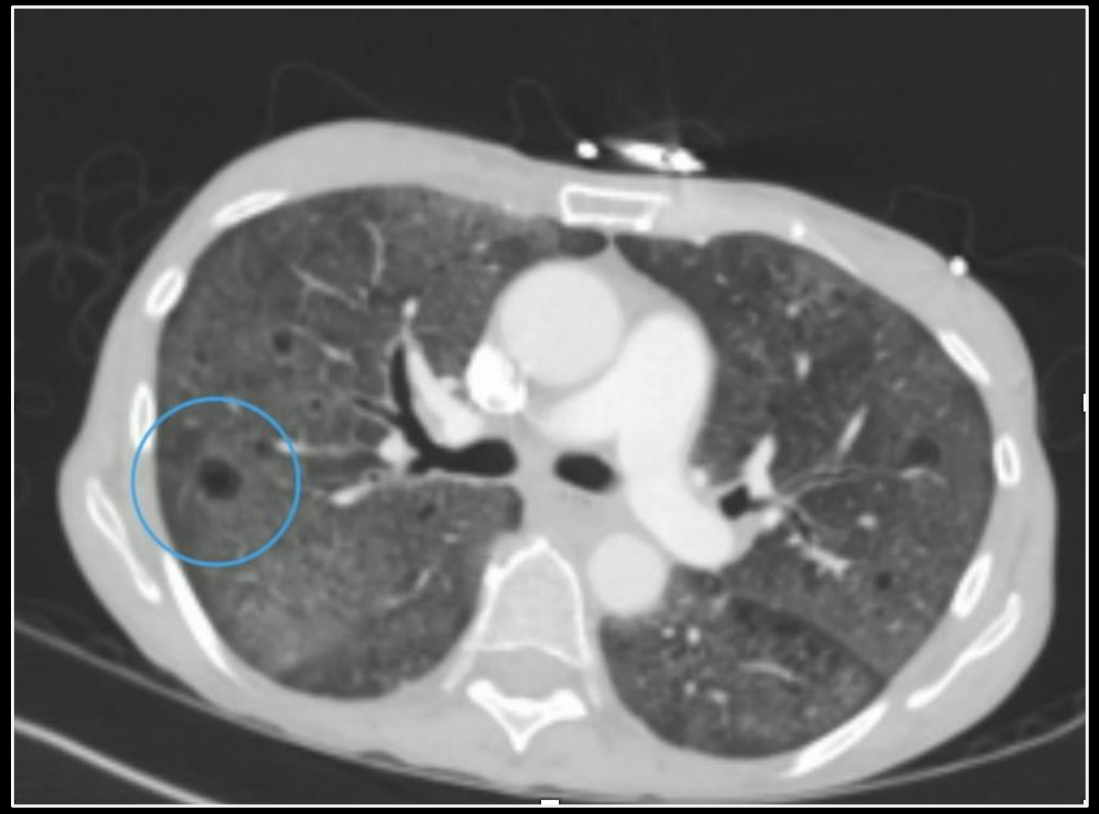
Ground glass opacity

Adenovirus pneumonia



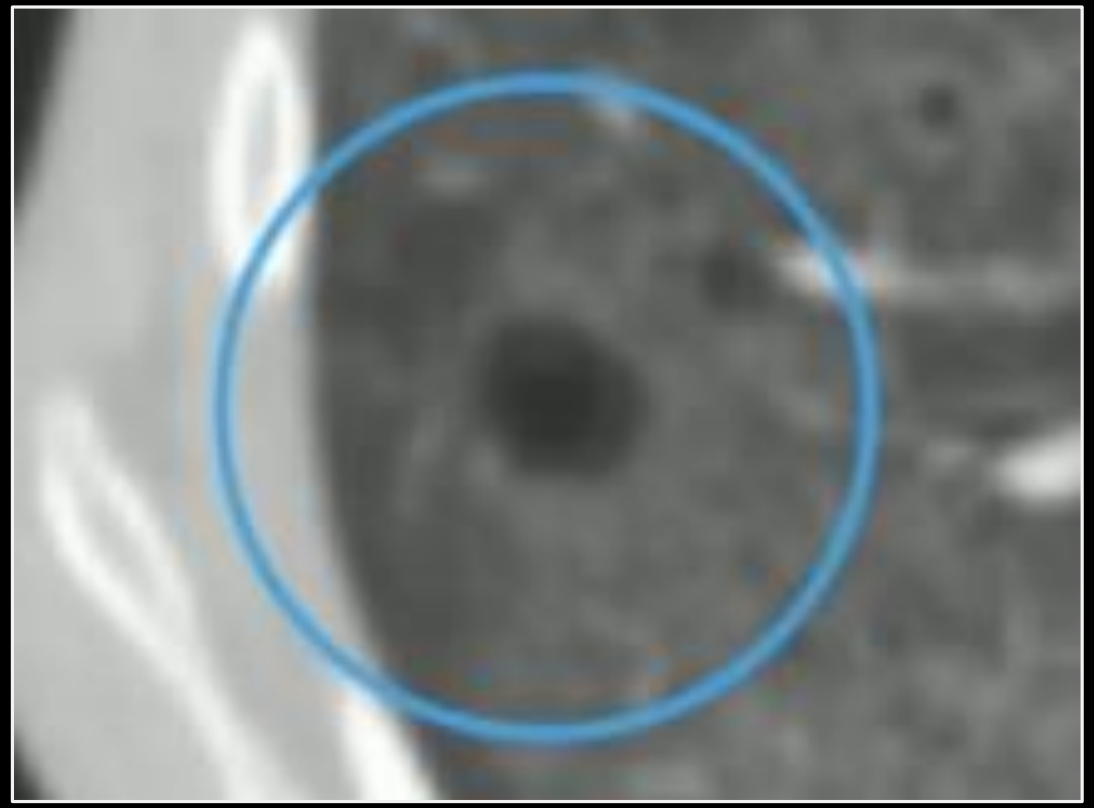
Ground glass opacity
Focal pneumatocoeles

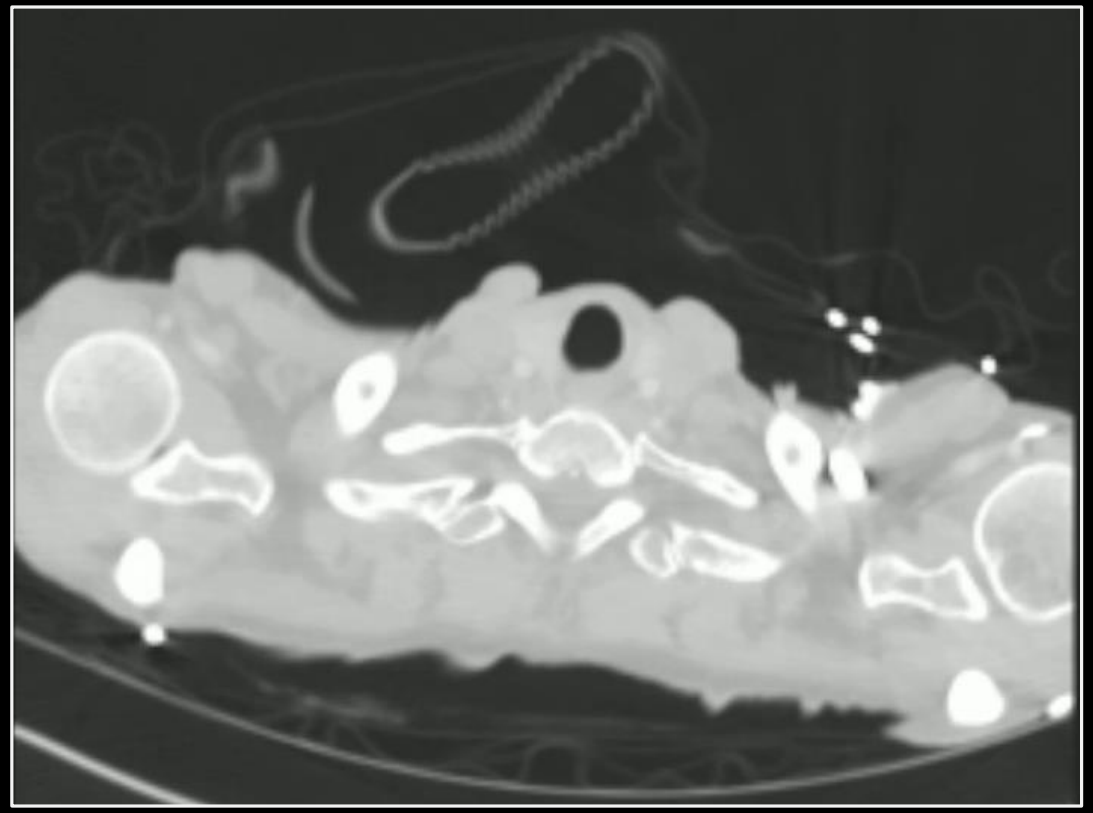
Pneumocystis carinii pneumonia

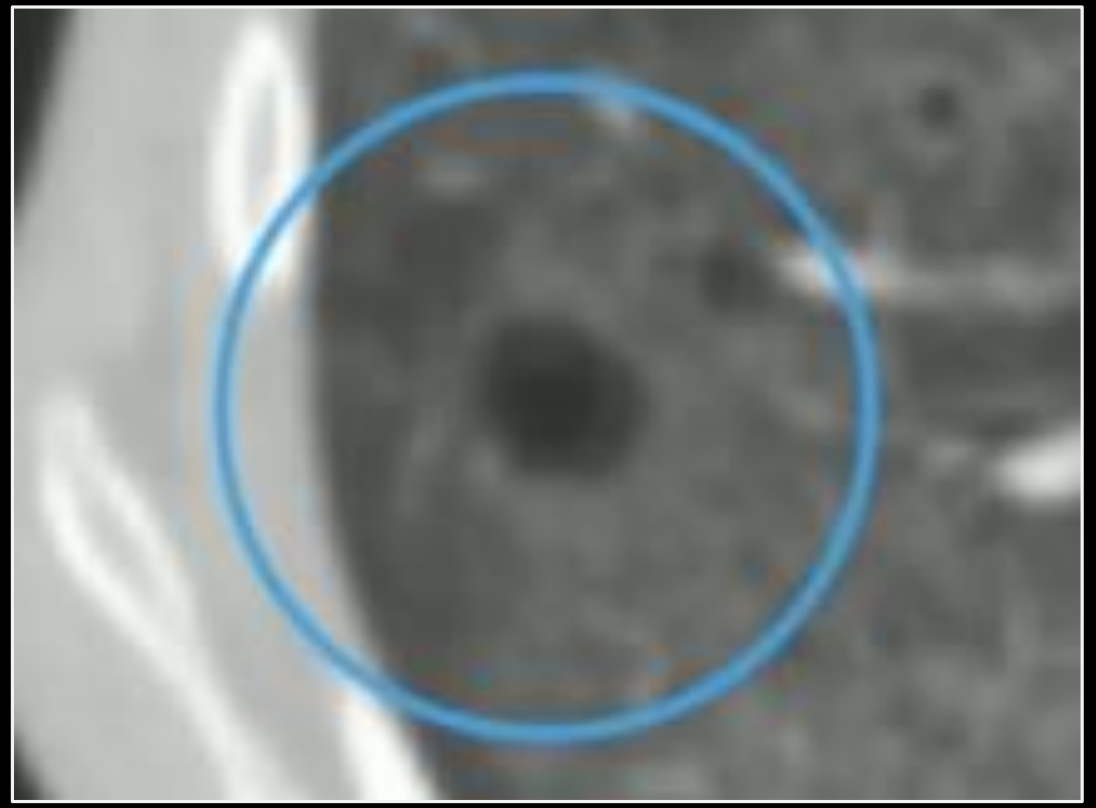


Ground glass opacity
Focal pneumatocoeles

Pneumocystis carinii pneumonia

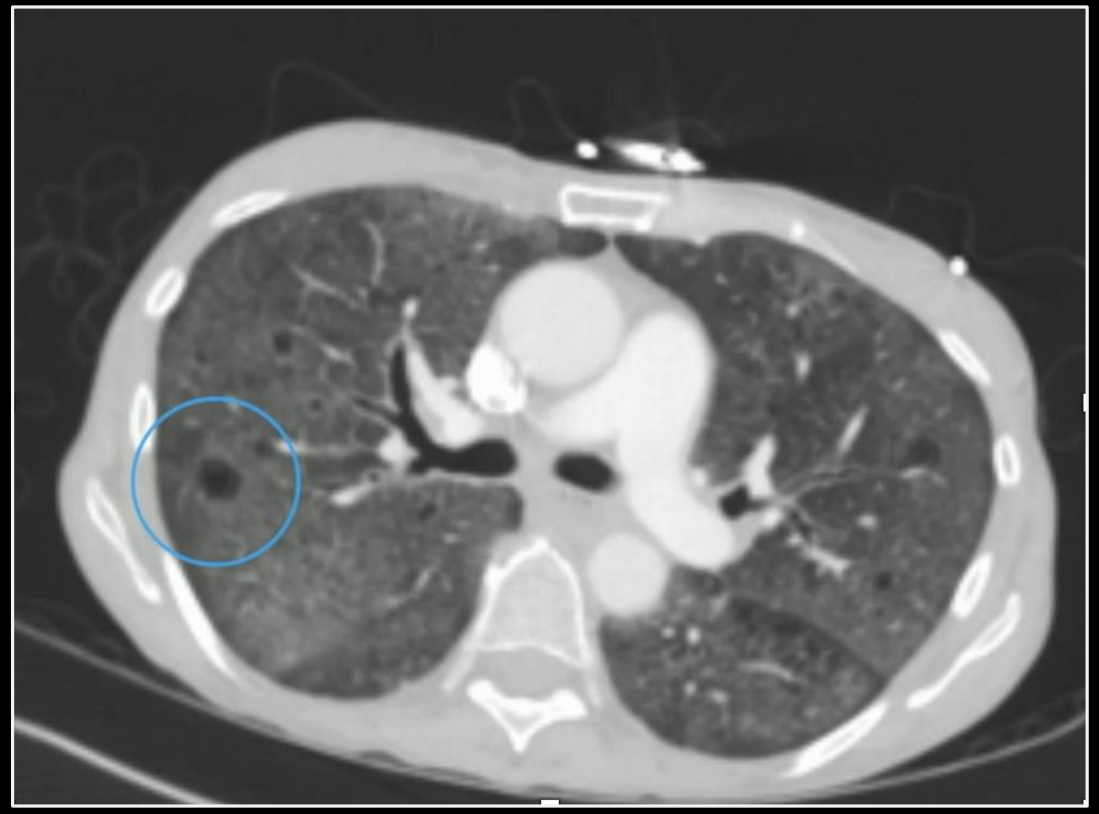






Ground glass opacity
Focal pneumatocoeles

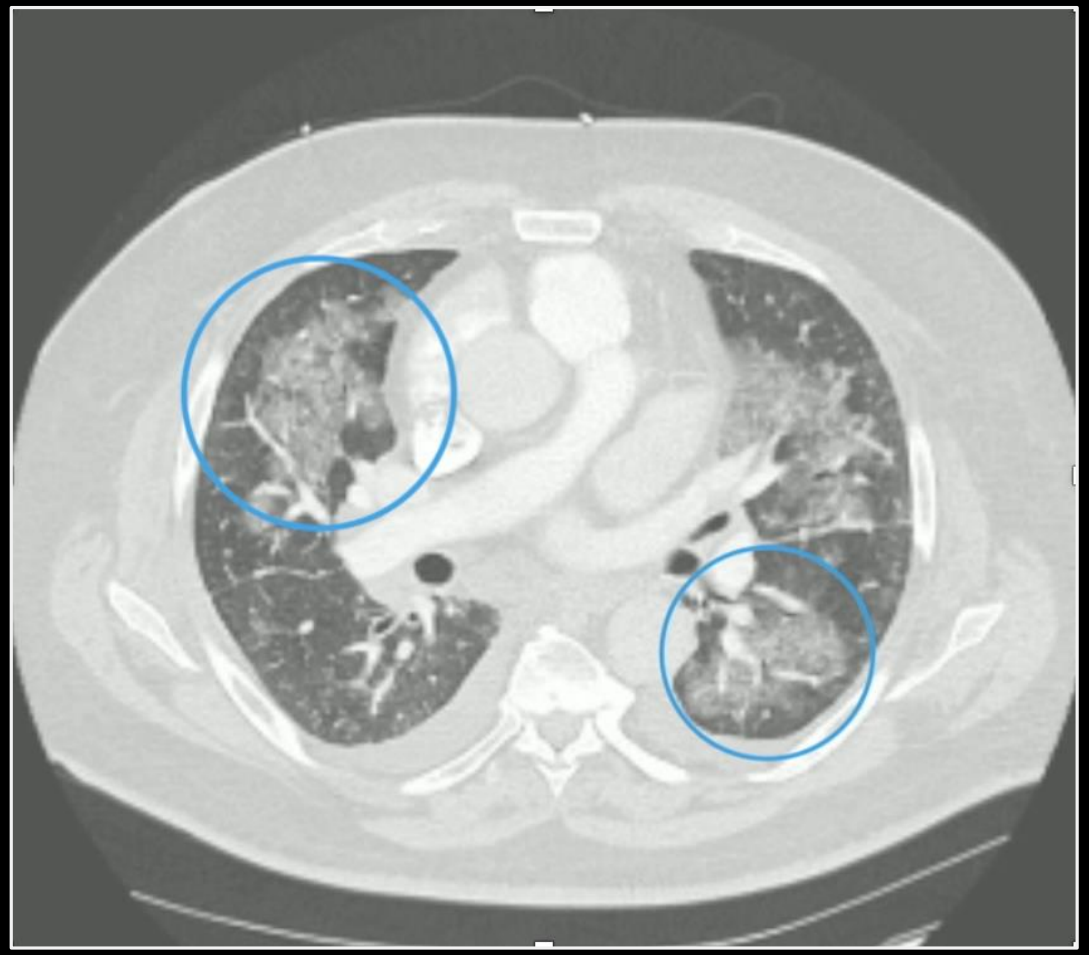
Pneumocystis carinii pneumonia



Ground glass opacity

Interlobular septal prominence

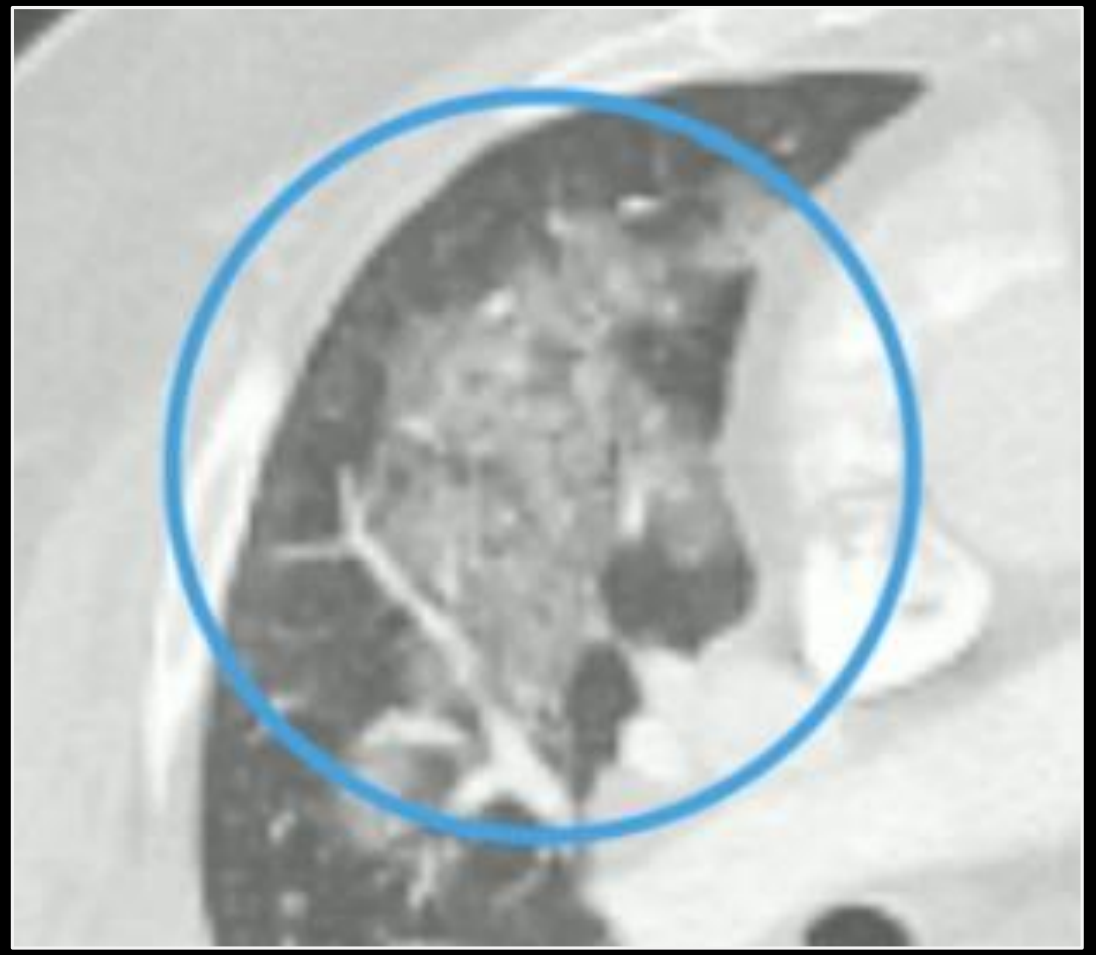
Congestive heart failure



Ground glass opacity

Interlobular septal prominence

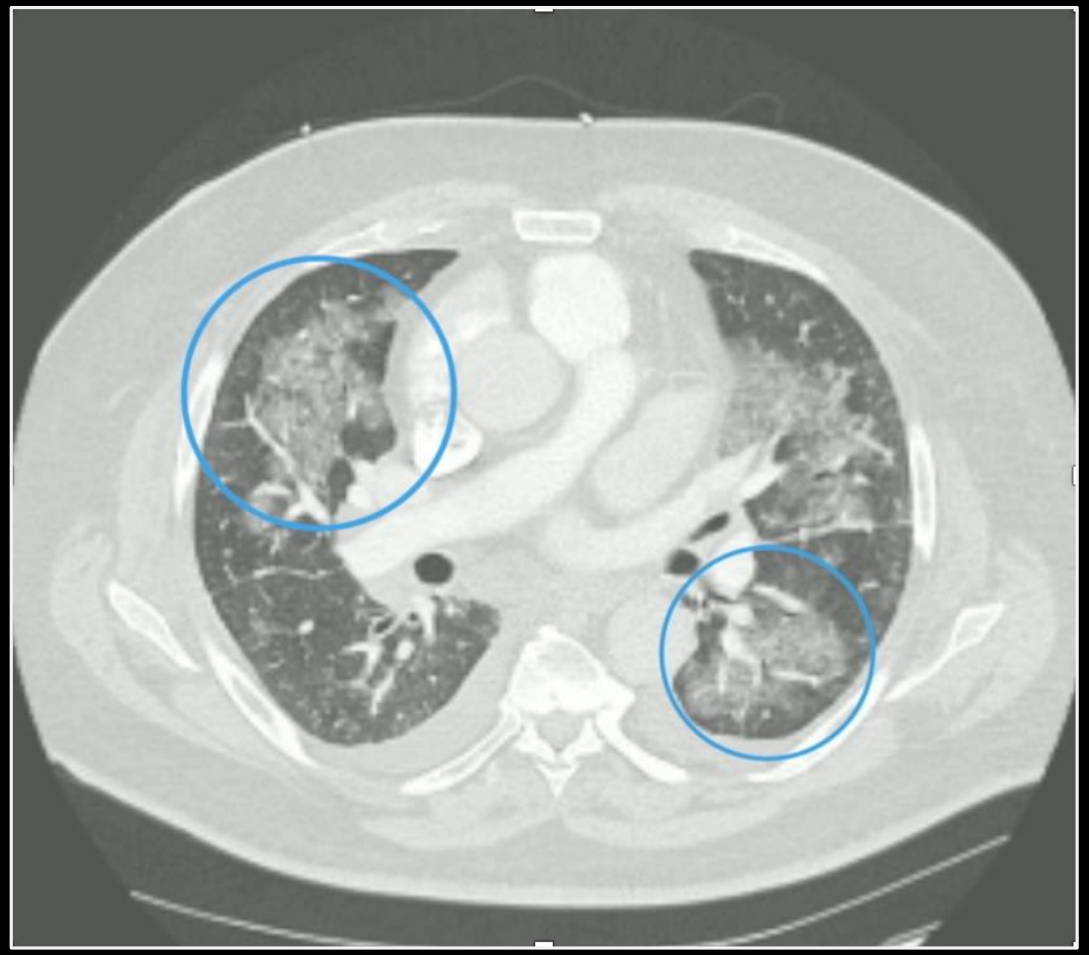
Congestive heart failure



Ground glass opacity

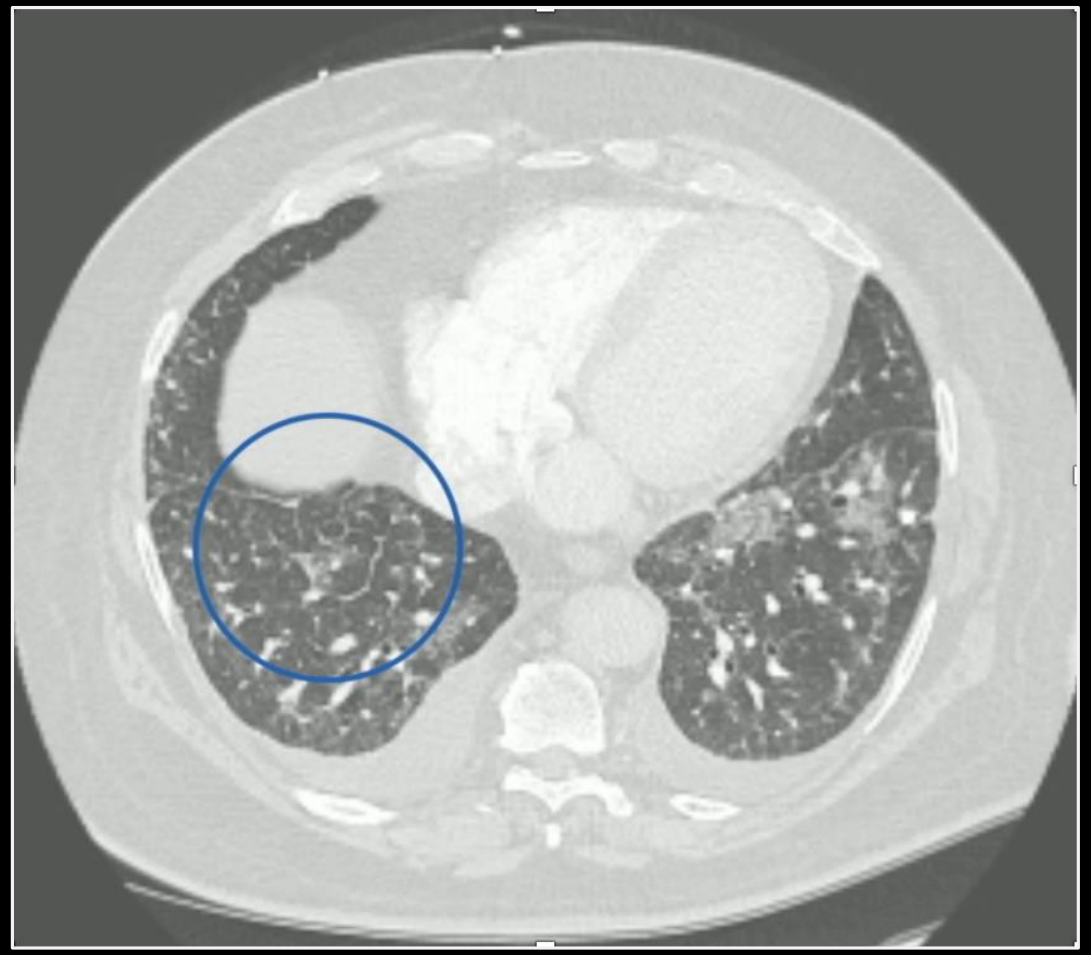
Interlobular septal prominence

Congestive heart failure



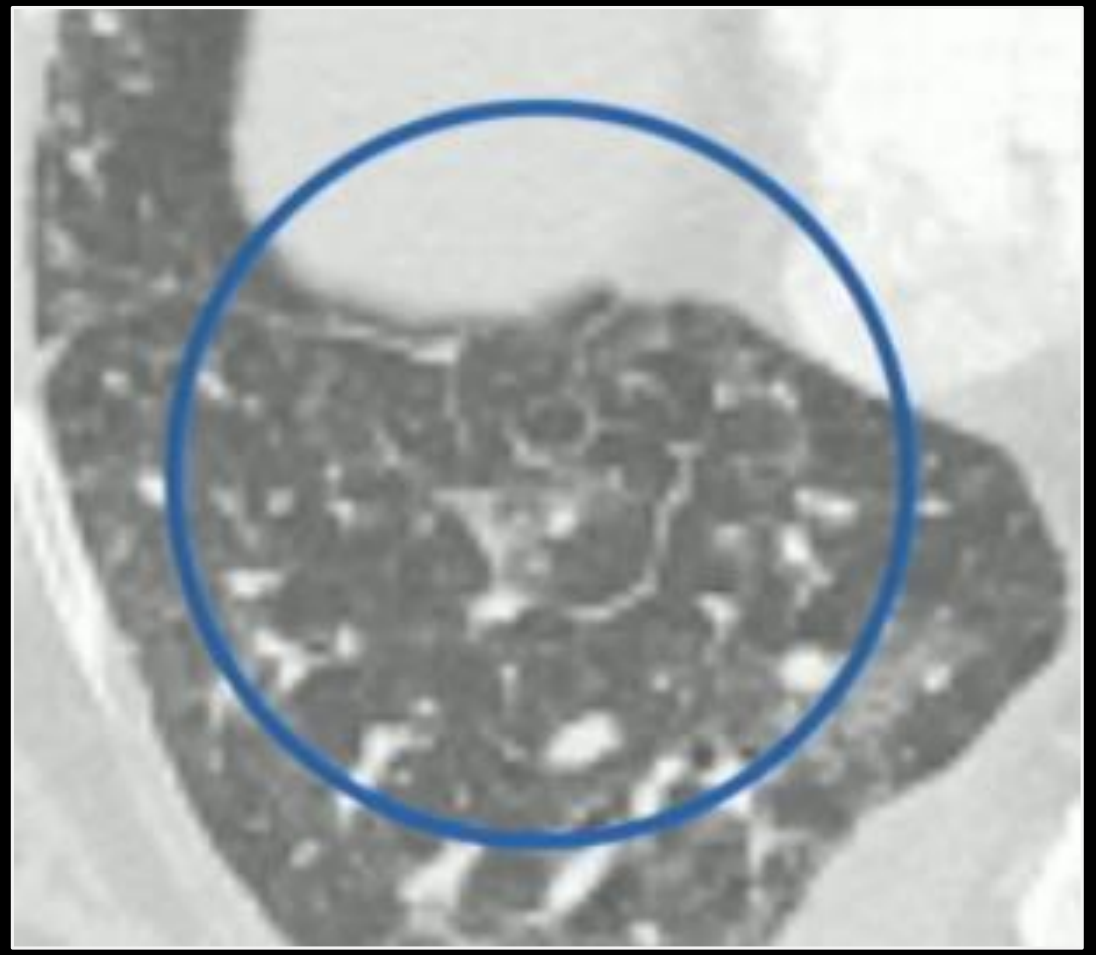
Ground glass opacity
Interlobular septal prominence

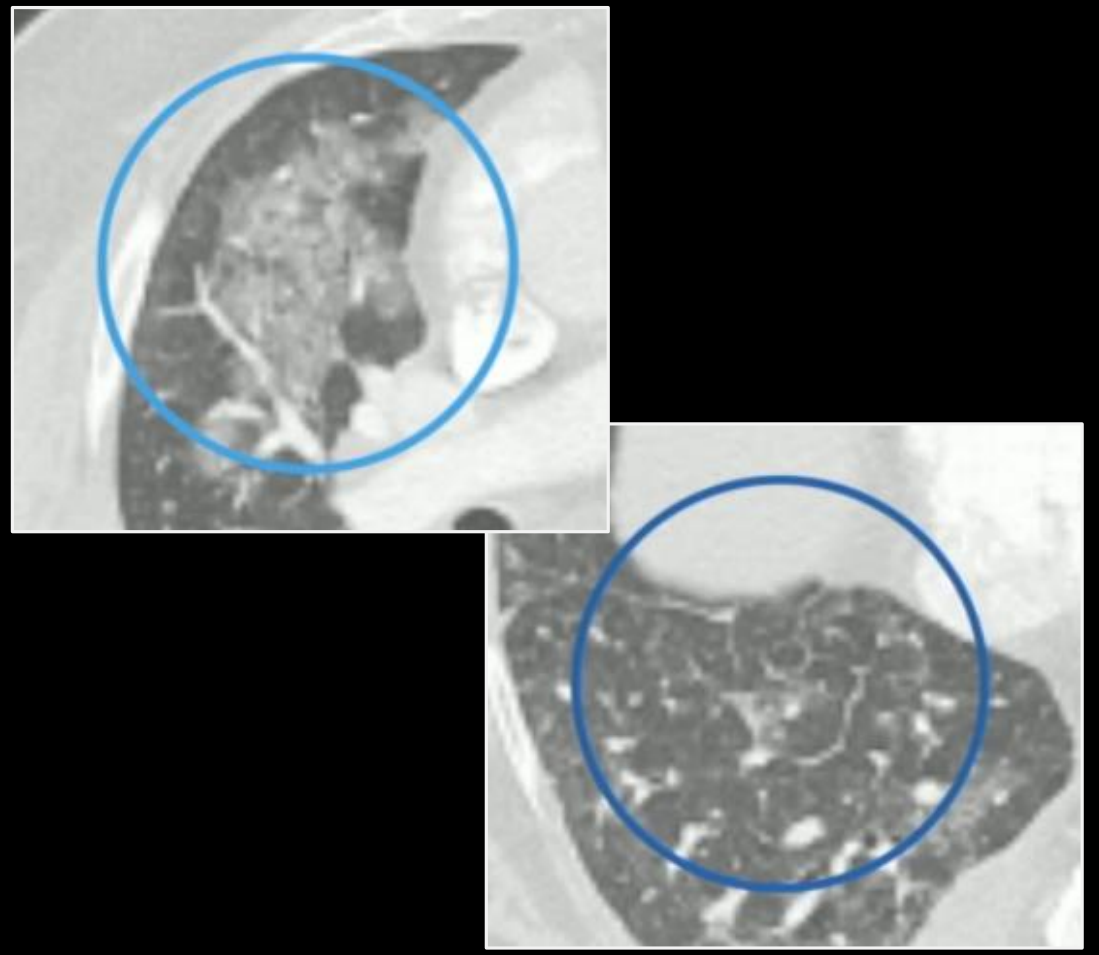
Congestive heart failure



Ground glass opacity
Interlobular septal prominence

Congestive heart failure

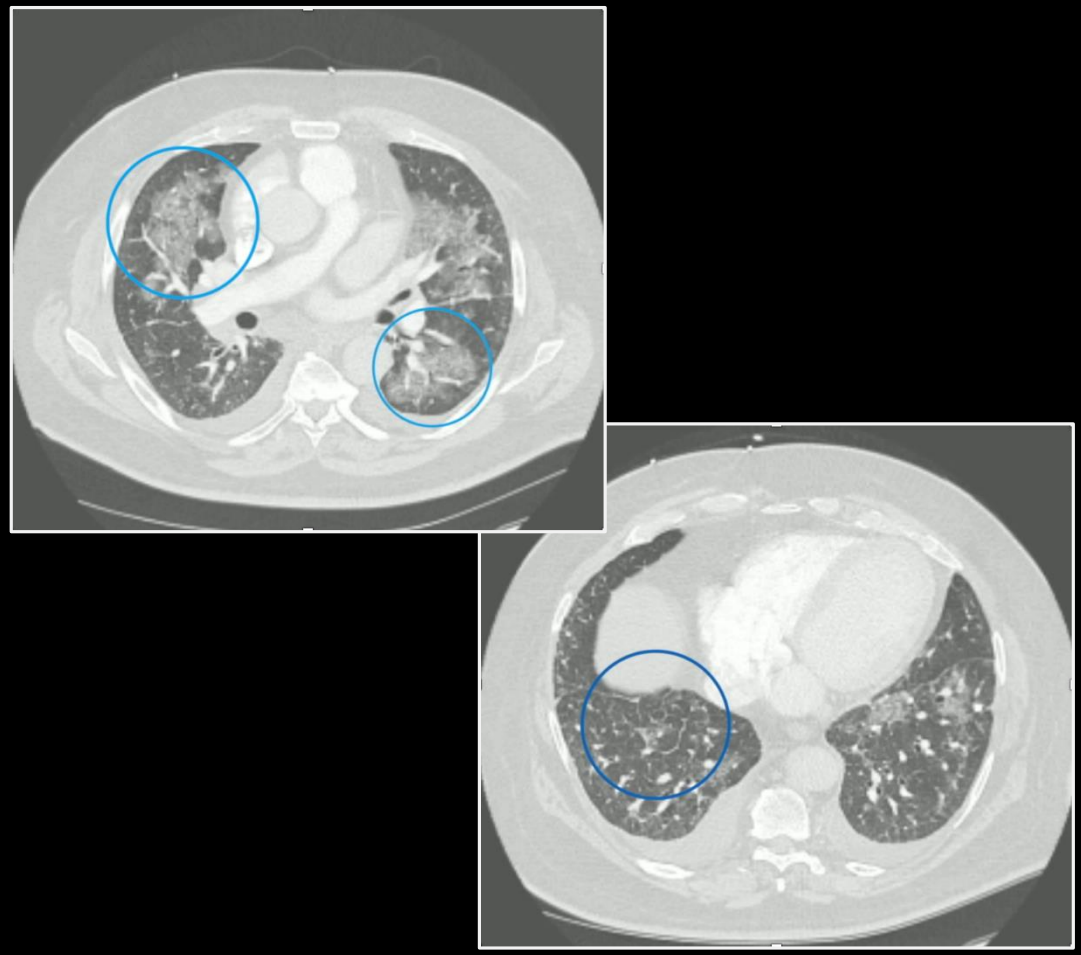


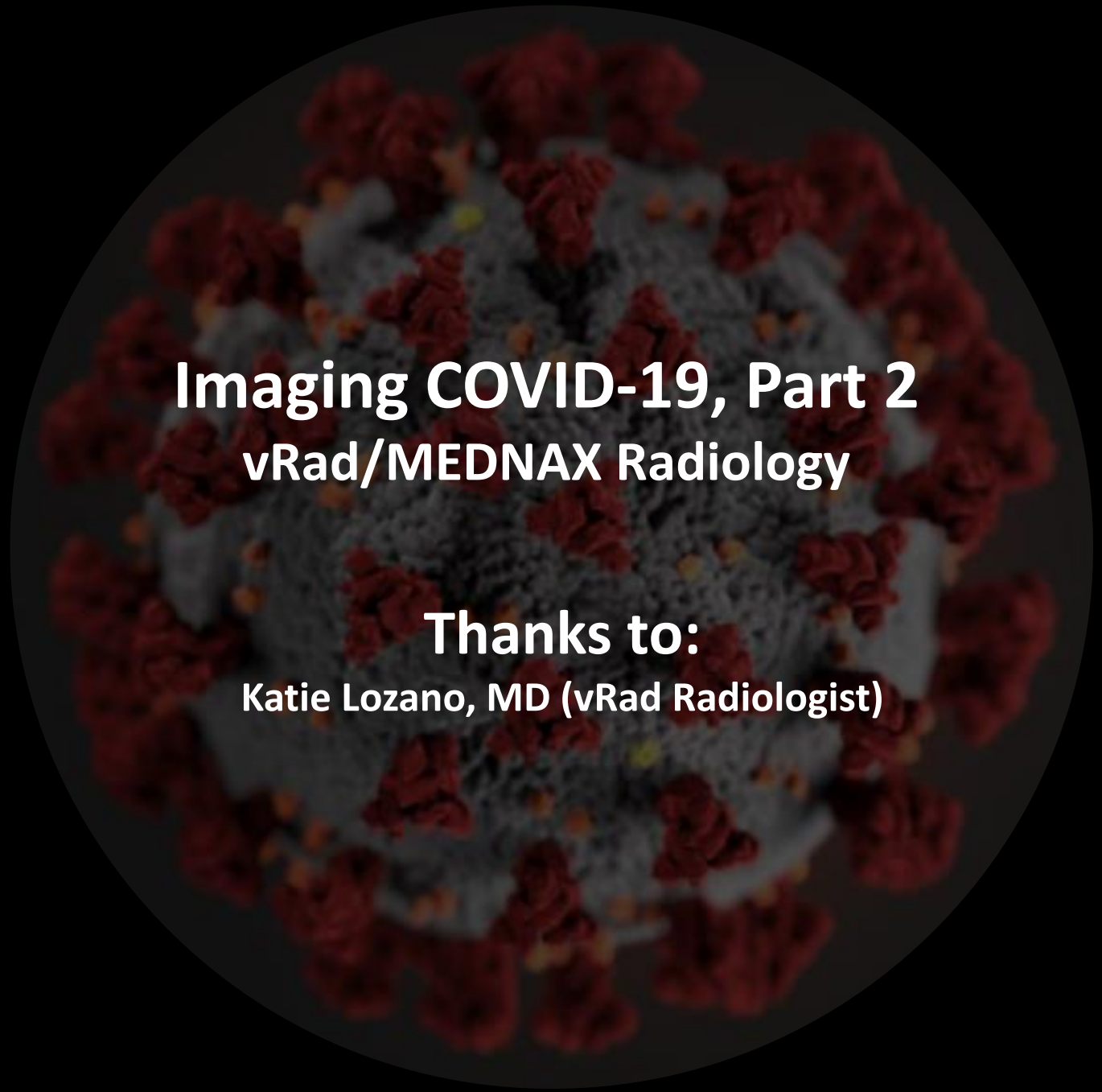


Ground glass opacity

Interlobular septal prominence

Congestive heart failure





Imaging COVID-19, Part 2

vRad/MEDNAX Radiology

Thanks to:

Katie Lozano, MD (vRad Radiologist)

(1) Bluemke D. Special Edition Podcast. Radiology 2020; published online Feb 26 2020.

(2) Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, Diao K, Lin B, Li K, Li S, Shan H, Jacobi A, Chung M. Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection. Radiology 2020; published online Feb 20 2020.

(3) Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, Xia L. Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases.

(4) Fang Y, Zhang H, Zie J, Lin M, Yin L, Pang P, Ji W. Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR. Radiology 2020; published online Feb 19 2020.

(5) Ng M, Lee EYP, Yang J, Yand F, Li X, Wang H, Lue MM, Lo CS, Leung B, Khong P, Hui CK, Yuen K, Kuo MD. Imaging Profile of the COVID-19 Infection: Radiologic Finding and Literature Review. Radiology 2020; published online Feb 13 2020.

(6) Pan F, Ye Tm Sun P, Gui S, Liang B, Li L, Zheng D, Wang J, Hesketh R, Yang L, Xheng C. Time Course of Lung Changes on Chest CT During Recovery From 2019 Novel Coronavirus (COVID-19) Pneumonia. Radiology 2020; published online Feb 13 2020.

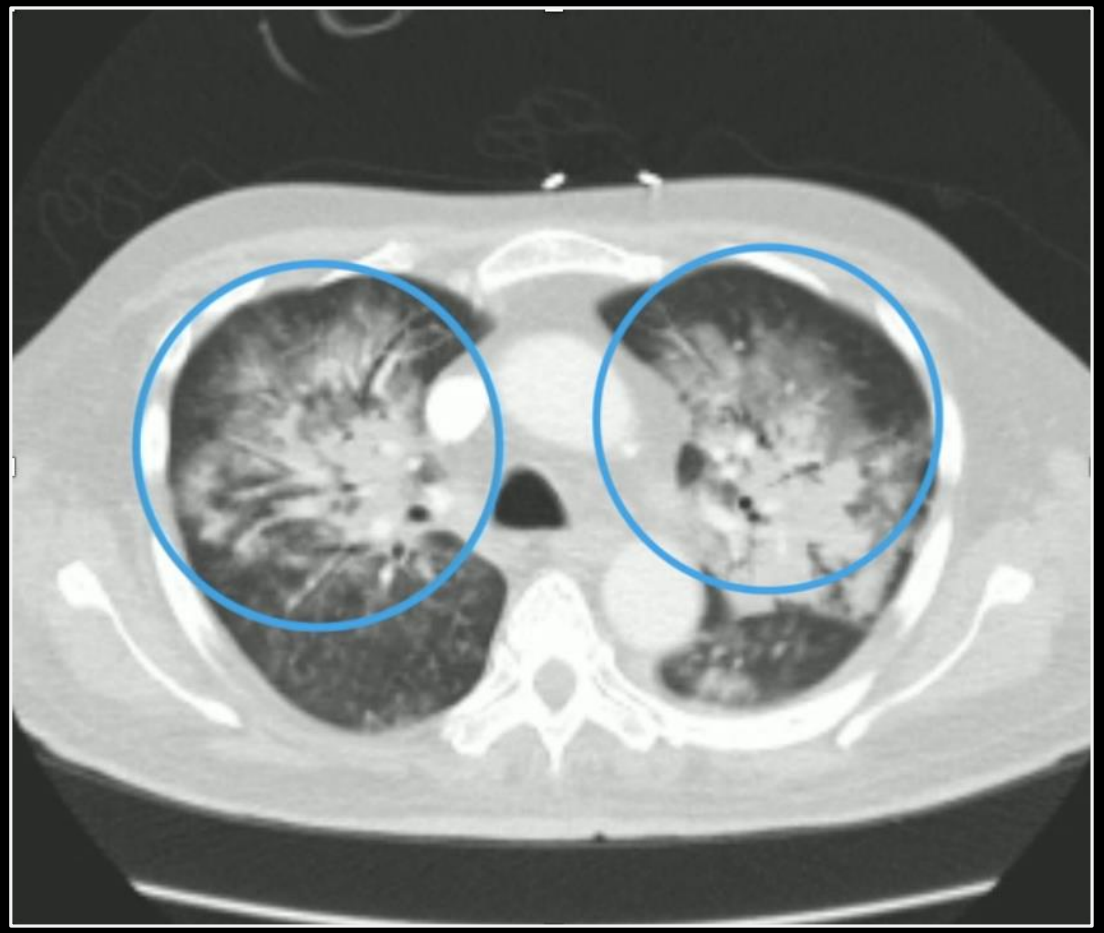
(7) Zu ZY, Jiang MD, Xu PP, Chen W, Ni QQ, Lu GM, Zhang LJ. Coronavirus Disease 2019 (COVID-19): A Perspective from China. Radiology 2020; published online Feb 21 2020.

(8) Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, Cui J, Xu W, Yang Yan Z, Jacobi A, Li K, Li S, Shan H. CT Imaging Features of 2019 Novel Coronavirus (2019-nCoV). Radiology 2020; published online Feb 4 2020.

Ground glass opacity

Consolidation

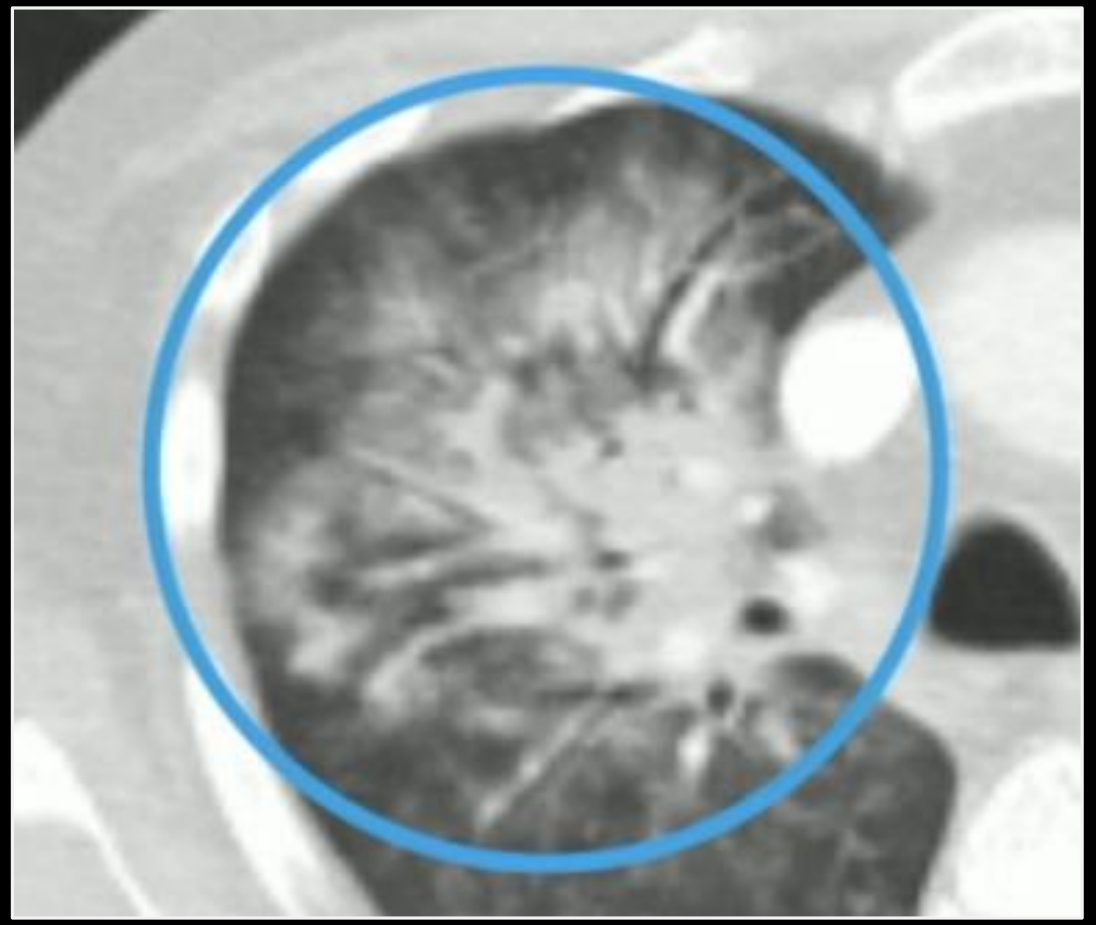
COVID-19 pneumonia



Ground glass opacity

Consolidation

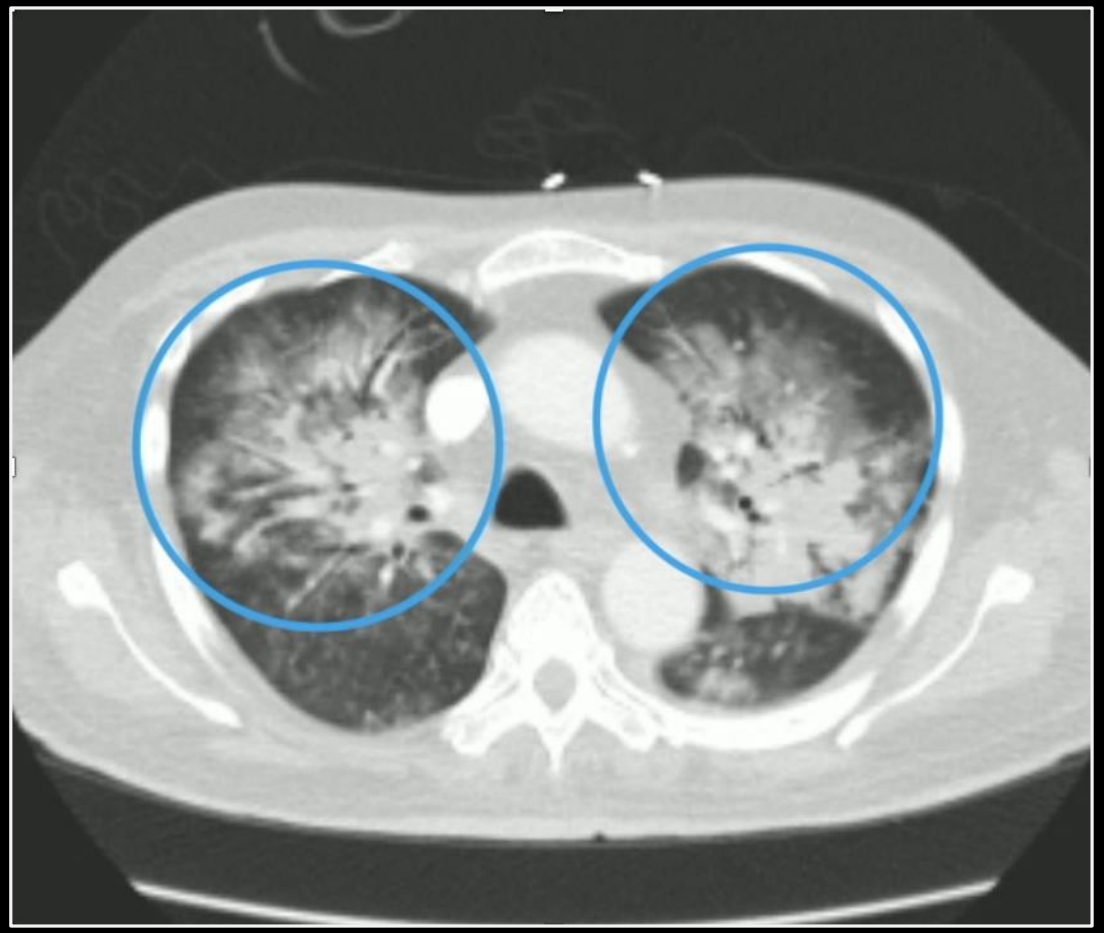
COVID-19 pneumonia



Ground glass opacity

Consolidation

COVID-19 pneumonia

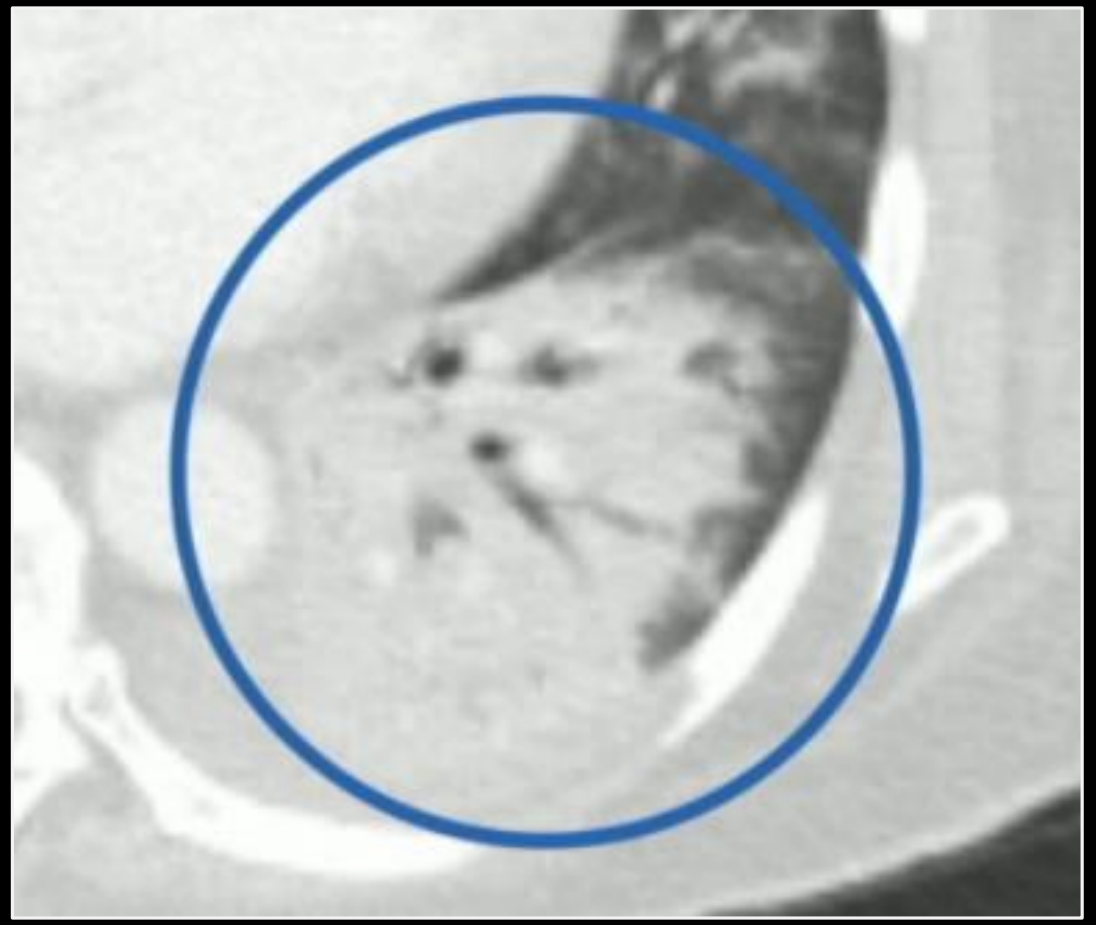


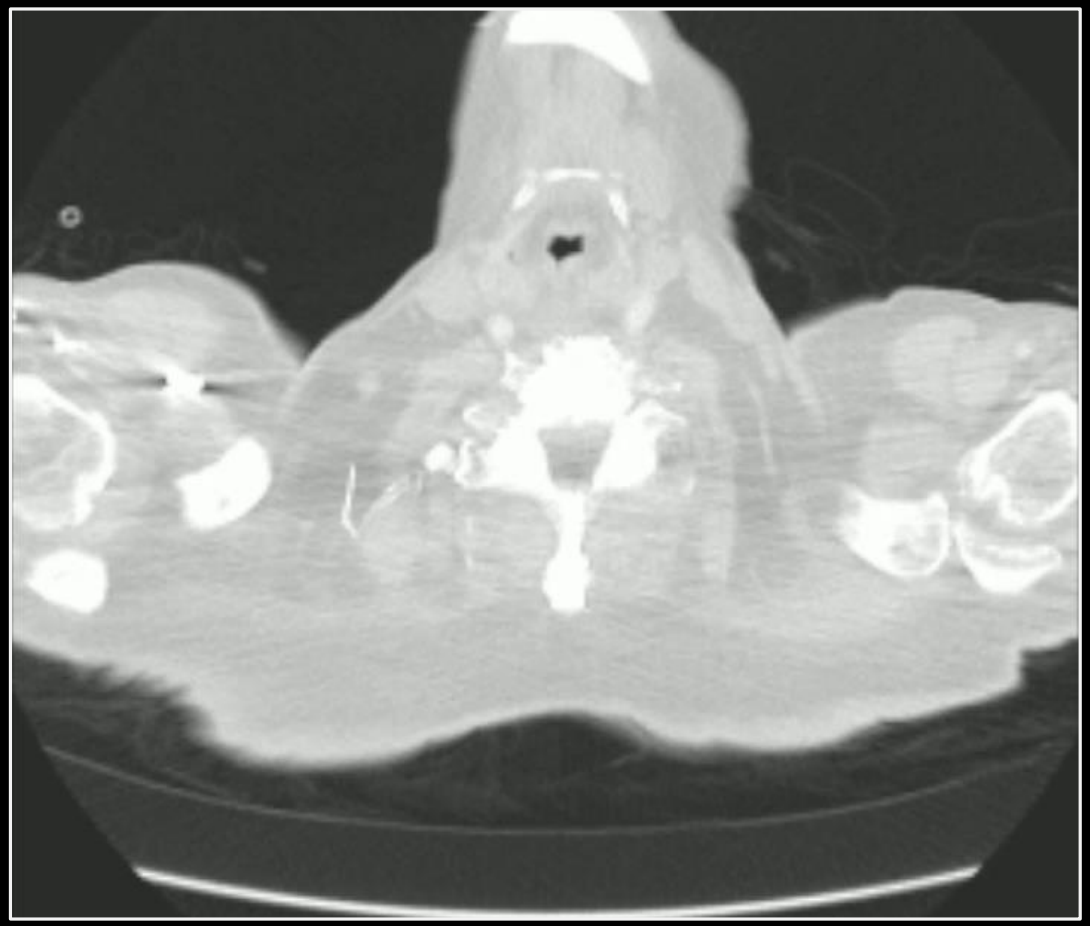
Ground glass opacity
Consolidation

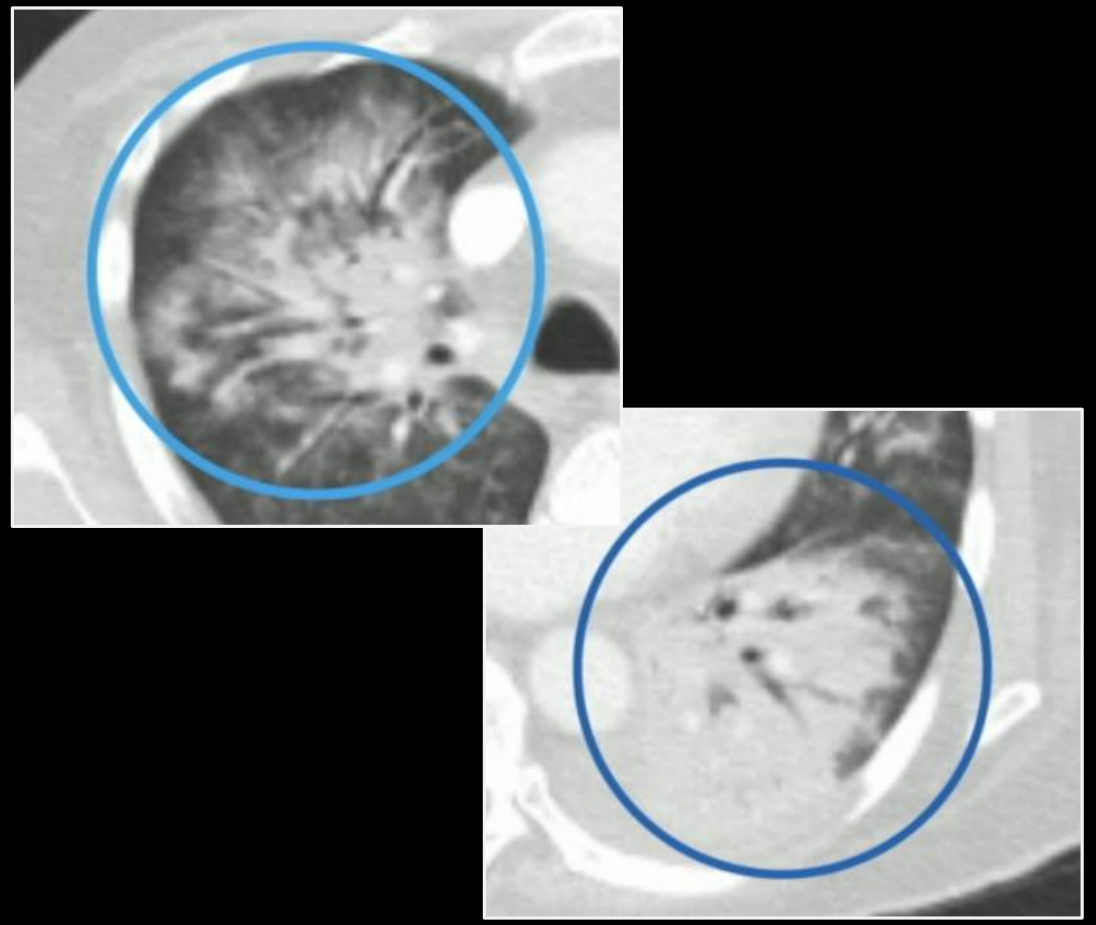
COVID-19 pneumonia

Ground glass opacity
Consolidation

COVID-19 pneumonia

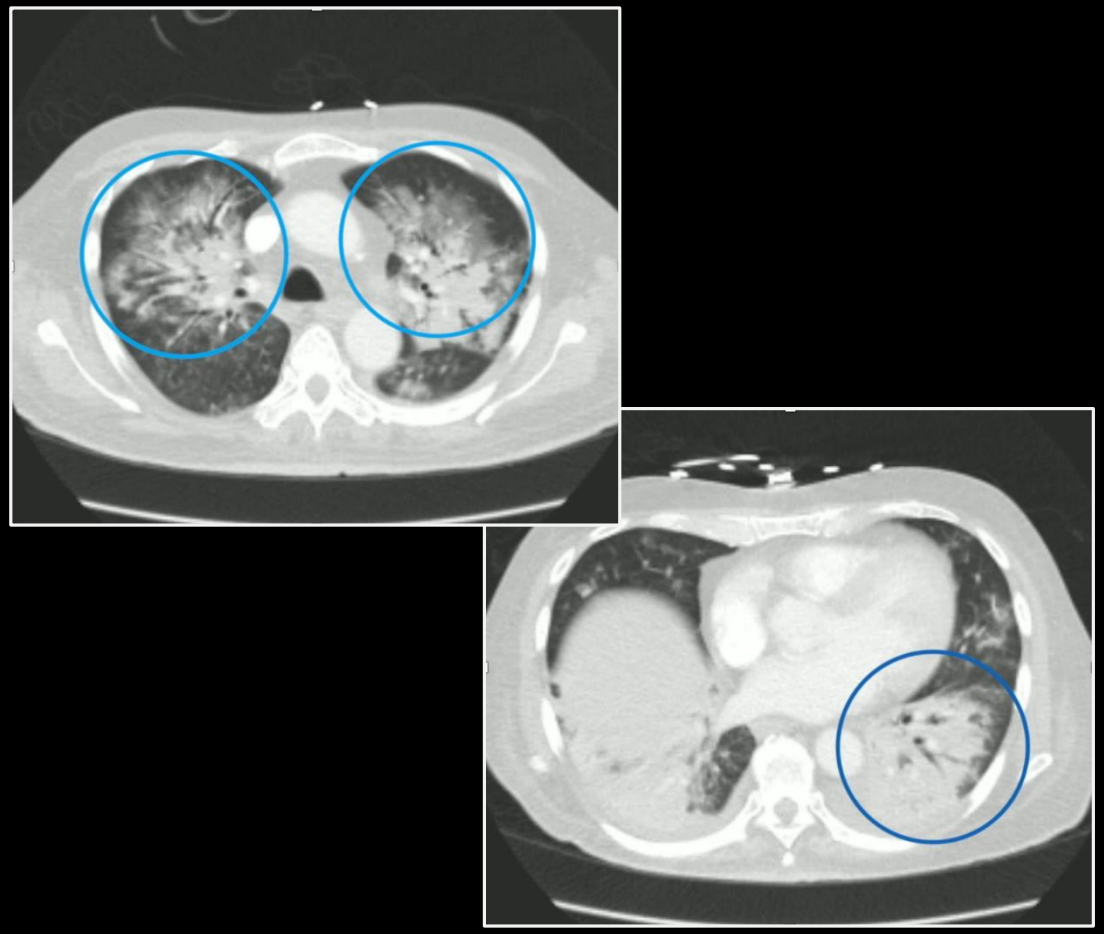




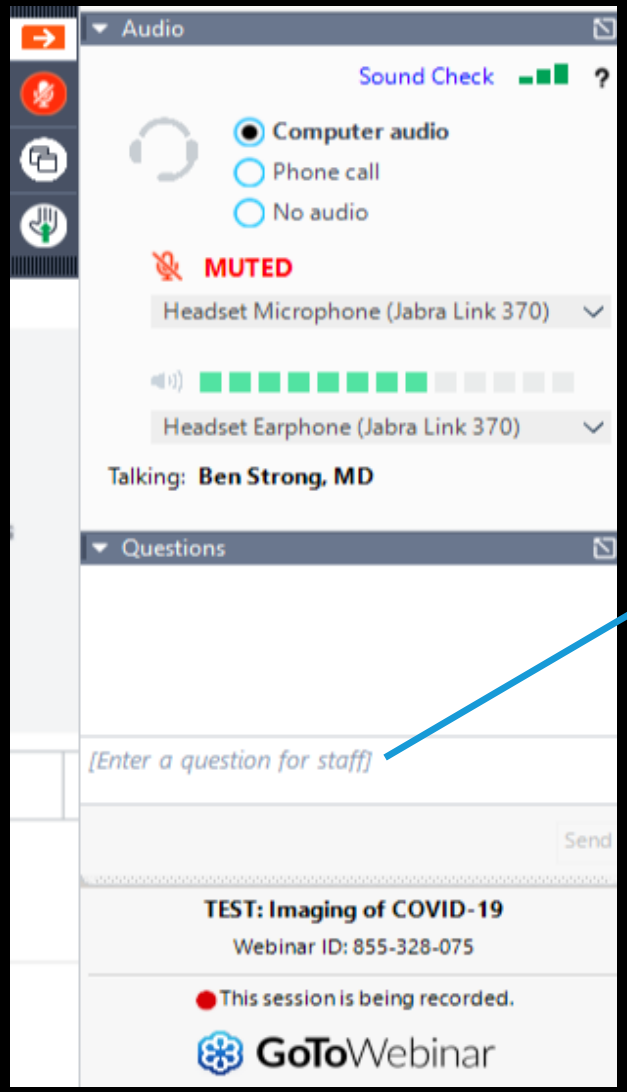


Ground glass opacity
Consolidation

COVID-19 pneumonia



Asking Questions



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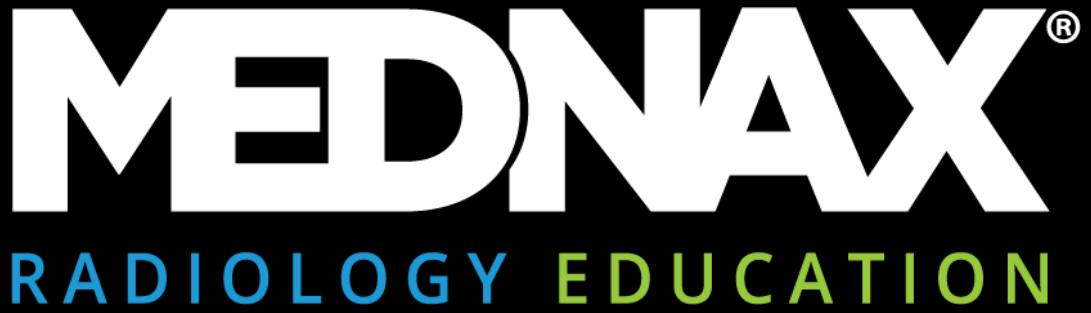
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