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EUROPEAN SOCIETY FOR EMERGENCY MEDICINE

WEBINAR COVID-19 in the series: How to treat the disease

Imaging in COVID-19

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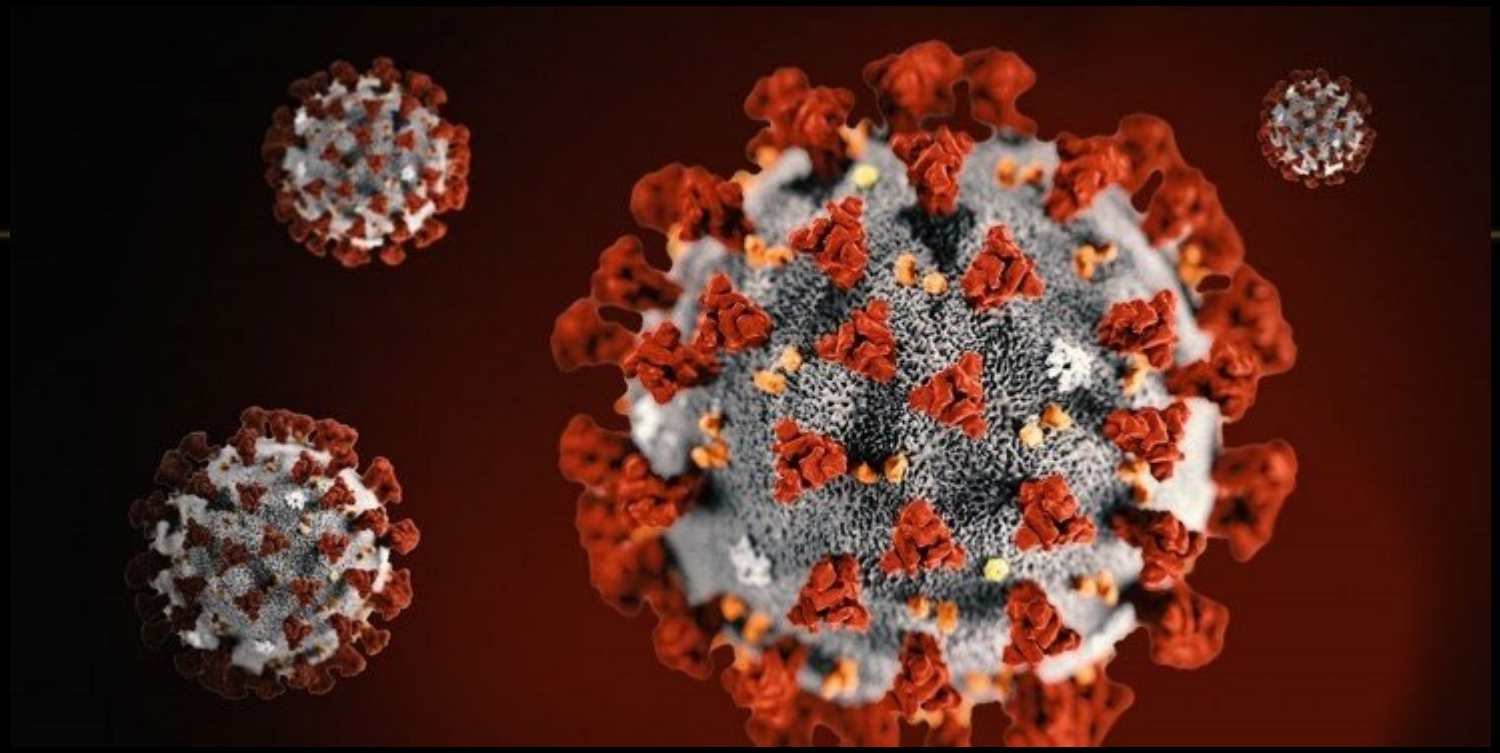
Position: a Consultant Cardiothoracic Radiologist for The Newcastle-Upon-Tyne Hospitals Foundation Trust
Country: UK

IS THERE ANY PLACE FOR CHEST X-RAY IN COVID 19 PATIENTS?



EMERGENCY DEPARTMENT

- Acutely Unwell – positive diagnosis
- Tests
  - PCR specific
  - Imaging – not specific to single condition
  - Comorbidities – dual pathology
- CXR – guide to severity and monitoring

- GOLD STANDARD -> COMBINATION

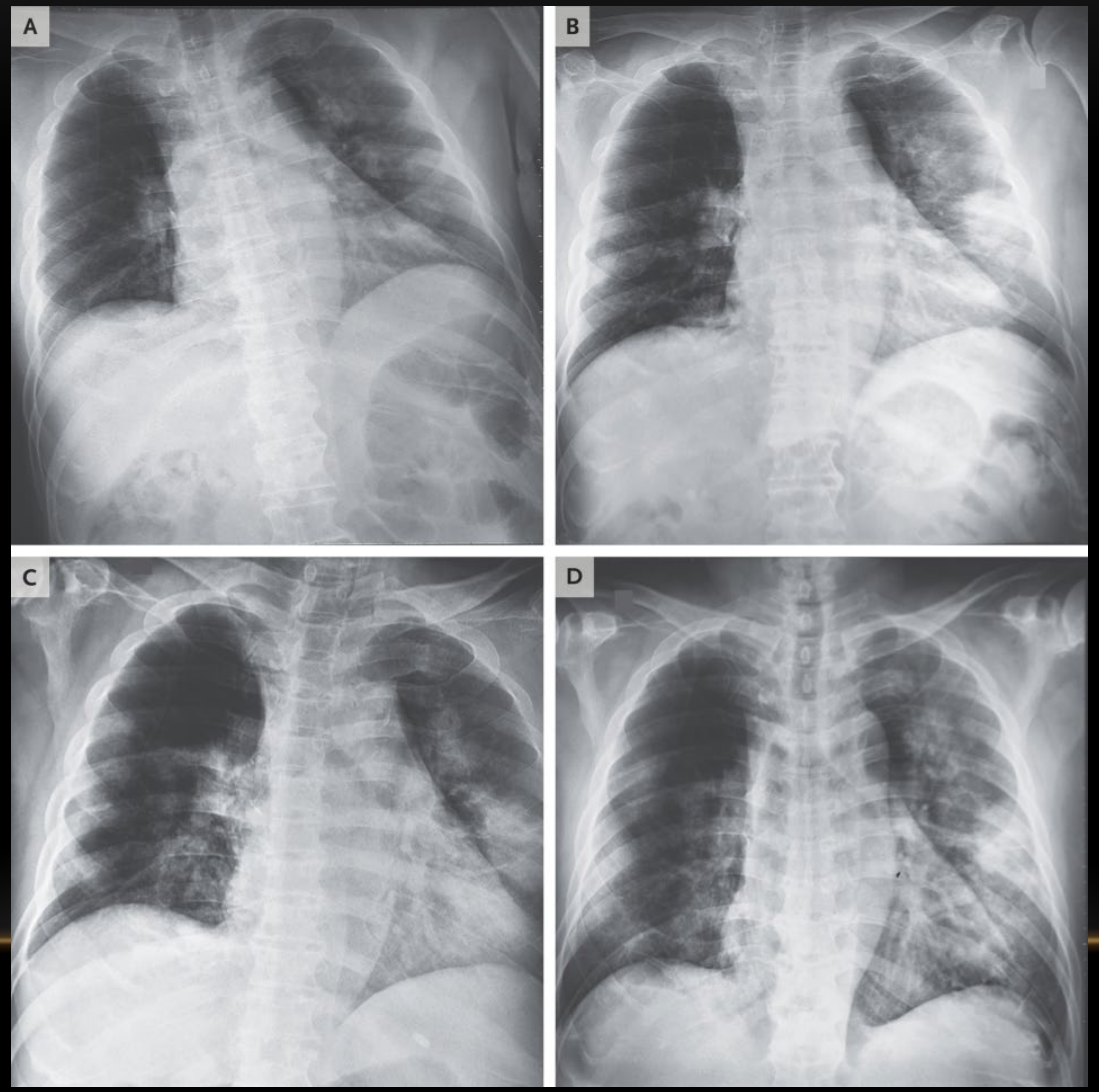
CXR - EVIDENCE COVID-19

- Data limited
- Case reports
- 3 retrospective studies
  - 64 patients
  - 3 of 5 patient had abnormal CXR with abnormal CT
  - 4 of 20 abnormal CXR with abnormal
- CXR not sensitive (limited data)

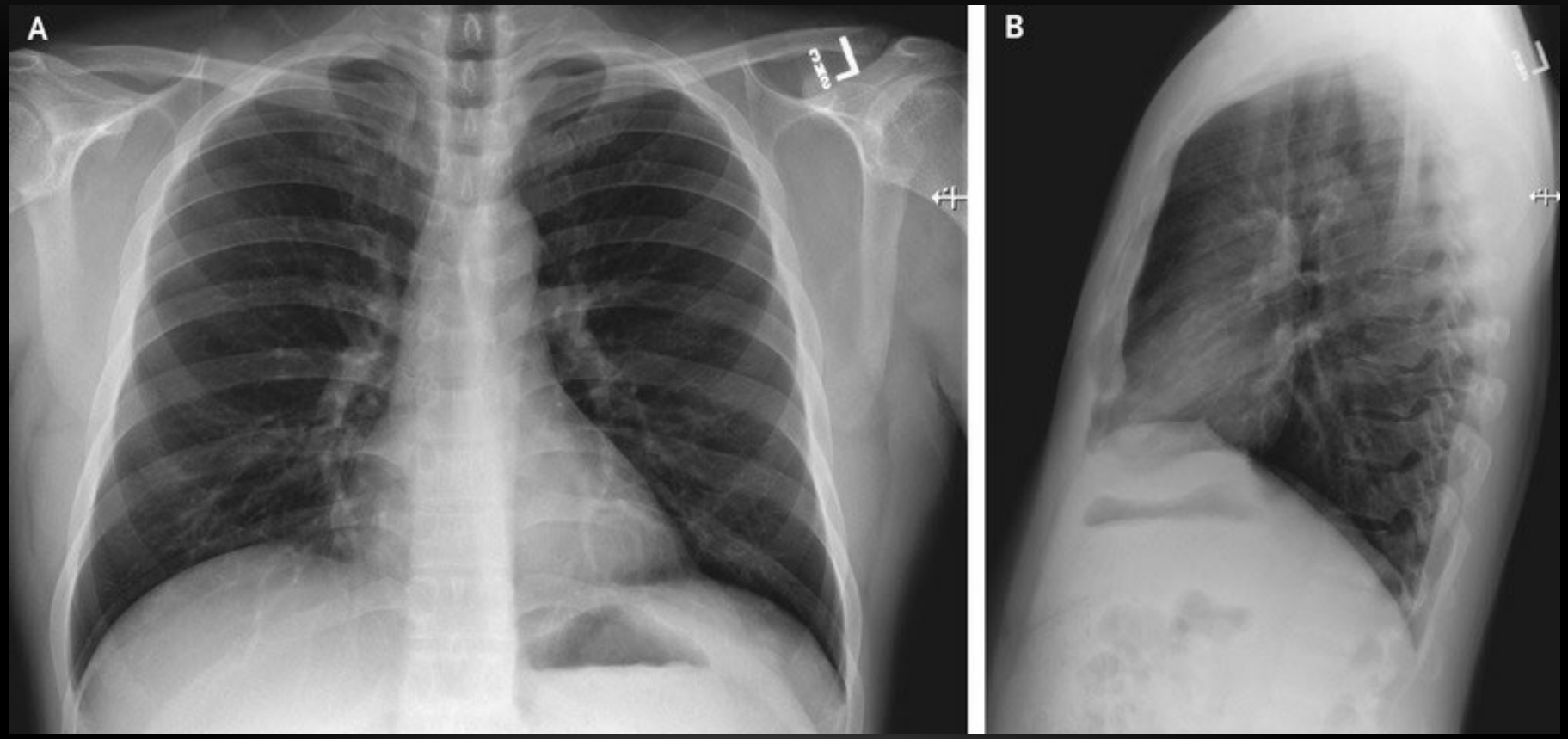
Table 2. Overall radiographic findings on chest x-ray (CXR) in 64 patients. Figures are presented as whole numbers with percentages in brackets.

Characteristic	Number (% of 64 patients)
Number of normal baseline CXRs	20 (31%)
Number of abnormal baseline CXRs	44 (69%)
Number of patients with normal baseline CXRs later becoming abnormal	7 (11%)
Type of parenchymal opacity at baseline CXR	
Consolidation	30 (59%)
Ground glass opacities	21 (41%)
Distribution at baseline CXR	
Peripheral predominant	26 (51%)
Perihilar predominant	6 (12%)
Neither peripheral nor perihilar	19 (37%)
Right lung	10 (20%)
Left lung	9 (18%)
Bilateral lungs	32 (63%)
Upper zone predominant	0 (0%)
Lower zone predominant	32 (63%)
No zonal predominance	19 (37%)
Other features on baseline CXR	
Pleural effusion	2 (3%)
Pulmonary nodules	0 (0%)

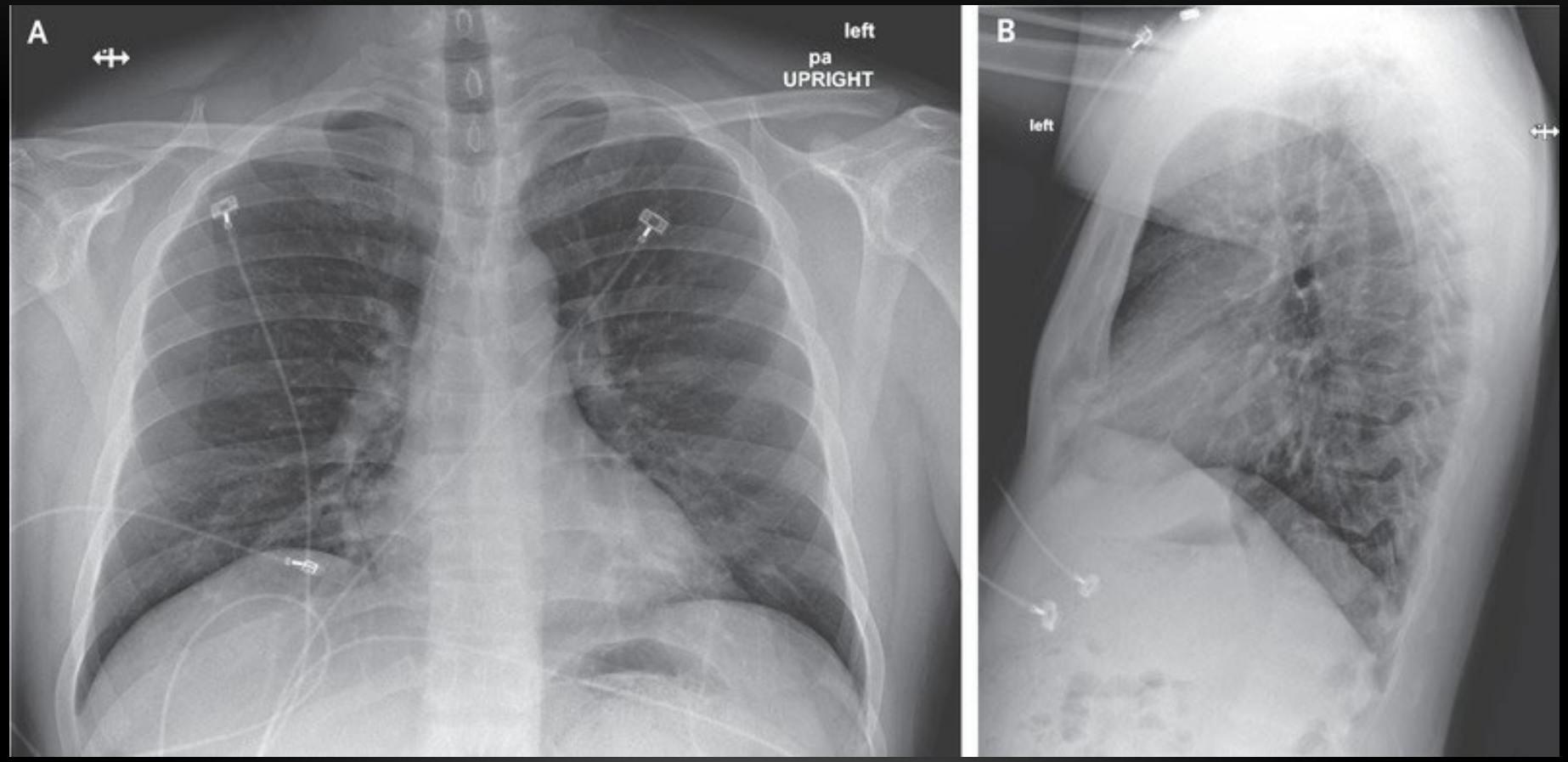
CXR – SERIAL CHANGES



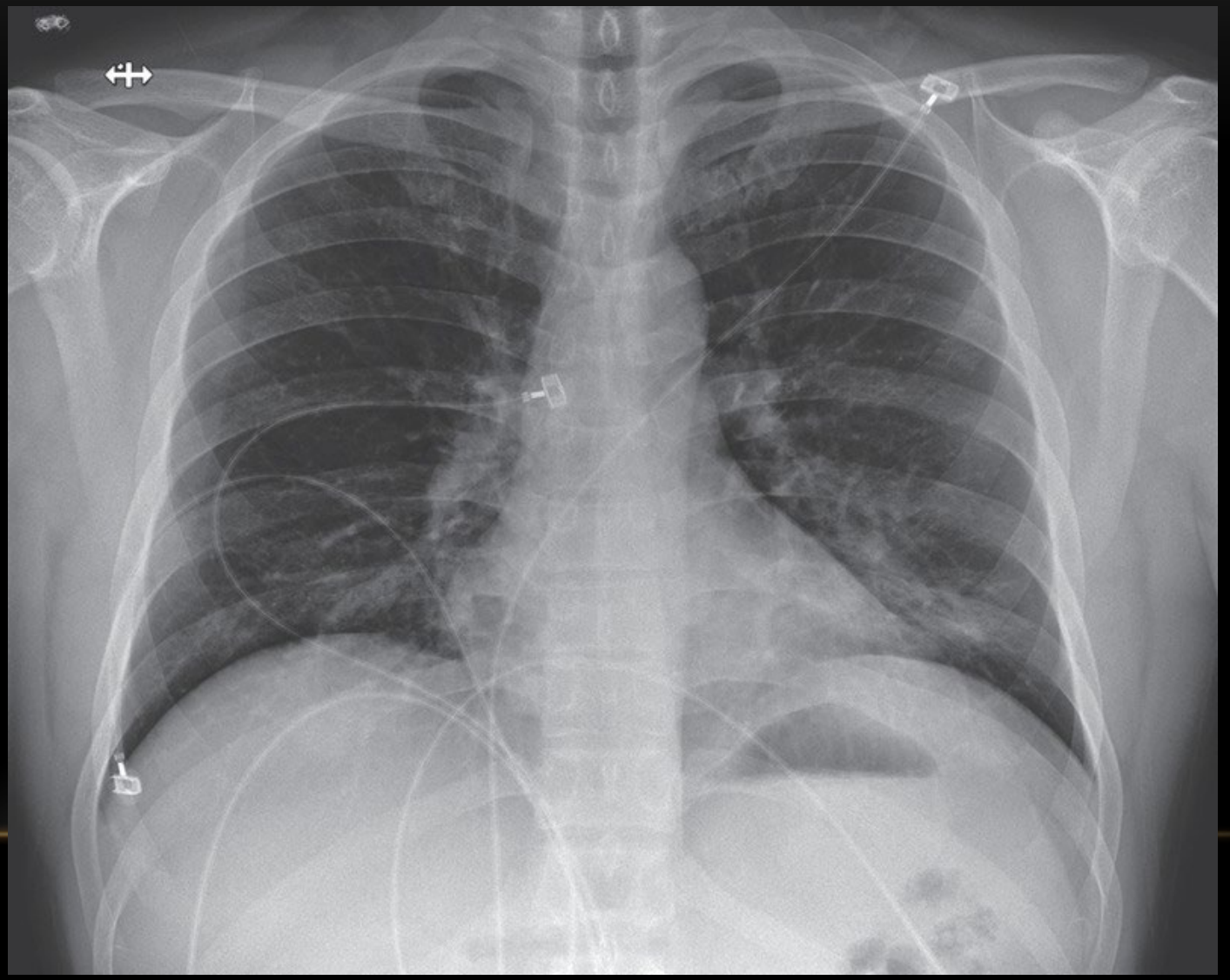
CASE 2 - DAY 4



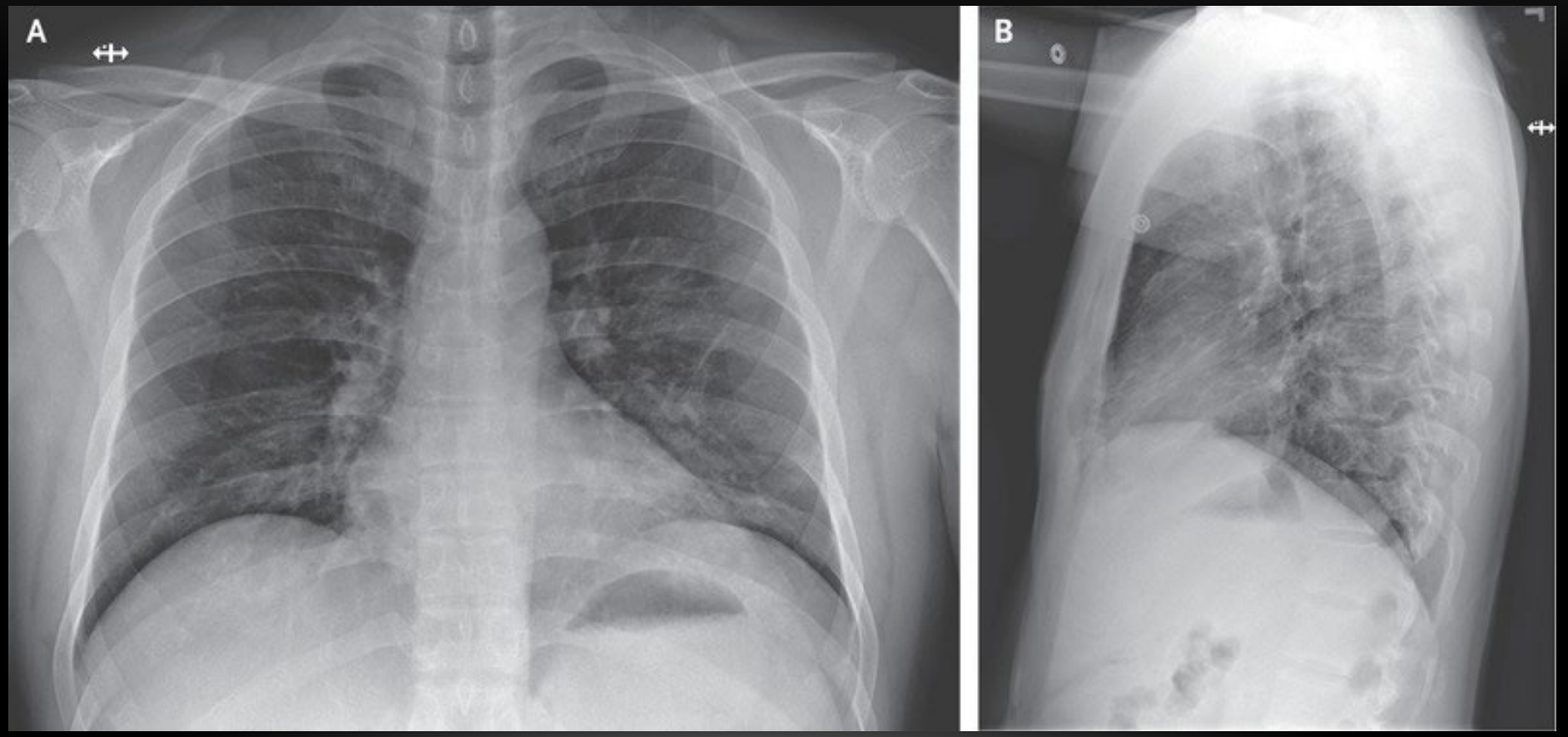
CASE 2 - DAY 7



CASE 2 -DAY 9

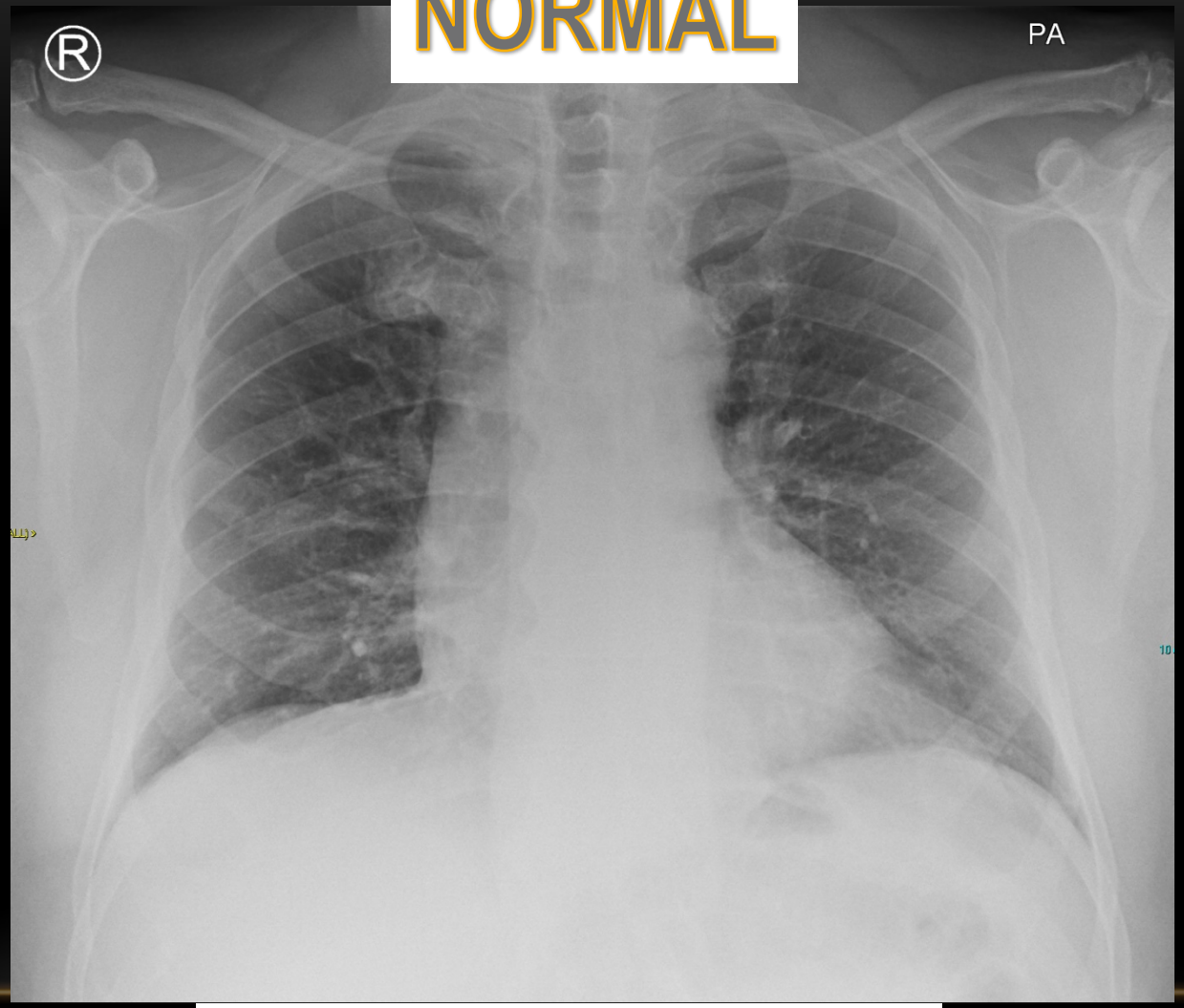


CASE 2 - DAY 10



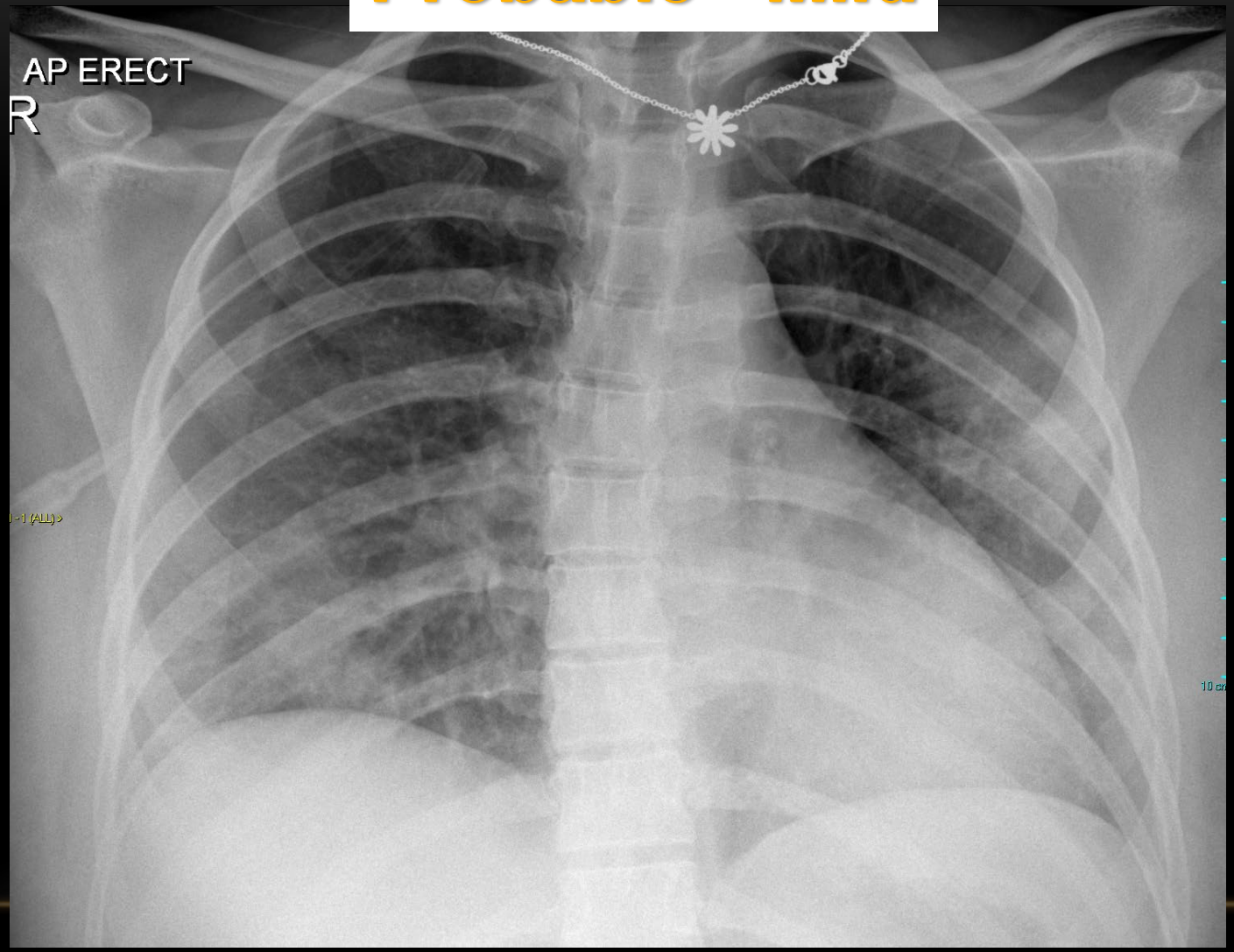
CXR

NORMAL

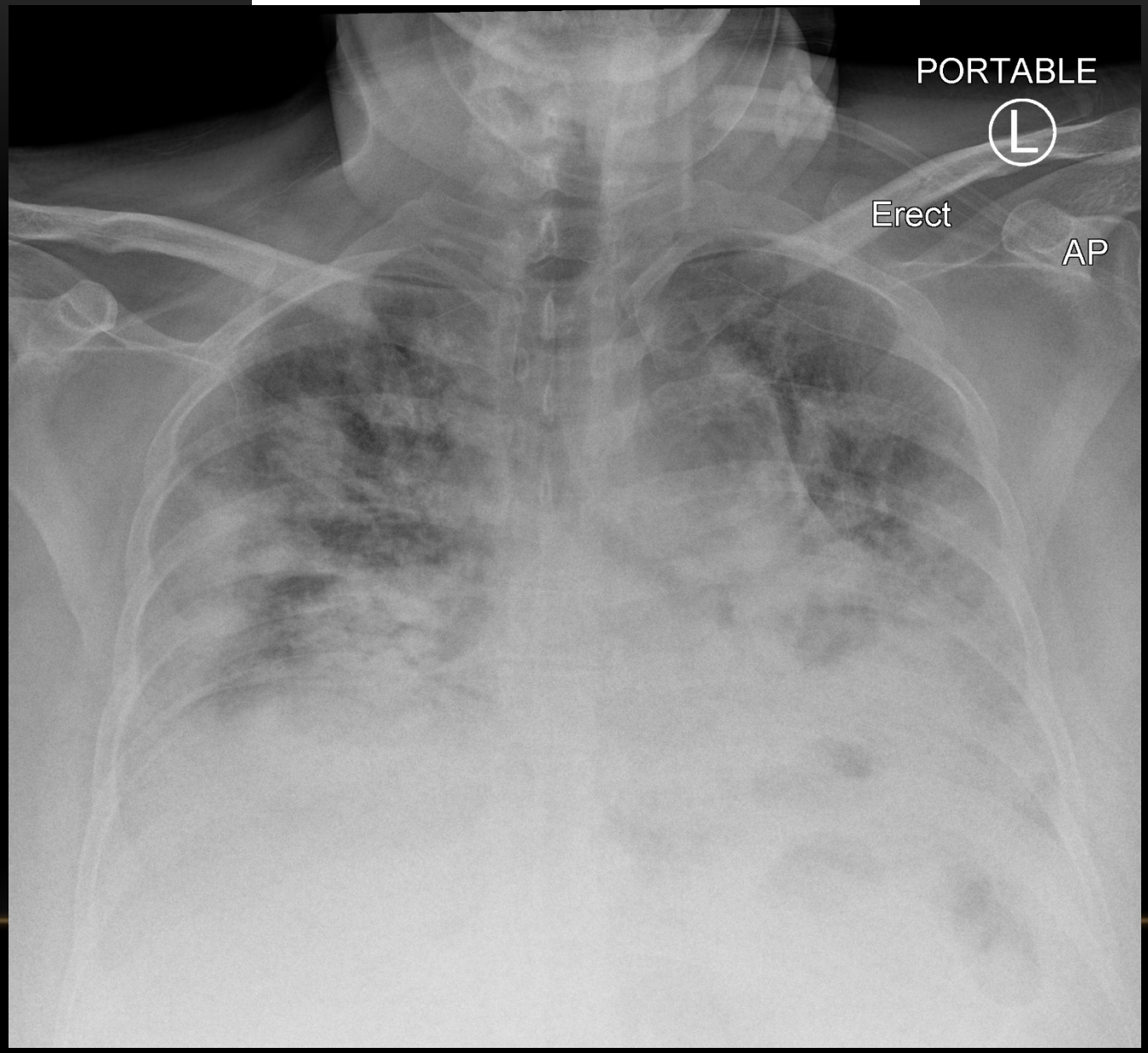


EARLY AND MILD

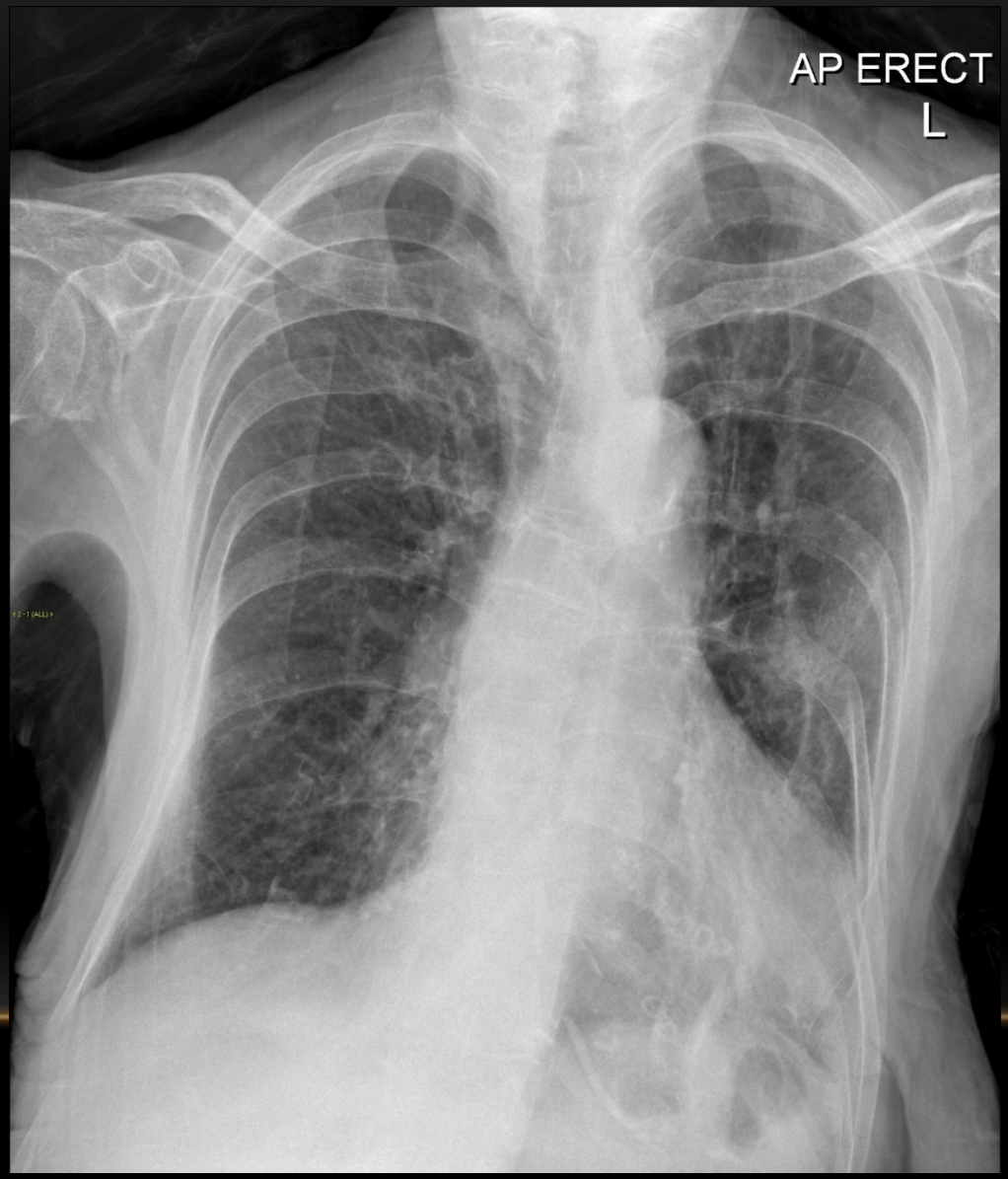
Probable - Mild



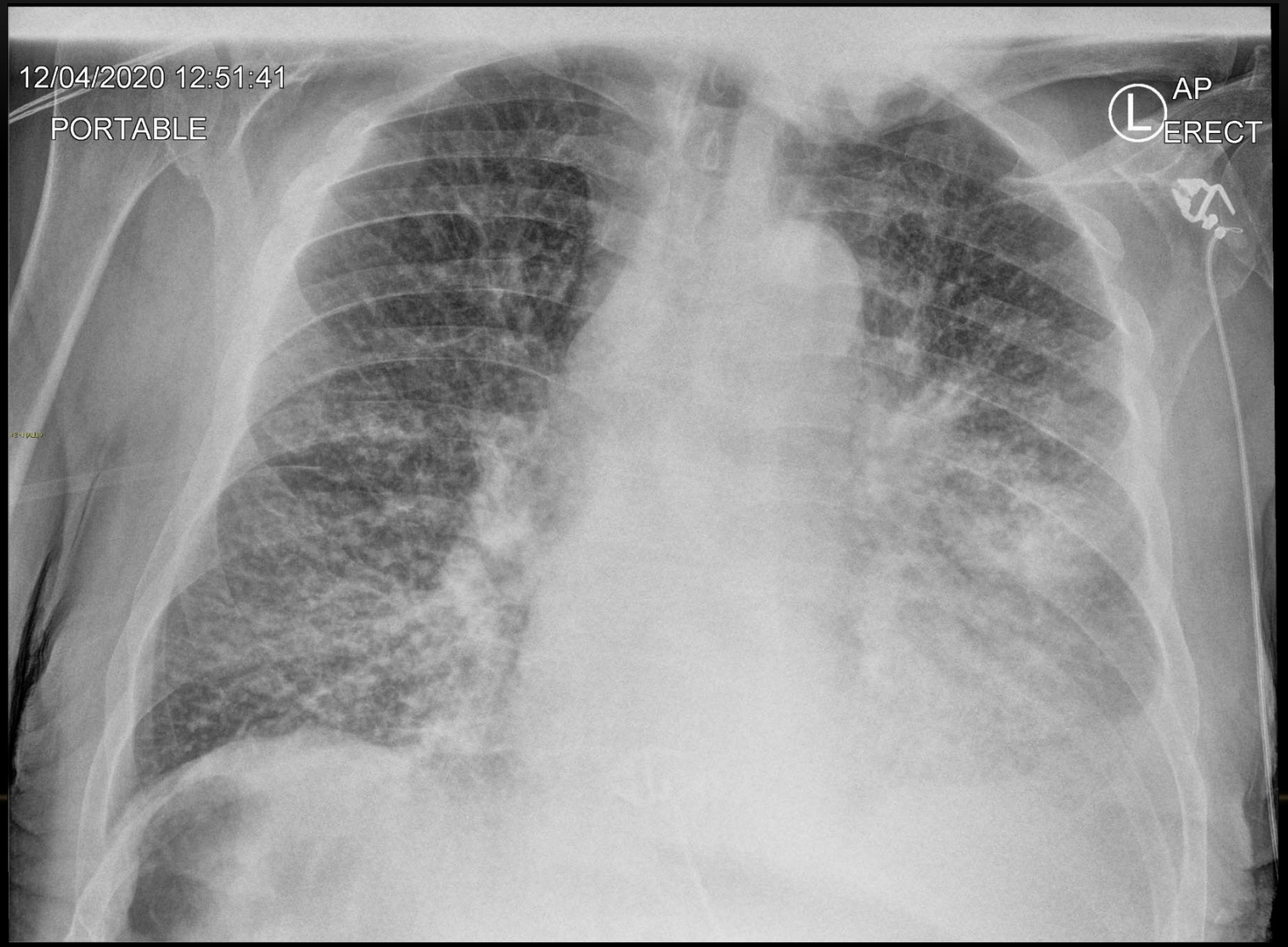
Probable - Severe



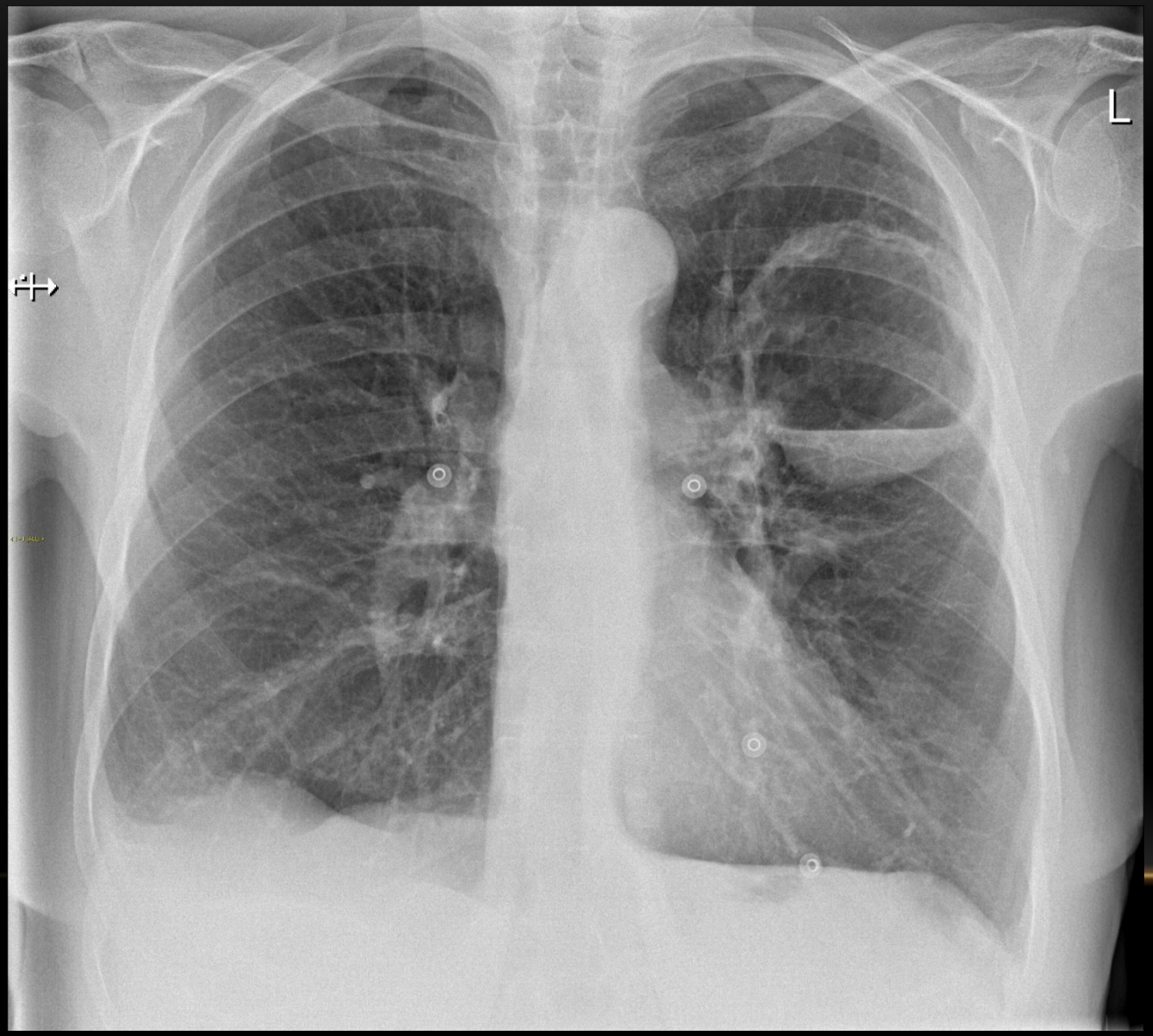
Possible - Asymmetrical



Indeterminate COVID-19

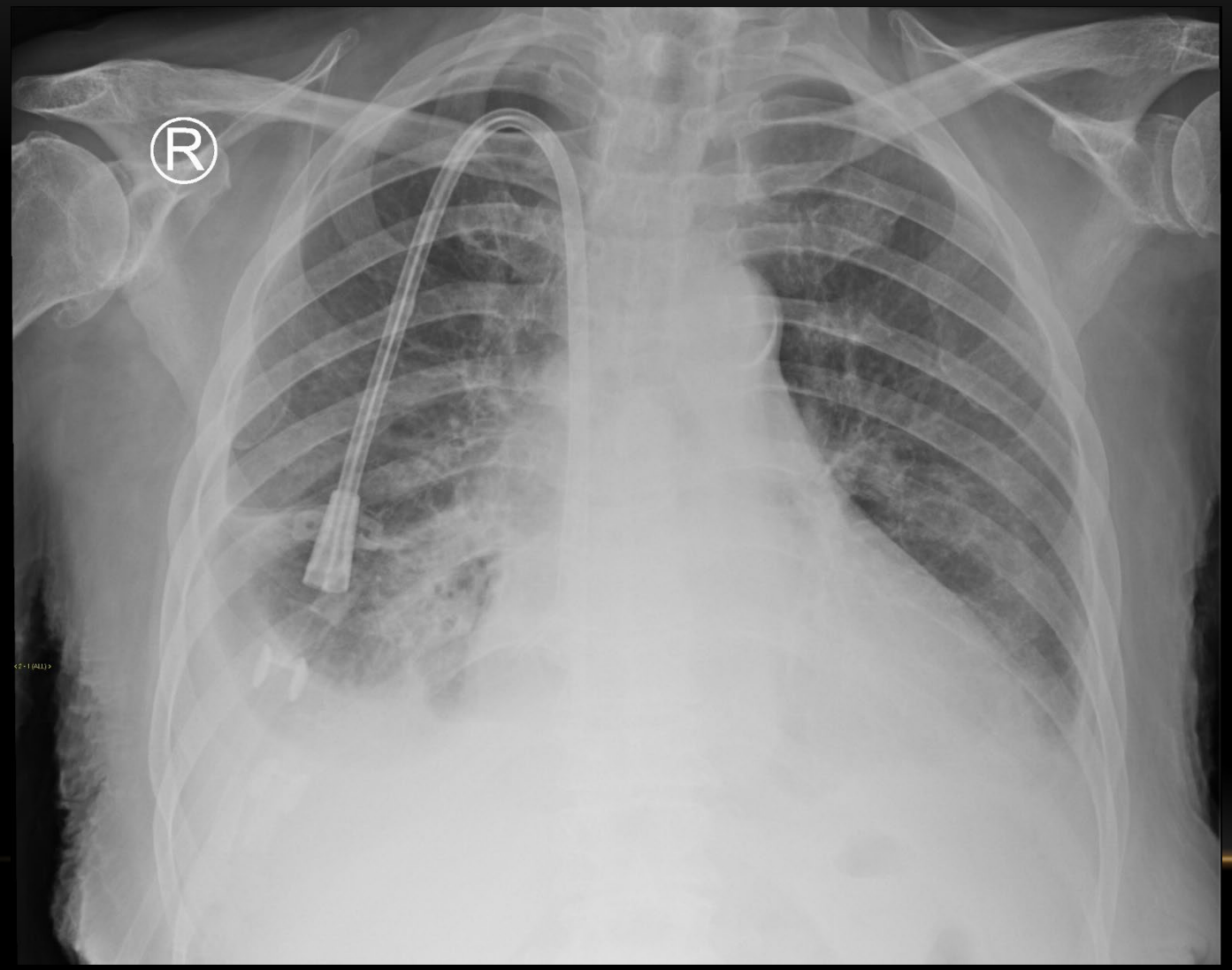


Non COVID-19



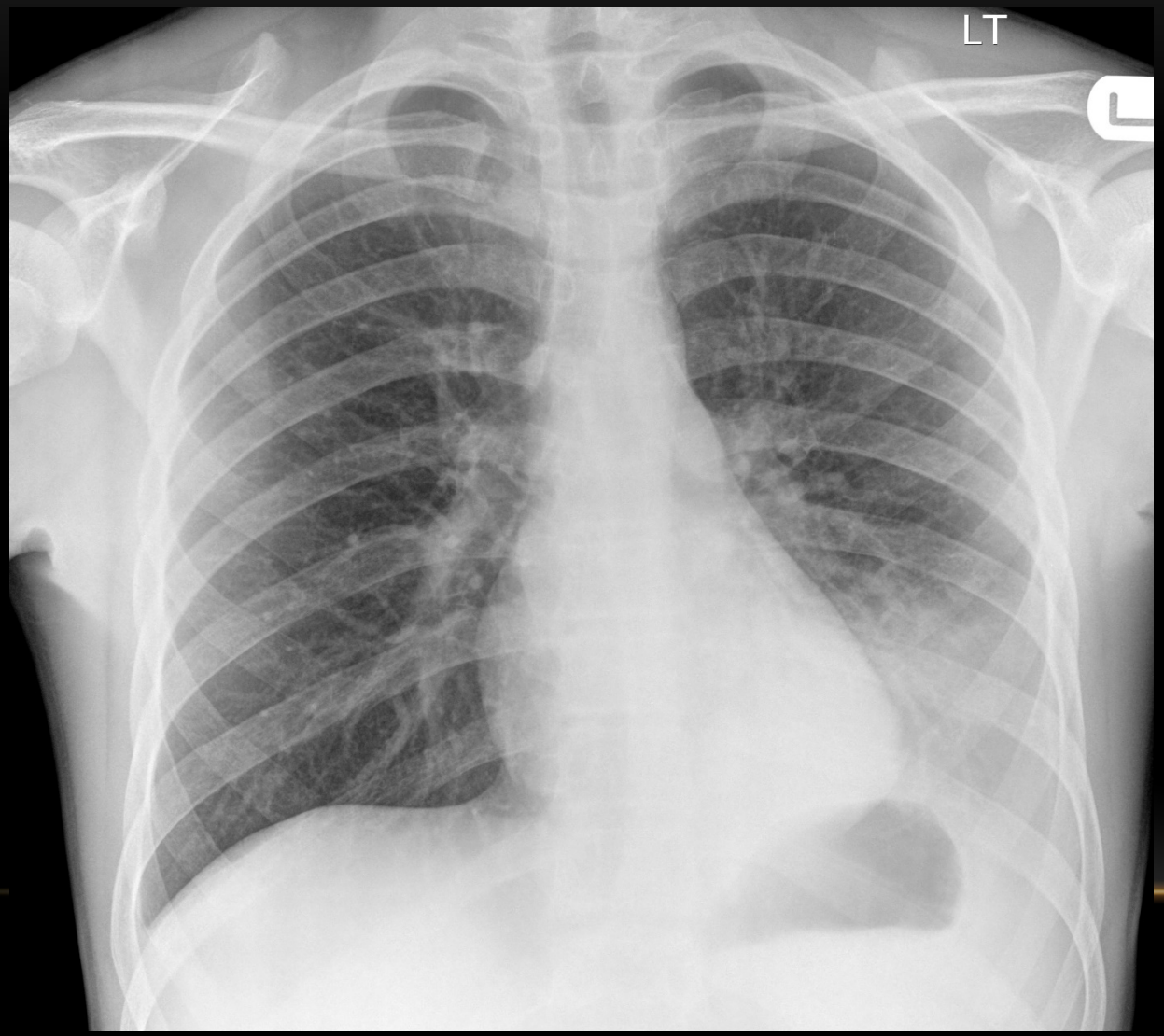
Cavitation

Non COVID-19



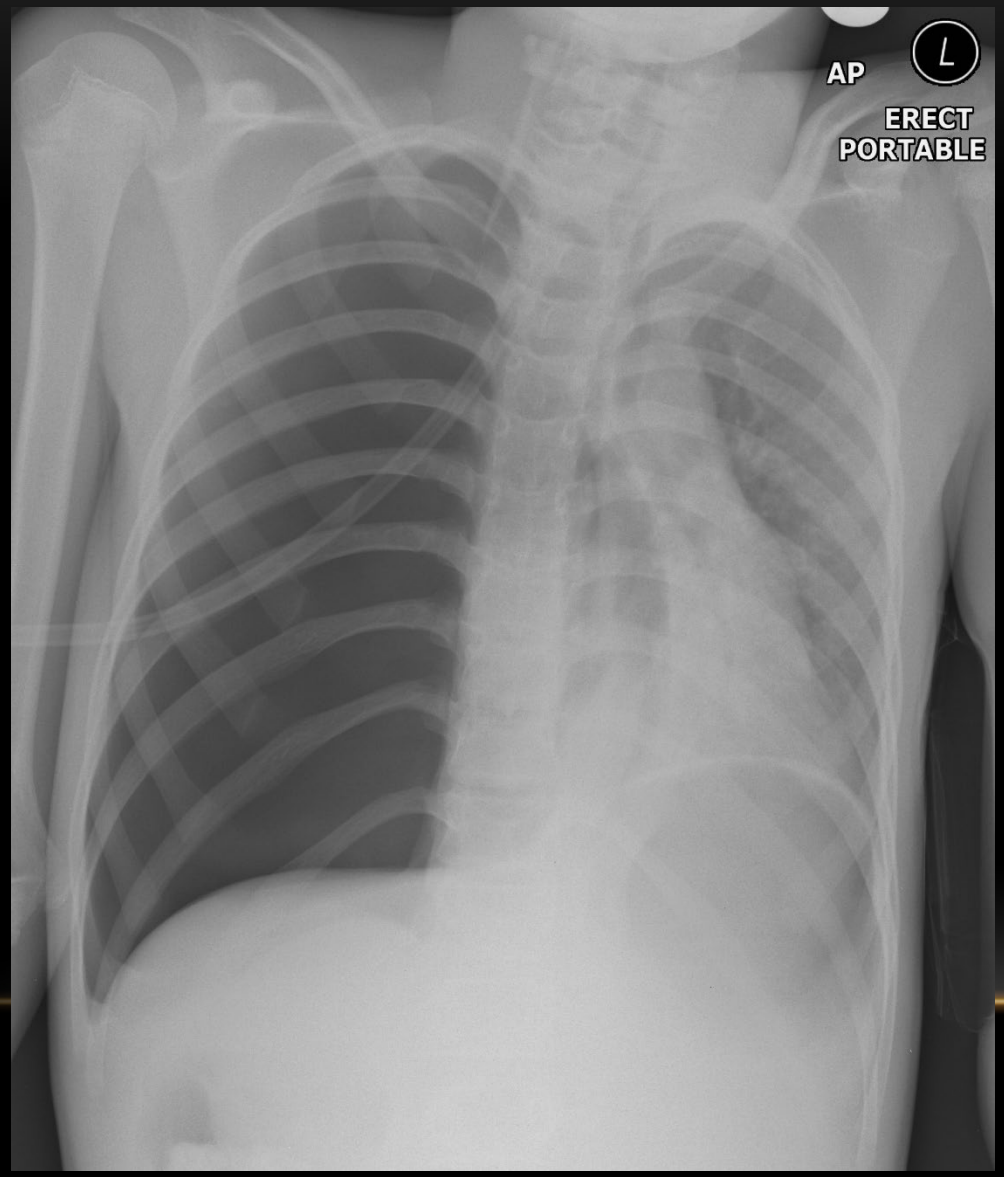
Pleural effusions

Non COVID-19



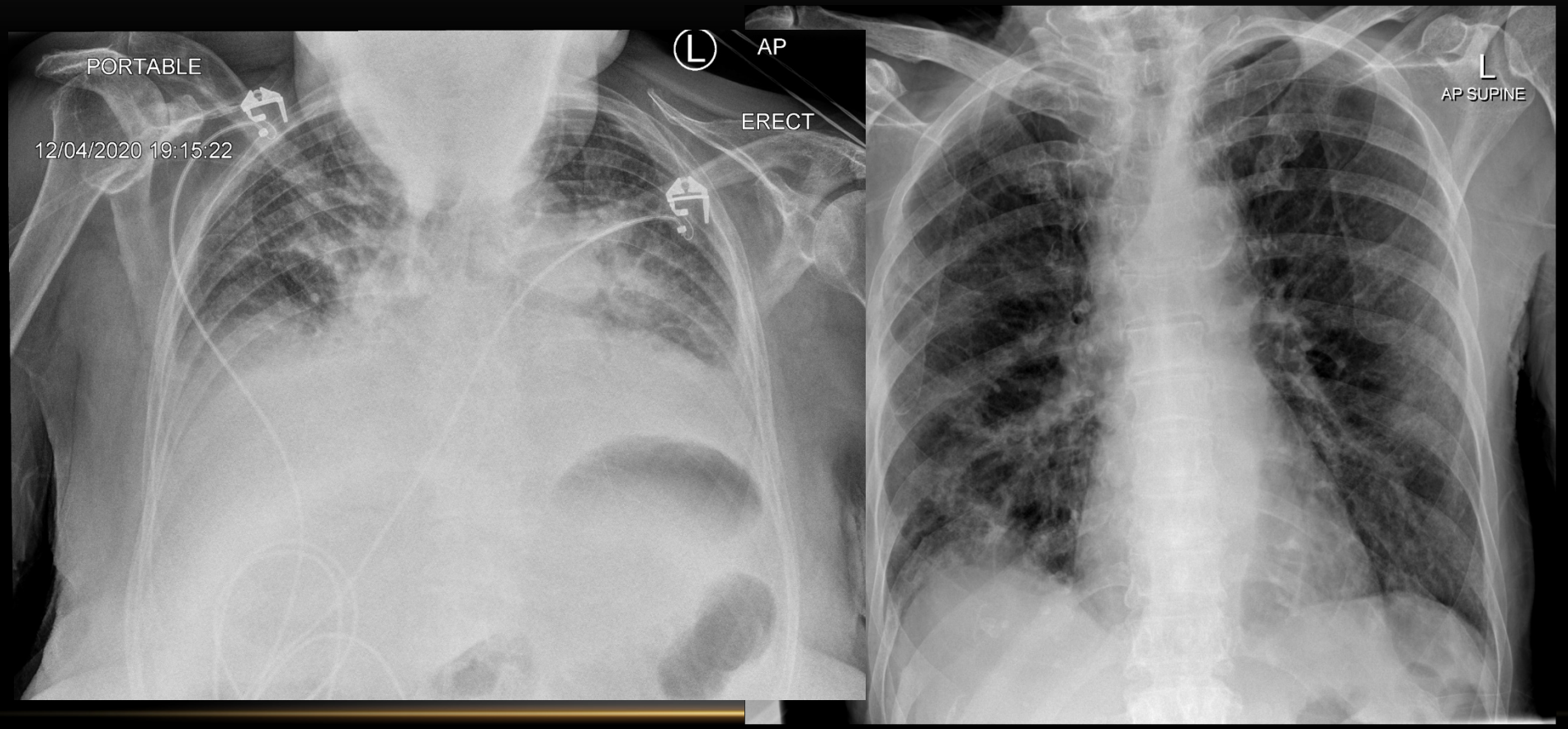
Lobar pneumonia

Non COVID-19



Pneumothorax

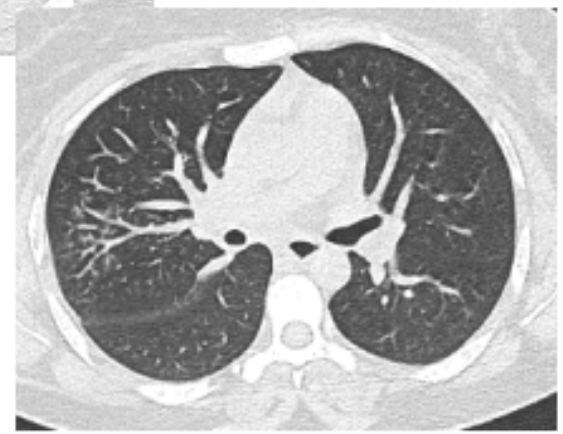
Suboptimal



Alternative diagnosis

The following would be unusual in COVID -19 infection:

- Lobar pneumonia
- Cavitating infections
- Tree-in bud changes



Differentiating abnormalities in the presence of underlying emphysema or interstitial lung disease maybe difficult

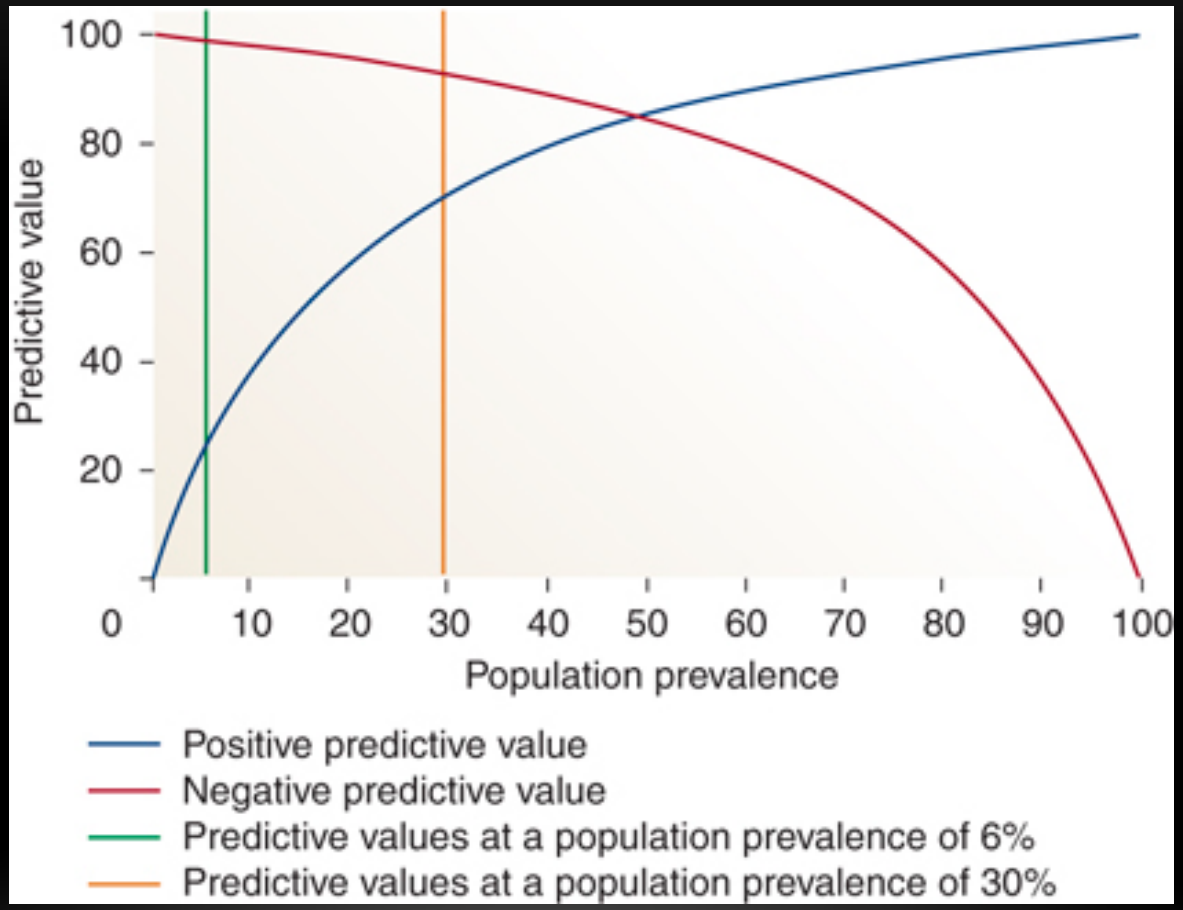
CXR IN COVID-19

- Normal – does not exclude COVID-19
- Some patterns make COVID less likely

- Meta-analysis CT and PCR: pooled specificity 37%

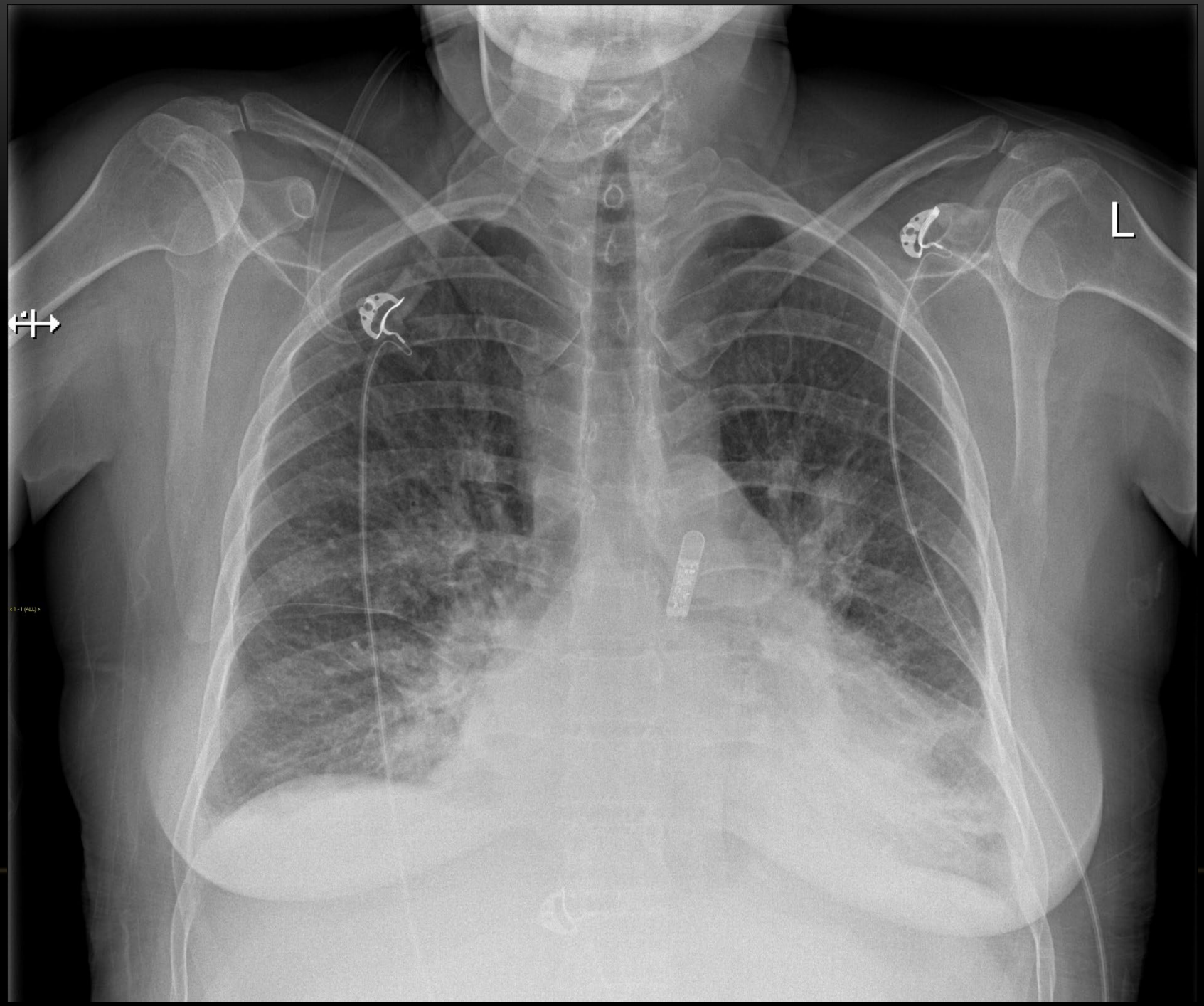
- Radiologists will get it wrong in isolation!

EFFECT PREVALENCE



CLINICAL VIGNETTE

- A 56 year old woman presents with chest pain, shortness of breath and fever.
- Which of the following tests are indicated?
- A. Full blood count
- B. CRP
- C. D-dimer
- D. CXR
- E. CTPA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COMING TO HOSPITAL FOR OTHER REASONS

- 89 year old falls and fractures her hip
- Should she have a CXR pre operatively?

- Asymptomatic therefore screening for unsuspected disease
- Good test would have a high negative predictive value
  - PCR
  - CT
  - Combination PCR and CT

CONCLUSION

- Symptomatic patient
- CXR - assess for alternative diagnoses (even if point of care test)
  - Guide need for additional imaging or treatment
- Marker severity
- Baseline for complications or progression
- Non specific – impact of prevalence

- Asymptomatic patients – not a good rule out test

https://www.bsti.org.uk/training-and-education/covid-19-bsti-imaging-database/

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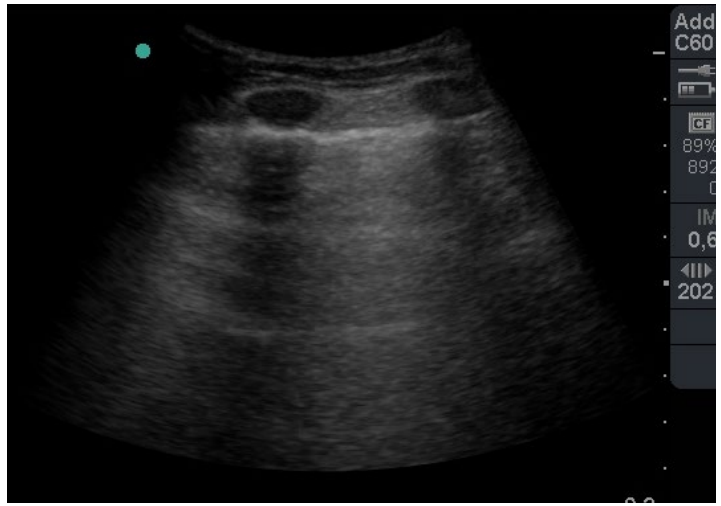
WEBINAR COVID-19 in the series: How to treat the disease

Chest ultrasound: a systematic evaluation helps early staging and control of evolution

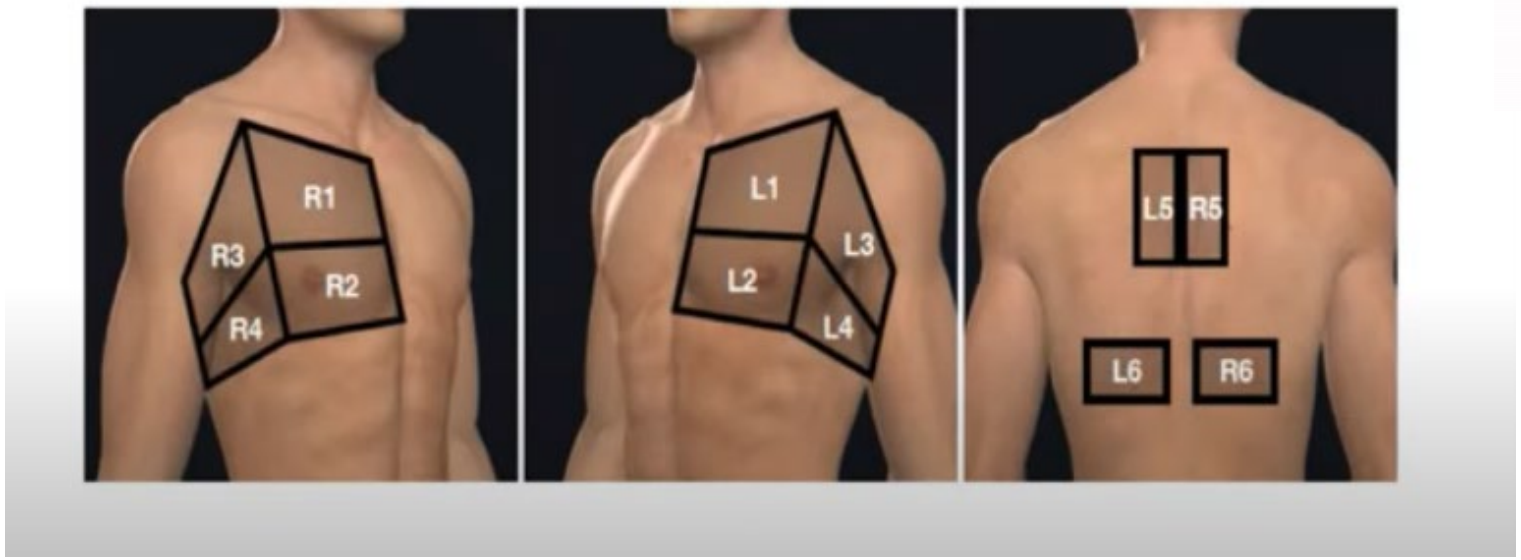
Name: Eugenia Belotti M.D.
Position: ER – Papa Giovanni XXIII Hospital – Bergamo
Country: Italy

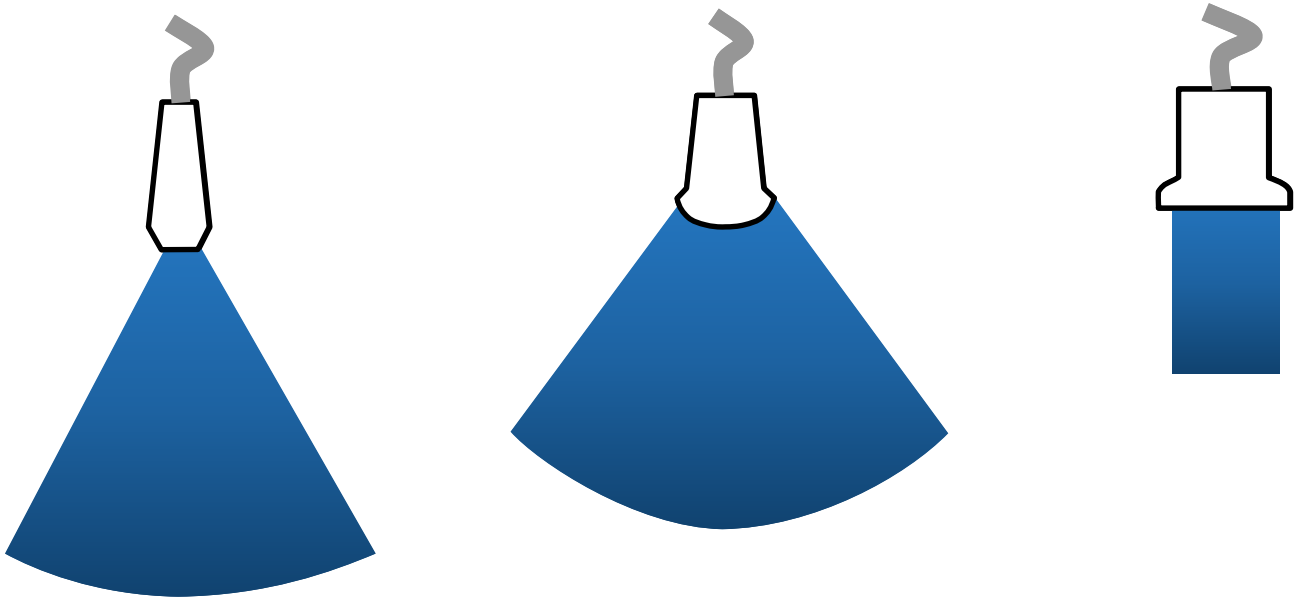
LUNG US

Difference between lung US and traditional US:
Real images vs Artifacts



LUNG US: how to perform



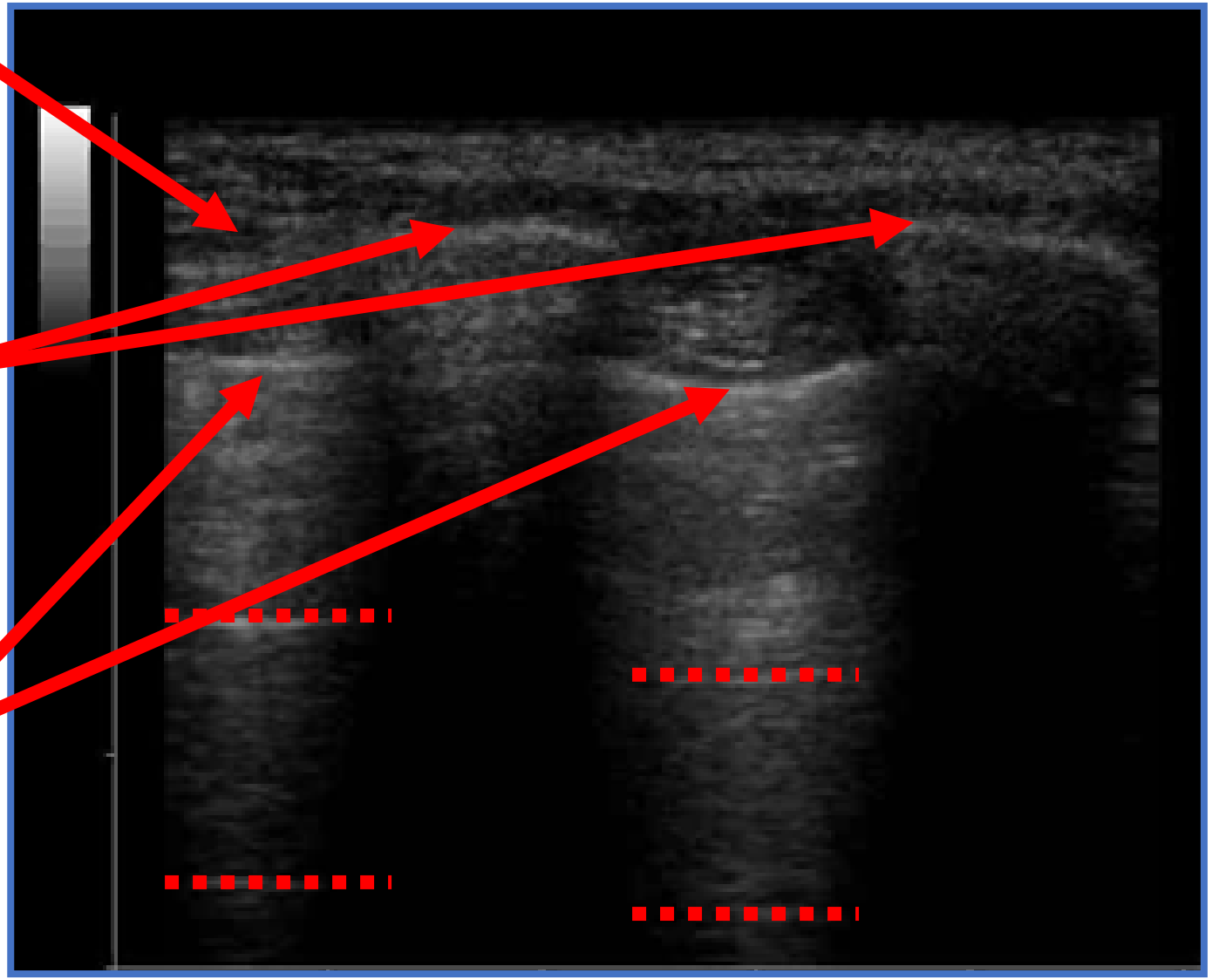


LUNG US: longitudinal scan

Real images:
Skin-subcutaneous tissues-intercostal muscles

Real images + artifact:
Bone cortex + acoustic shadow

Artifacts:
Pleural line + A lines



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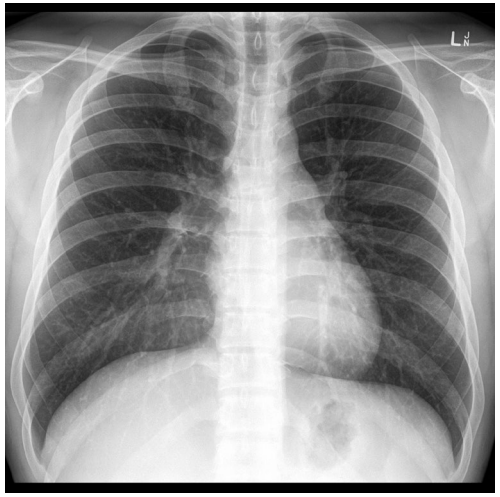
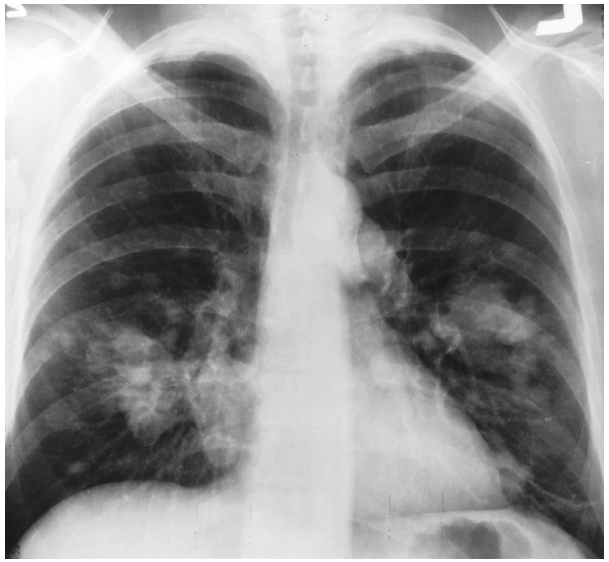
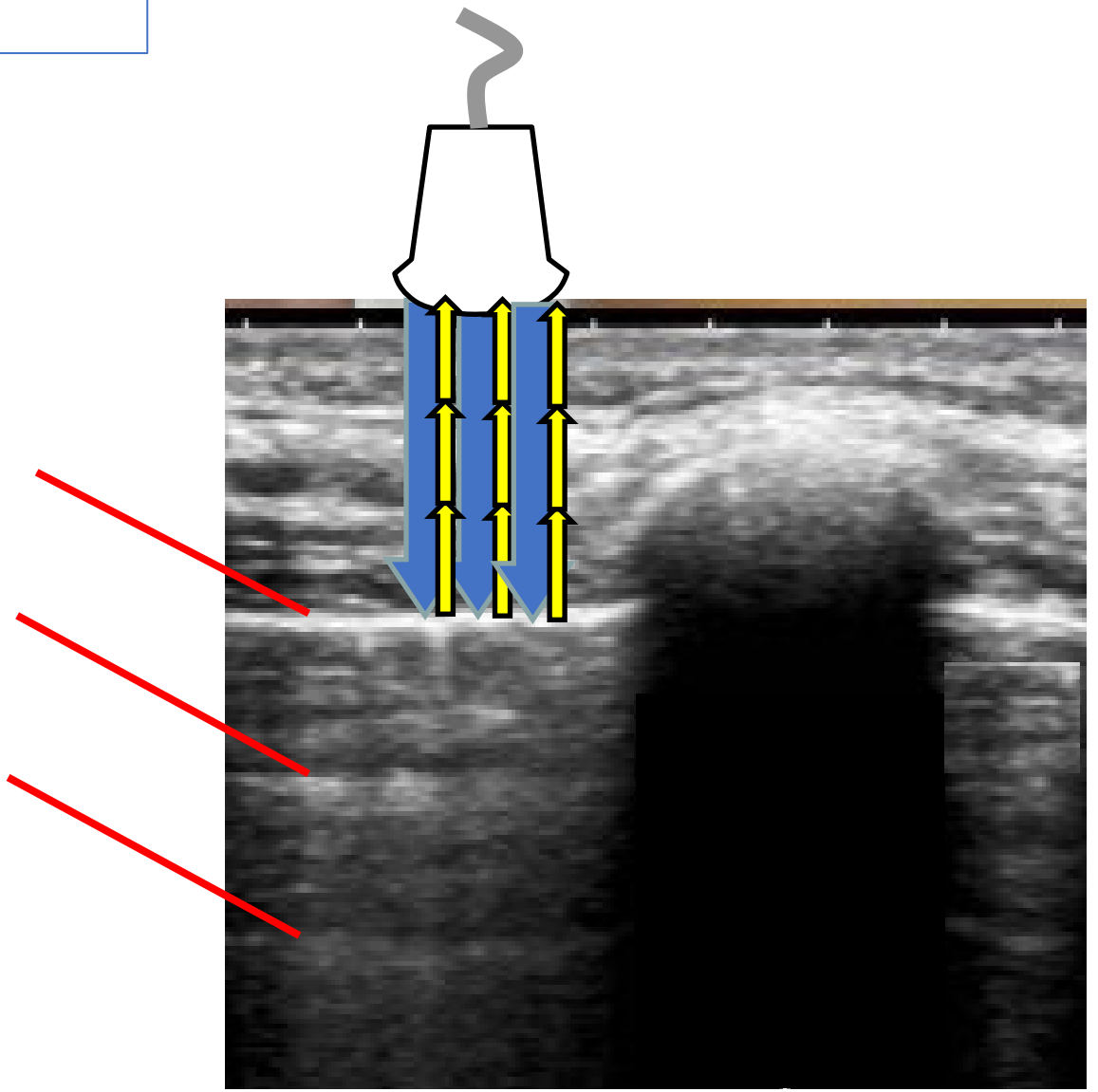
LUNG US: normal pattern: A lines Reverberation artifacts







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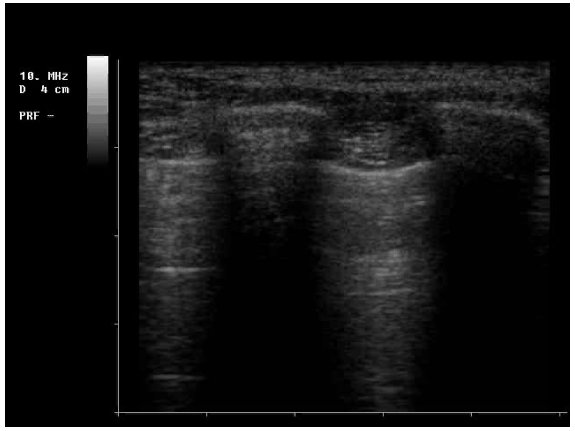
Pattern of lung involvement in COVID-19

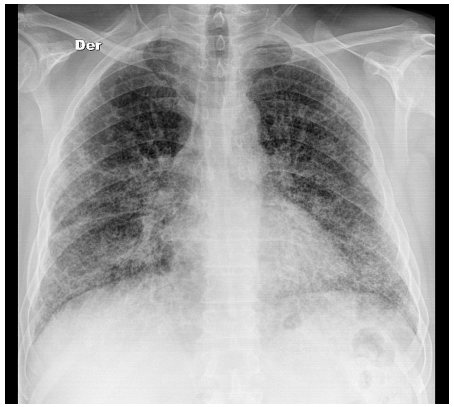
Patchy or confluent lesions tend to be distributed along the pleura.

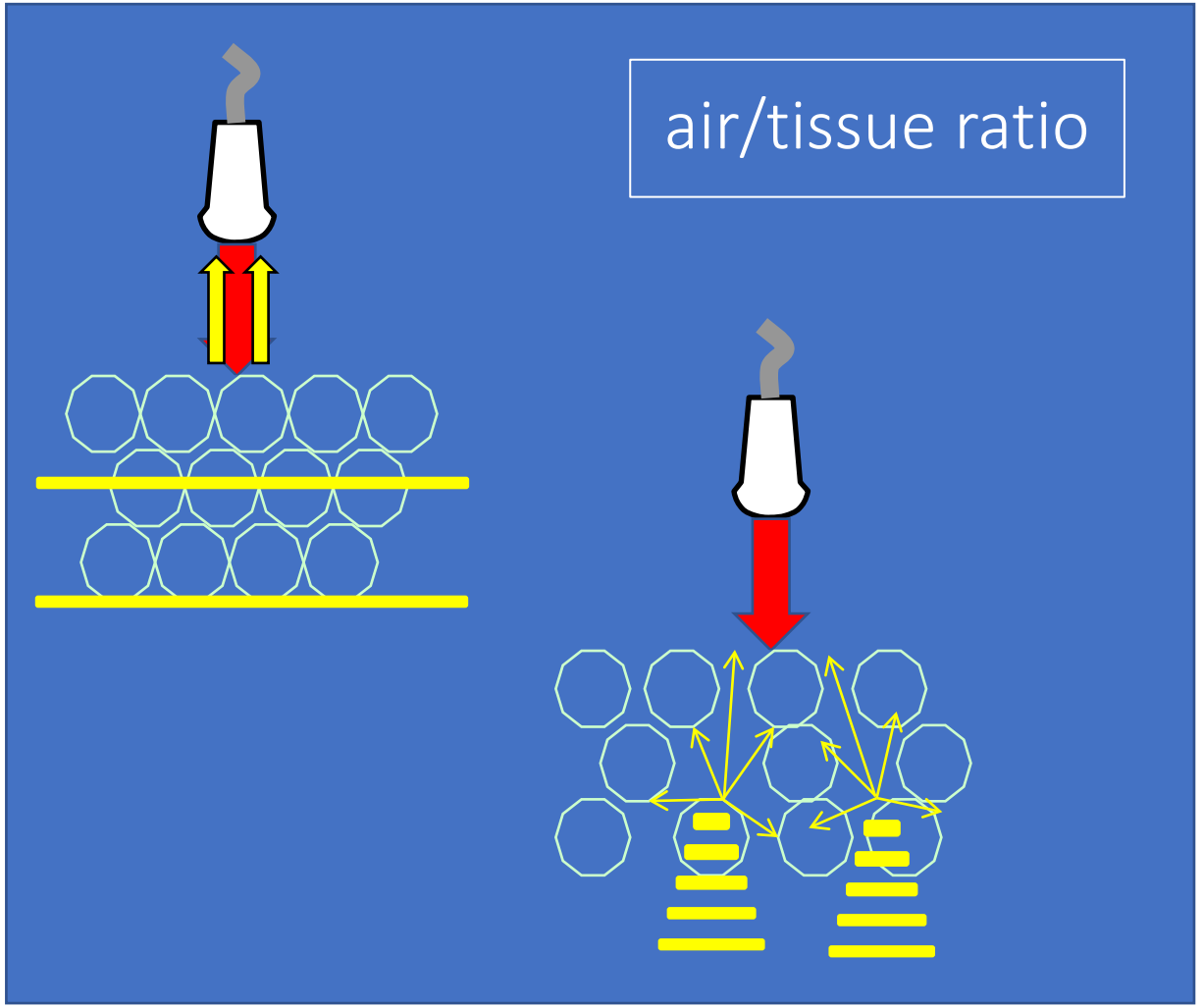
Bernheim A, Mei X, Huang M, et al. Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection . Radiology. https://doi.org/10.1148/radiol.2020200463.11.

Yoon SH, Lee KH, Kim JY, et al. Chest radiographic and CT findings of the 2019 novel coronavrus disease (COVID-19): analysis of nine patients treated in Korea. Korean J Radiol 2020; 21:494–500

LUNG US: interstitial syndrome: B lines







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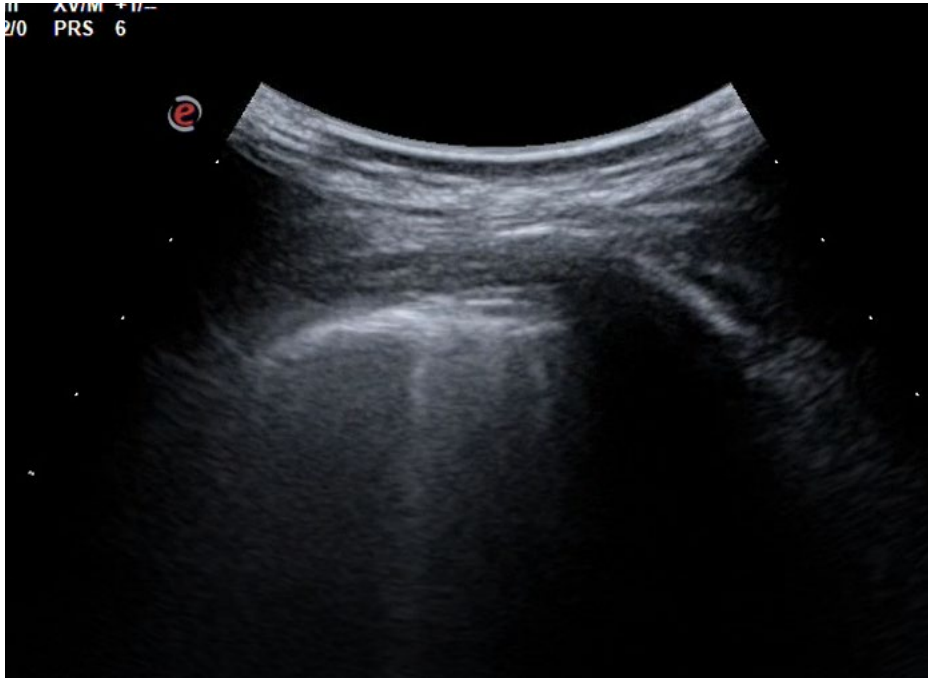
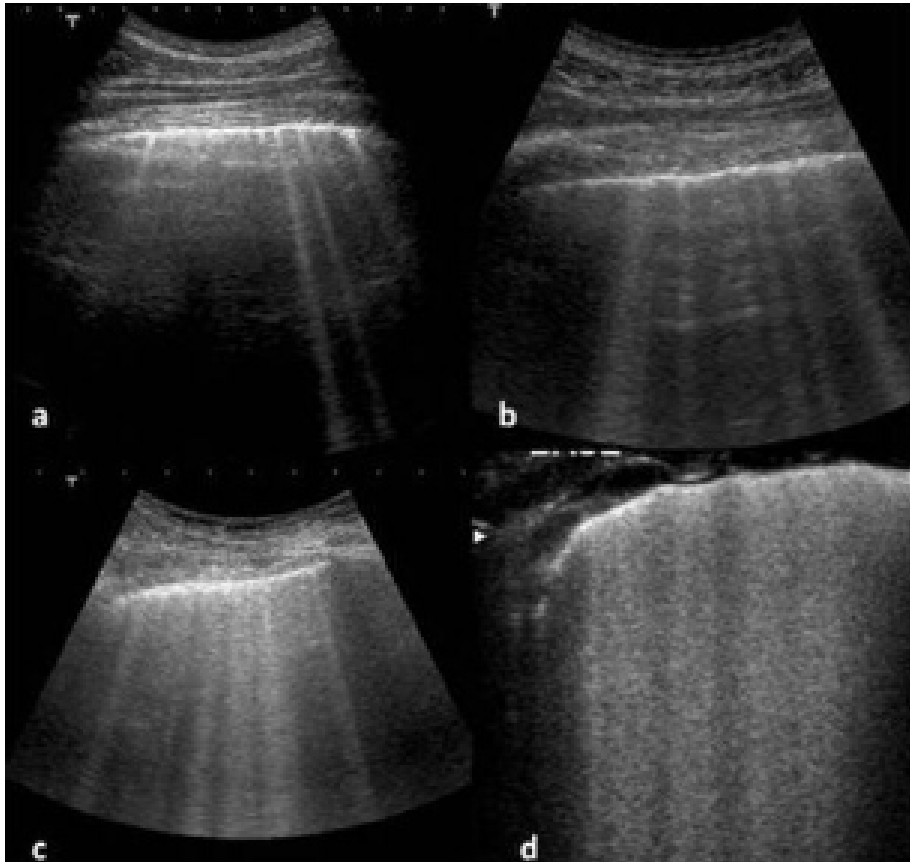
LUNG US:
interstitial syndrome defintion:
almost 3 B lines in 1 intercostal space in longitudinal view





Interstitial syndrome progression:
from singles B lines to white lung

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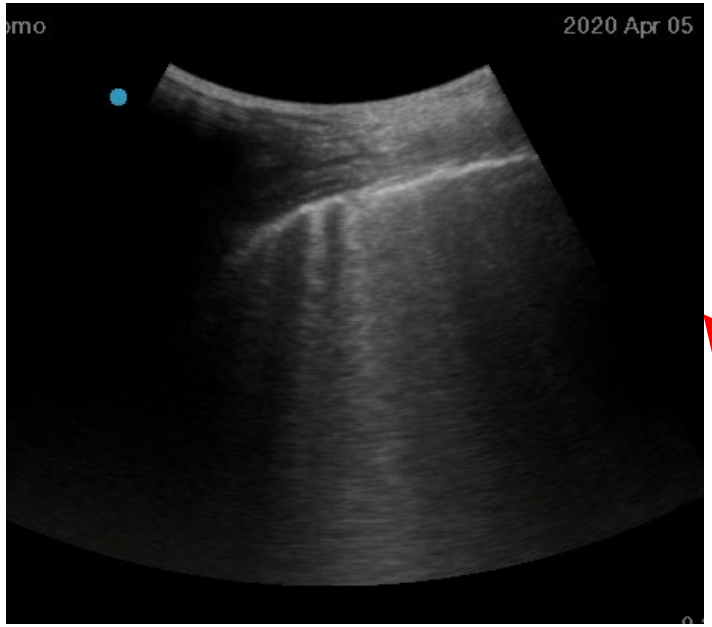

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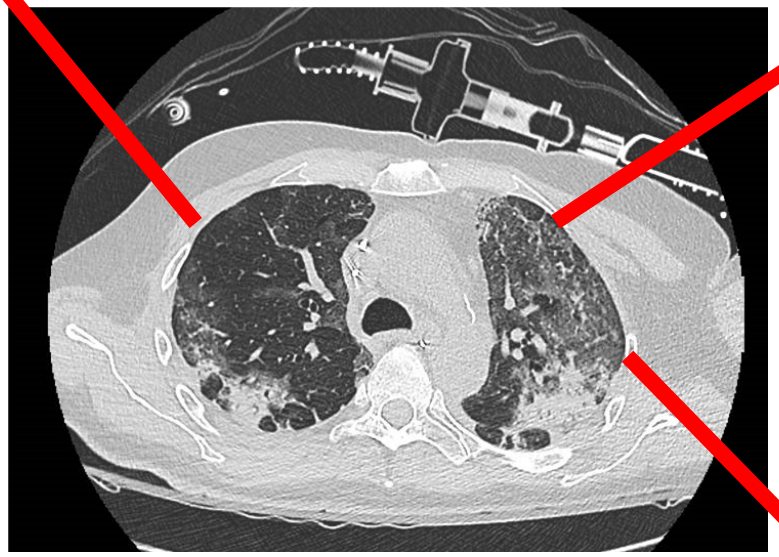
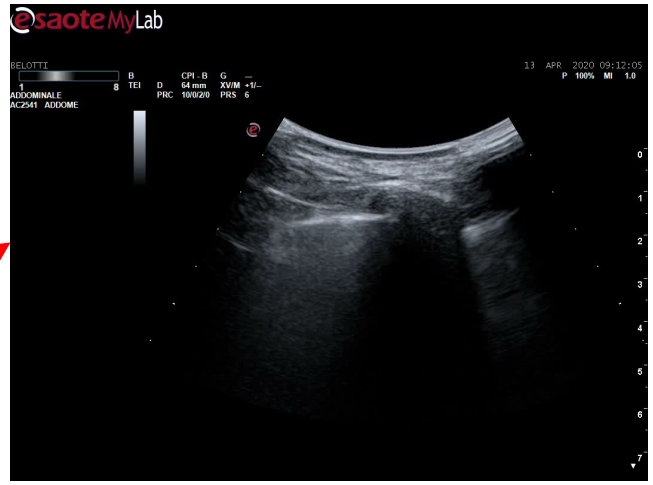
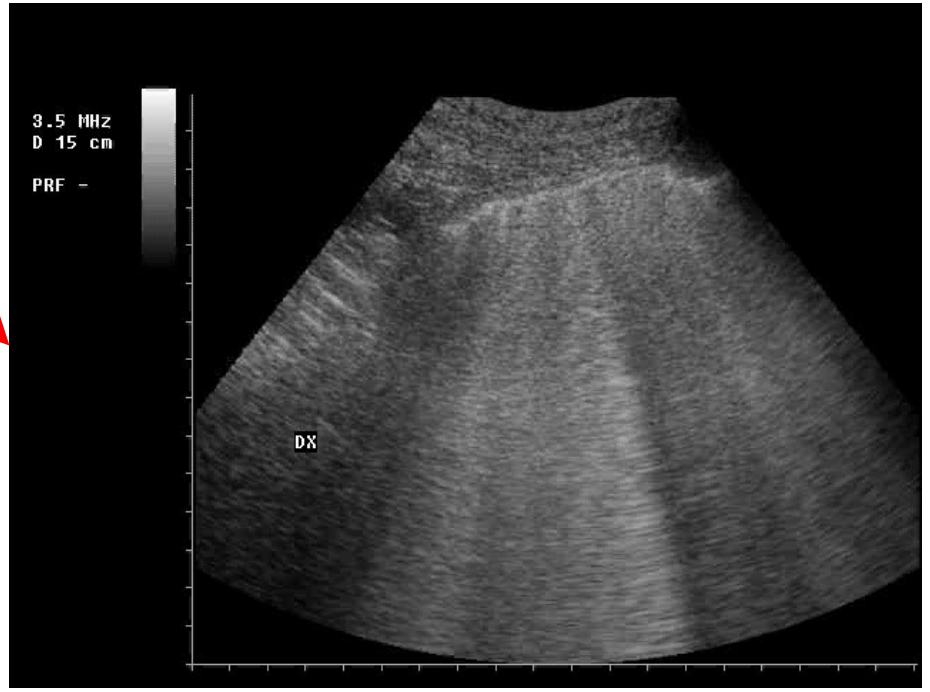
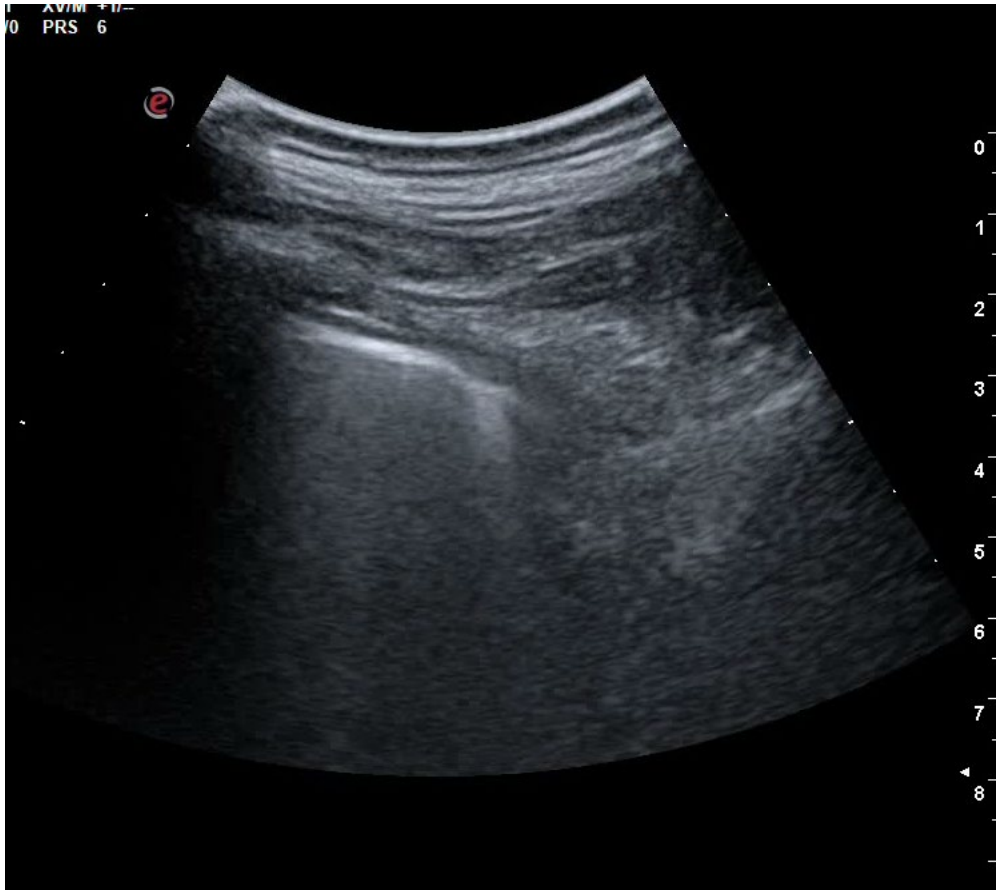






LUNG US in COVID:
Interstitial syndrome progression:
from singles B lines to white lung

Interstitial syndrome:
Pulmonary edema VS COVID-19



Irregular pleural line
Reduction in sliding

Regular pleural line
Normal sliding

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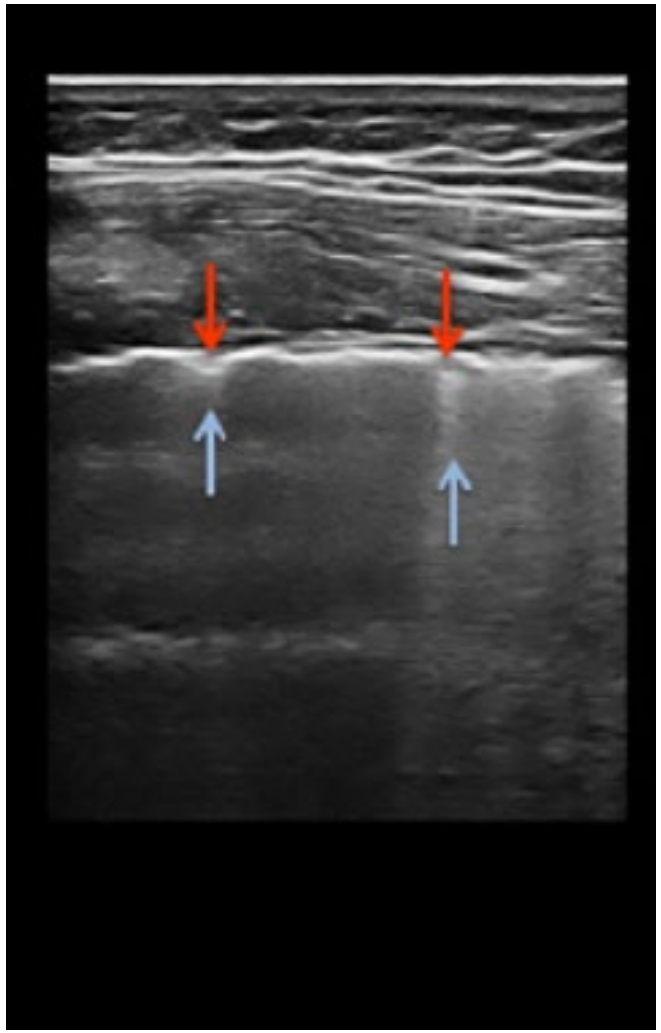
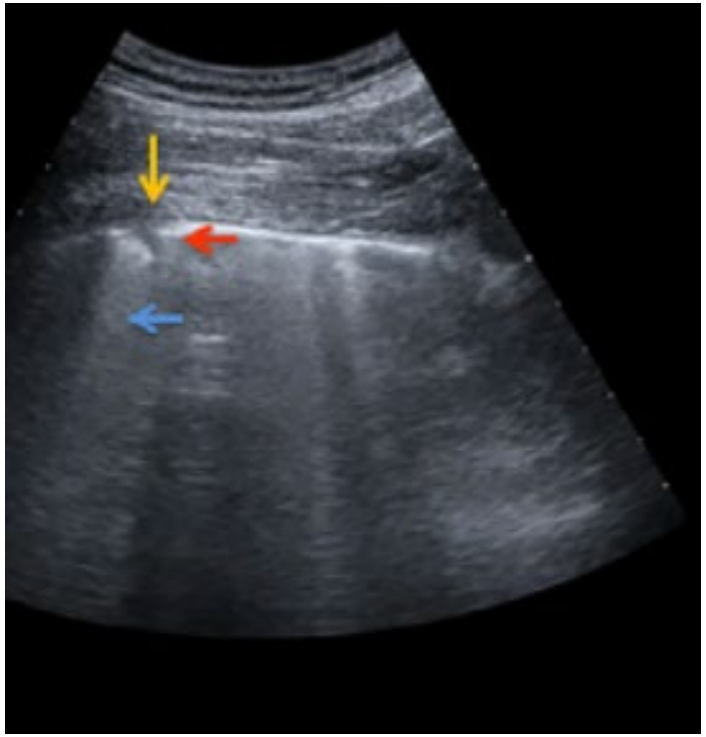
Interstitial syndrome in COVID-19





Irregular pleural line

Modified by Soldati G. J Ultrasound Med 2020 Mar 30 doi 10.1002/jum.15285

Intensive Care Med
https://doi.org/10.1007/s00134-020-05996-6

LETTER

Findings of lung ultrasonography of novel corona virus pneumonia during the 2019–2020 epidemic

Qian-Yi Peng[1], Xiao-Ting Wang[2*], Li-Na Zhang[1*] and Chinese Critical Care Ultrasound Study Group (CCUSG)

20 pts; 12-zone method

Characteristic findings:

- Thickening of pleural line with irregularity
- B lines patterns: focal, multifocal, confluent
- Consolidations in variable patterns
- A lines during recovering phase

Different findings related to stage of disease, severity of lung injuries and comorbidities

RESEARCH ARTICLE *Infectious Diseases* *Pulmonology*

A preliminary study on the ultrasonic manifestations of peripulmonary lesions of non-critical novel coronavirus pneumonia (COVID-19)

Yi Huang, Sihan Wang, Yue Liu, Yaohui Zhang, Chuyun Zheng, Yu Zheng, Chaoyang Zhang, Weili Min, Ming Yu, Mingjun Hu

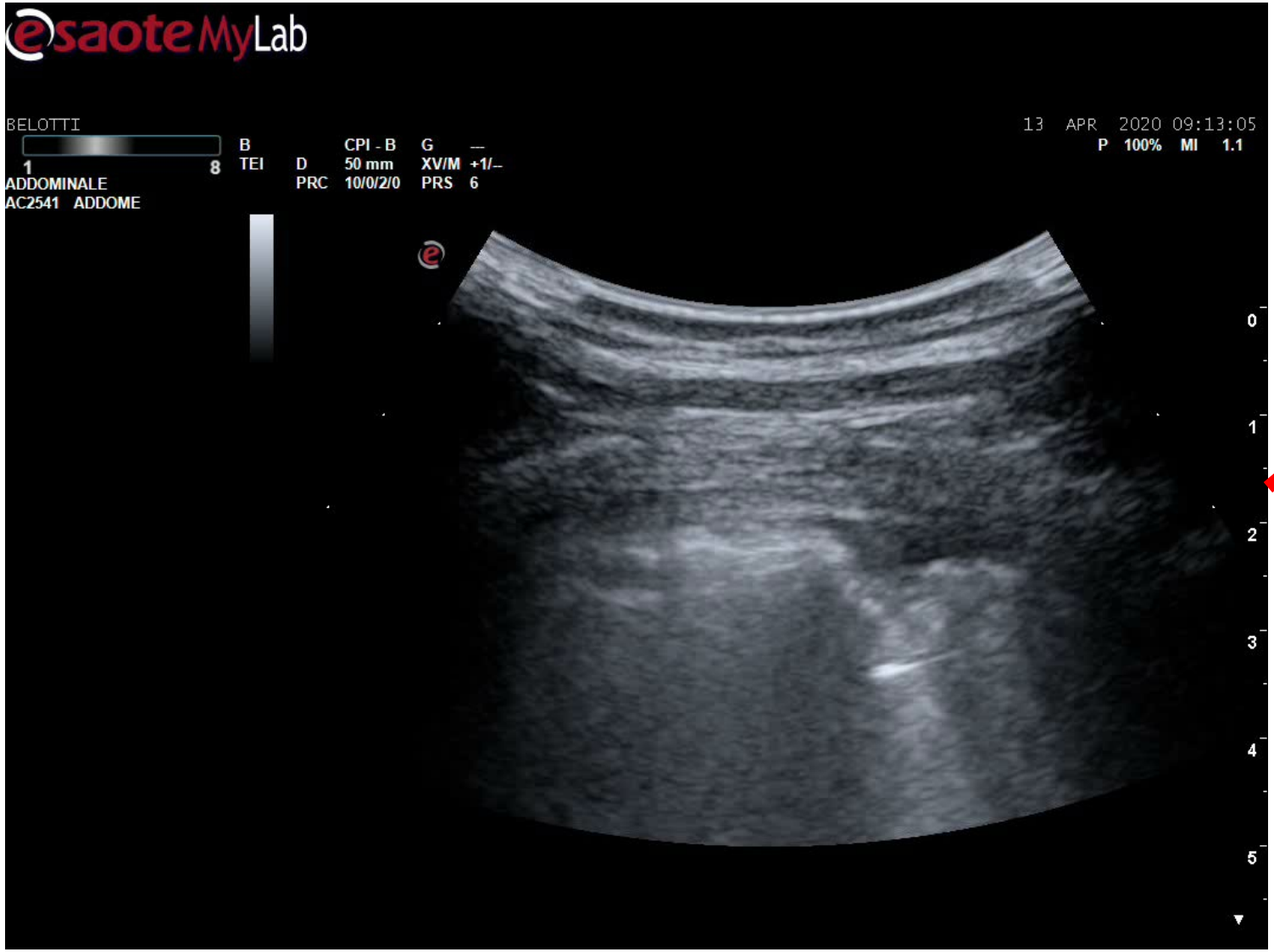
20 pts; Non-Critical COVID-19

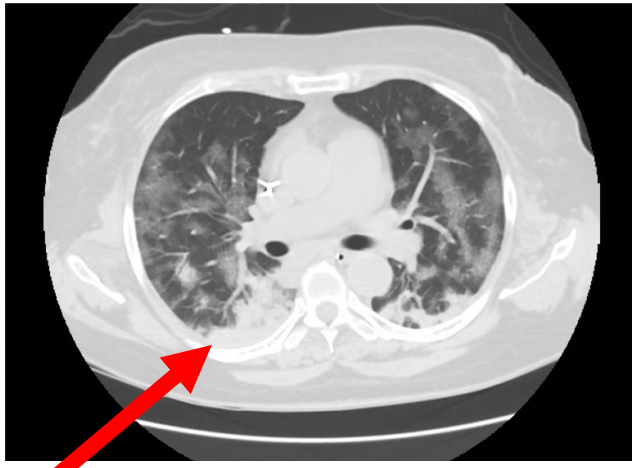
Characteristic ultrasonic manifestations:

A large number of B-lines, subpleural pulmonary consolidations in posterior and inferior areas of the lung

LUNG US:
Real images: parenchyma consolidations

Evolution of Interstitial Pneumonia in COVID-19: Subpleural Consolidations





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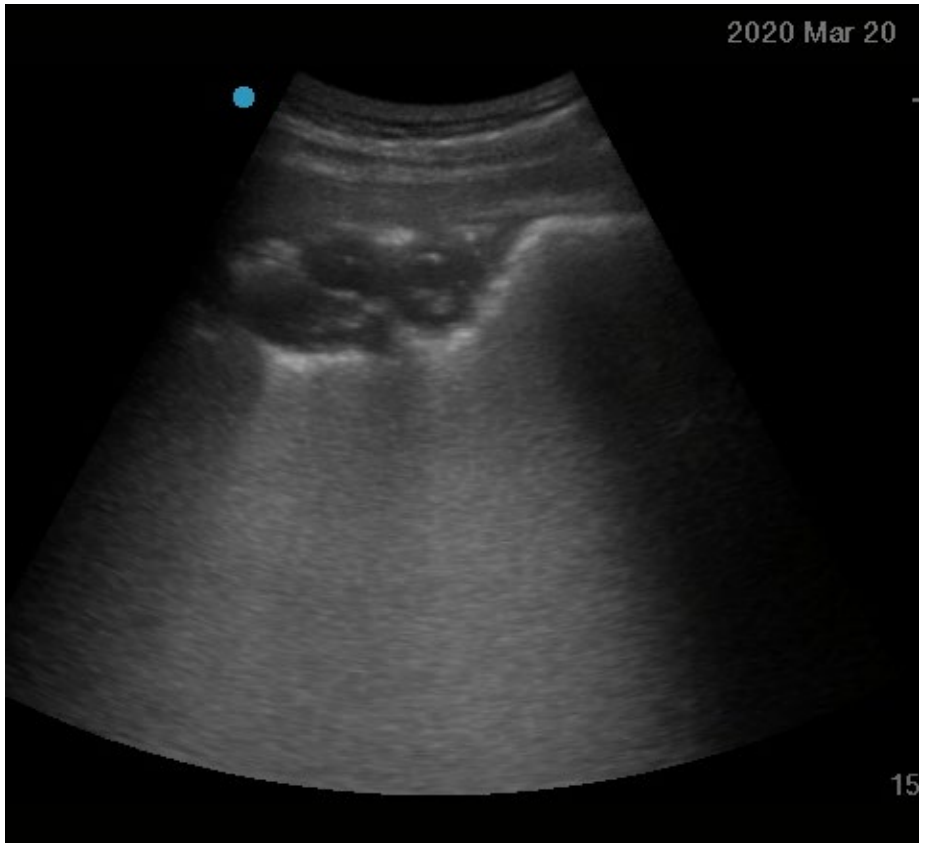
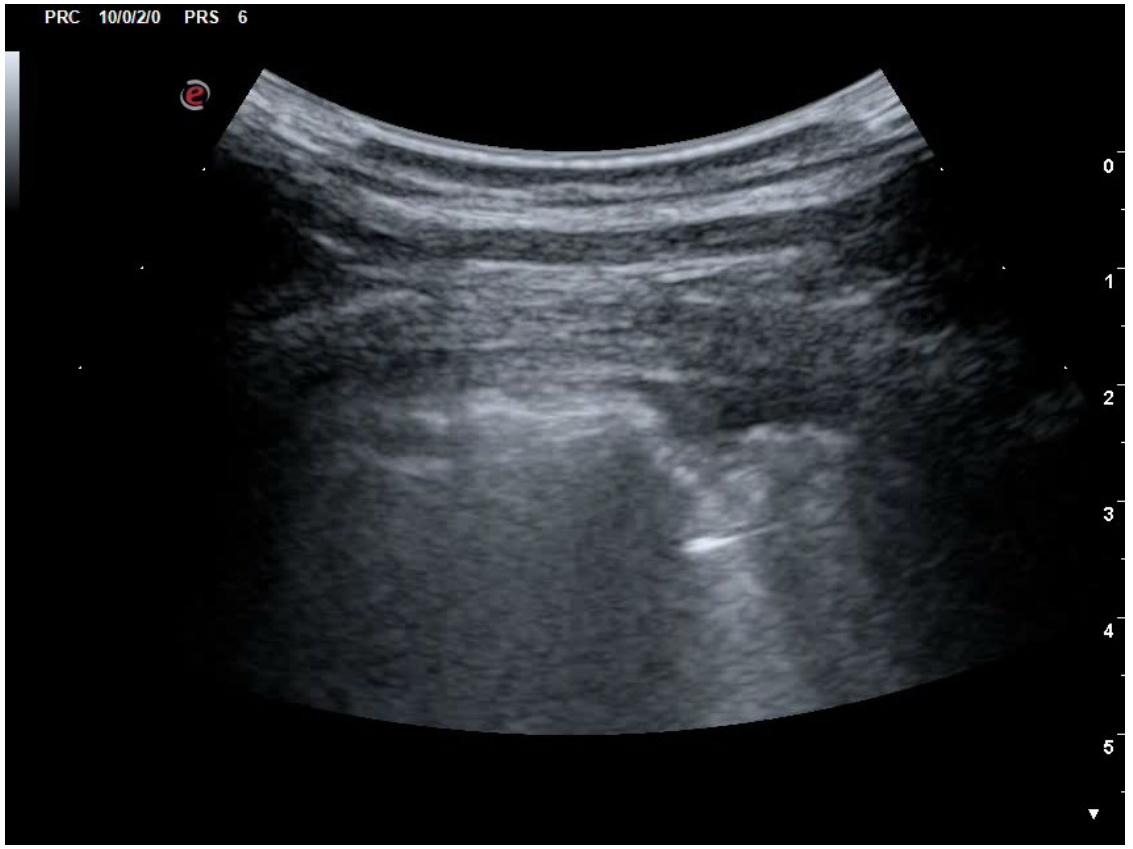
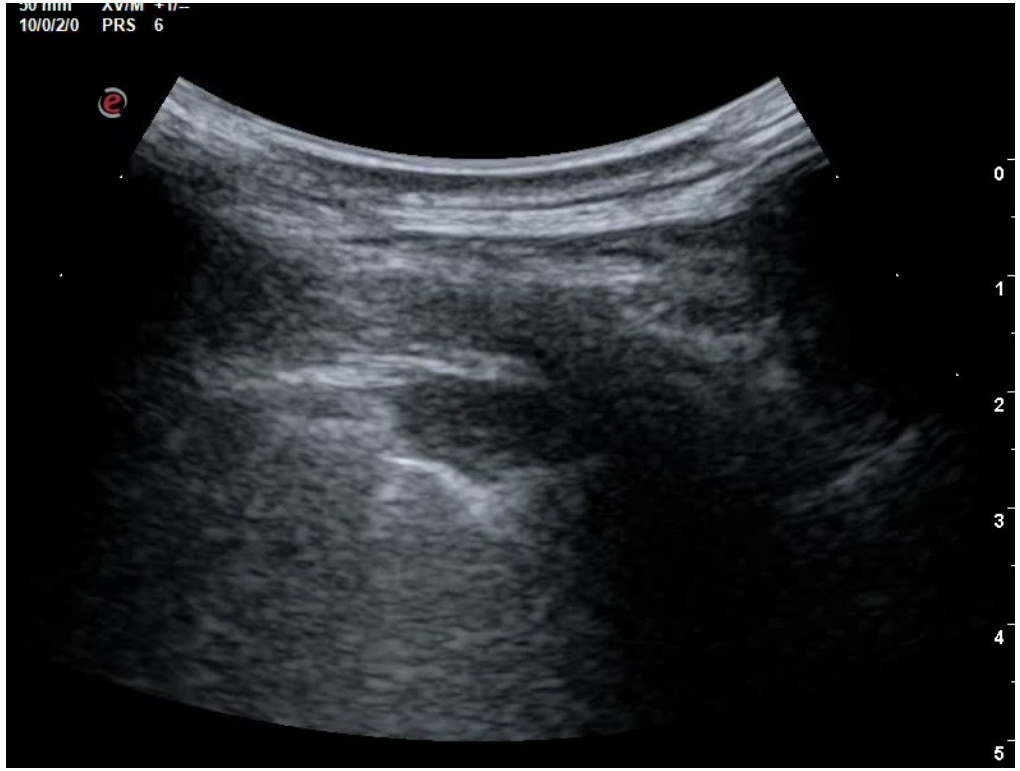




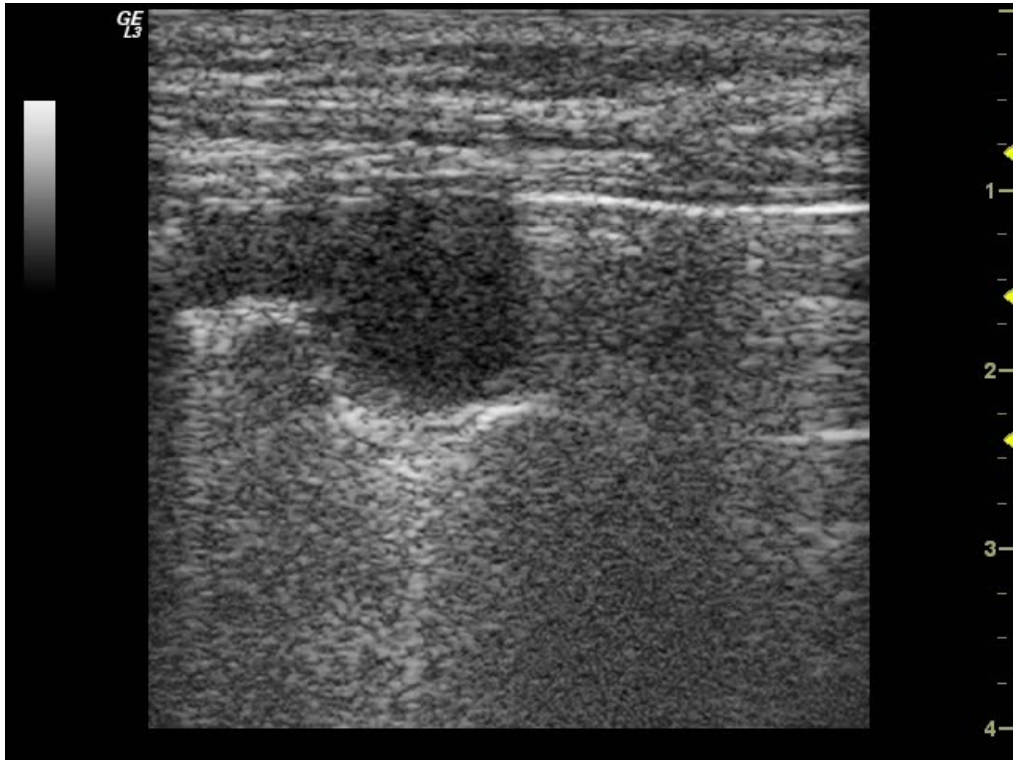
Evolution of Interstitial Pneumonia in COVID-19: Subpleural Consolidations

Subpleural consolidations: Pulmonary embolism VS COVID-19



Irregular shapes
Hyperechogenic
White spots

Triangular shape
Hypo-anechogenic
No air sign inside



Lung US Accuracy

Crit Care Med. 2018 Jul;46(7):e707-e714. doi: 10.1097/CCM.0000000000003129.

Diagnostic Accuracy of Chest Radiograph, and When Concomitantly Studied Lung Ultrasound, in Critically Ill Patients With Respiratory Symptoms: A Systematic Review and Meta-Analysis.

Winkler MH[1], Touw HR[1], van de Ven PM[2], Twisk J[2], Tuinman PR[1,3].

Imaging method	Overall sensitivity	Overall specificity
Chest X-Ray	49%	92%
Lung US	95%	94%

Radiology. 2020 Mar 13:200847. doi: 10.1148/radiol.2020200847. [Epub ahead of print]

Can Lung US Help Critical Care Clinicians in the Early Diagnosis of Novel Coronavirus (COVID-19) Pneumonia?

Poggiali E[1], Dacrema A[1], Bastoni D[1], Tinelli V[1], Demichele E[1], Mateo Ramos P[1], Marcianò T[1], Silva M[1], Vercelli A[1], Magnacavallo A[1].

12 pts

Strong correlation between CT and US

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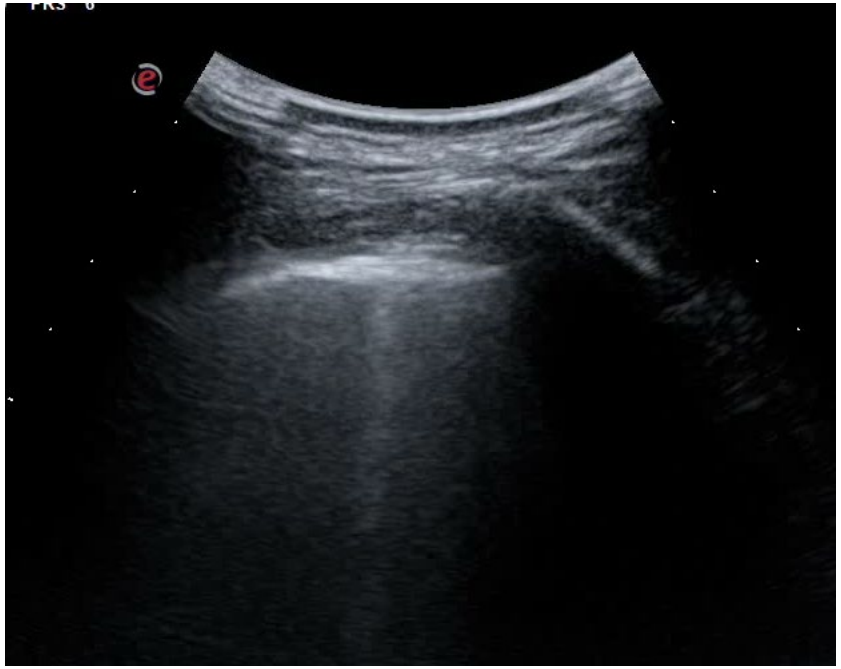
LUNG US in COVID
Take Home Messages

- More informations in case of “superficial” lung diseases
- Easy to learn and easy to perform in bedside modality (minor disease spread), safe, repeatable, low-cost, absence of radiations
- can provide differential diagnosis for interstitial syndrome
- Useful to describe interstitial disease degree and to follow disease progression/regression
- Easy identification of parenchyma consolidations
- Can provide differential diagnosis for subpleural consolidations (in particular vs PE)



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WEBINAR COVID-19 in the series: How to treat the disease

Imaging in COVID-19

Name: Andreas Saleh
Position: Chief radiologist, Munich Clinic Schwabing
Country: Germany

CT scan – the gold standard?
Different patterns in different stages

Andreas Saleh
Munich, Germany

MÜNCHEN
KLINIK

Role of CT in COVID-19 - highly controversial!

Pro CT

- CT has a high sensitivity
- CT has a high specificity
- PCR-testing has major limitations

Con CT

- CT has a low sensitivity
- CT has a low specificity
- PCR-testing is the gold standard

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CT imaging features in COVID-19 pneumonia

- Ground glass opacities
- Crazy-paving pattern
- Consolidation
- Subpleural curvilenar lines
- Halo sign
- Reversed halo sign

MÜNCHEN KLINIK

CT imaging features in COVID-19 pneumonia

- **Ground glass opacities**
- Crazy-paving pattern
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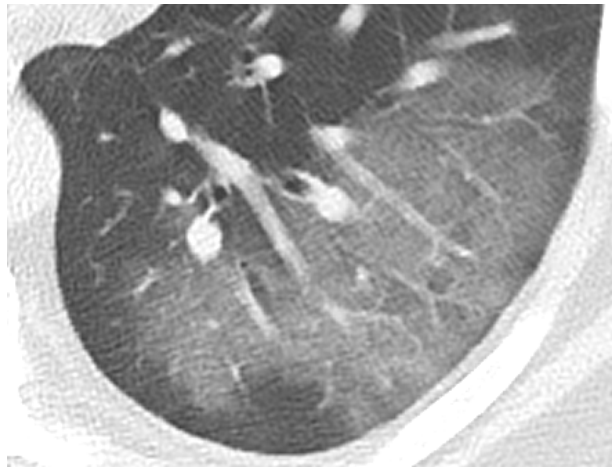
- Subpleural curvilenar lines
- Halo sign
- Reversed halo sign



DDx

- Viral pneumonia
- Pneumocystis pneumonia
- Pulmonary edema
- Alveolar hemorrhage
- Hypersensitivity pneumonitis
- Eosinophilic pneumonia
- NSIP
- Smoking related ILD
- Drug reaction
- …….

MÜNCHEN KLINIK

CT imaging features in COVID-19 pneumonia

- Ground glass opacities
- **Crazy-paving pattern**
- Consolidation
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DDx

- Alveolar proteinosis
- Viral pneumonia
- Pneumocystis pneumonia
- Pulmonary edema
- Alveolar hemorrhage
- Organizing pneumonia
- NSIP
- Lipoid pneumonia
- Drug reaction
- …….

MÜNCHEN KLINIK

CT imaging features in COVID-19 pneumonia

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- **Consolidation**
- Subpleural curvilenar lines
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DDx

- Pneumonia
- Pulmonary edema
- Aspiration
- Pulmonary hemorrhage
- Hypersensitivity pneumonitis
- Pulmonary infarct
- Eosinophilic pneumonia
- Organizing pneumonia
- …….

MÜNCHEN KLINIK

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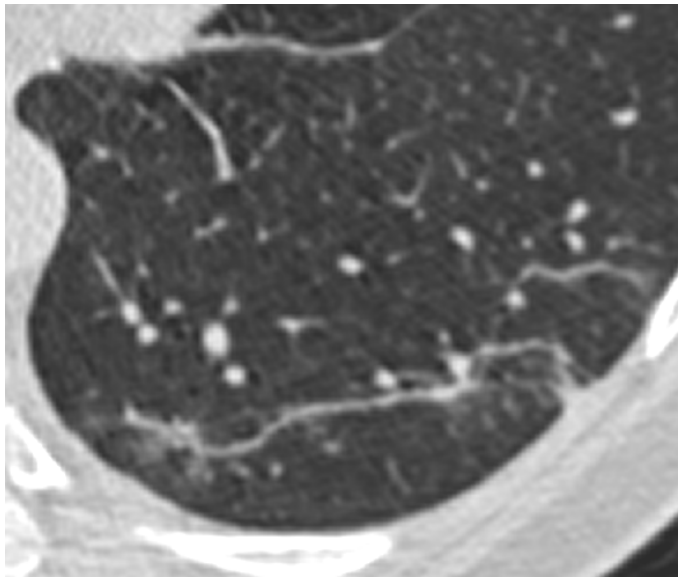

DDx

- Pulmonary edema
- Fibrosis
- Asbestosis
- …….

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CT imaging features in COVID-19 pneumonia

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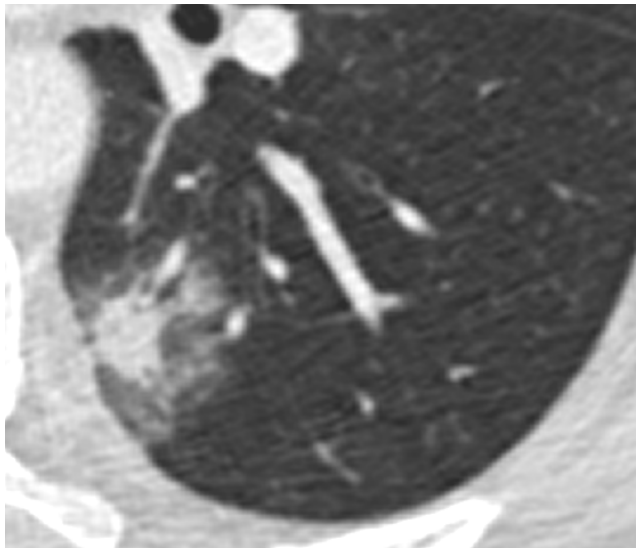

DDx

- Angioinvasive Aspergillosis
- Other fungi
- Viral pneumonia
- Organizing pneumonia
- Wegener Granulomatosis
- Kaposi Sarcoma
- …….

MÜNCHEN KLINIK

CT imaging features in COVID-19 pneumonia

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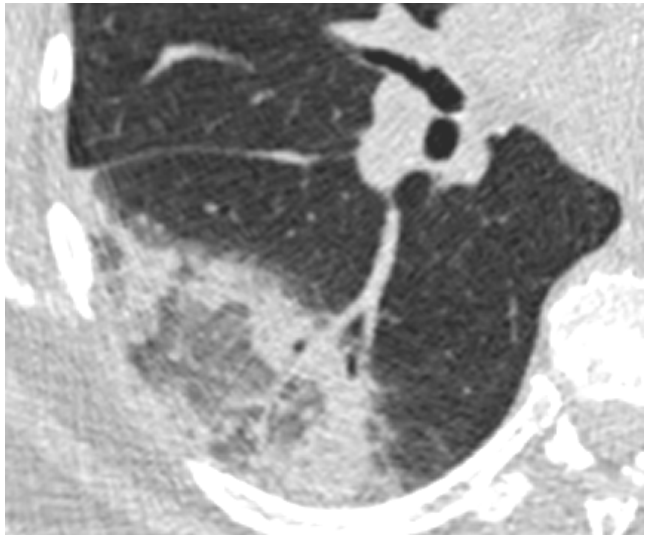

DDx

- Organizing pneumonia
- Fungal infection
- Pulmonary thromboembolism
- Tuberculosis
- Sarcoidosis
- …….

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None of these CT imaging features is specific for COVID-19

- Ground glass opacities
- Crazy-paving pattern
- Consolidation
- Subpleural curvilenar lines
- Halo sign
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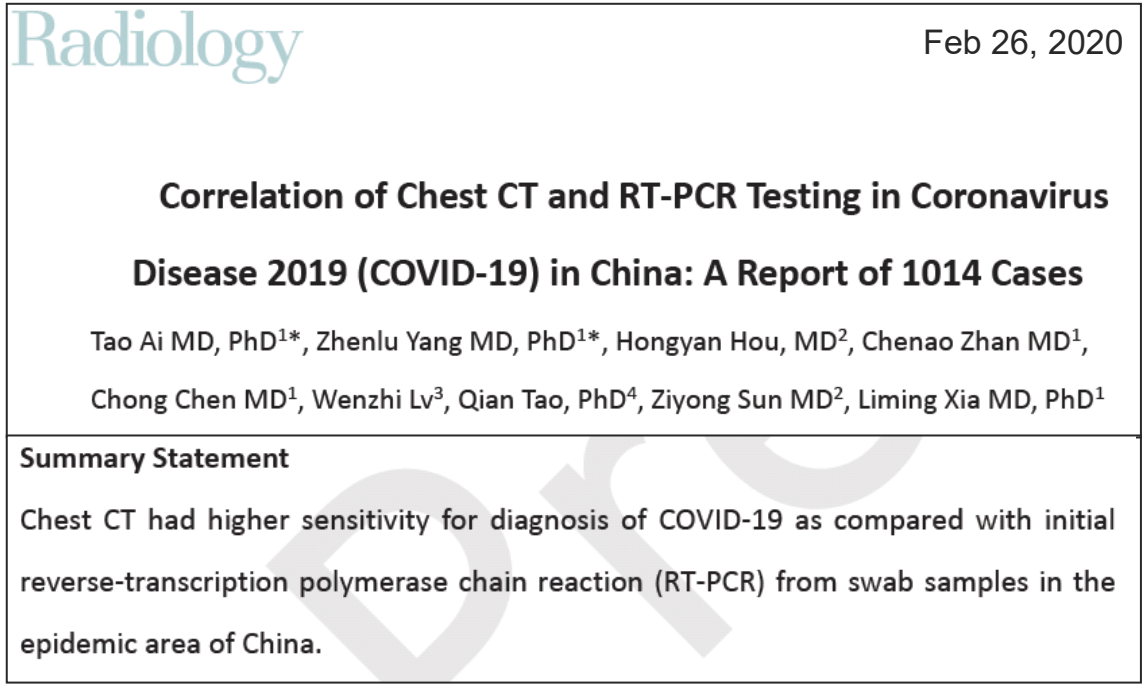

Radiology

Feb 26, 2020

Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases

Tao Ai MD, PhD[1]*, Zhenlu Yang MD, PhD[1]*, Hongyan Hou, MD[2], Chenao Zhan MD[1], Chong Chen MD[1], Wenzhi Lv[3], Qian Tao, PhD[4], Ziyong Sun MD[2], Liming Xia MD, PhD[1]

Summary Statement

Chest CT had higher sensitivity for diagnosis of COVID-19 as compared with initial reverse-transcription polymerase chain reaction (RT-PCR) from swab samples in the epidemic area of China.

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RCR position on the role of CT in patients suspected with COVID-19 infection

RCR position on coronavirus (COVID-19) and April/May/June RCR exams

RCR position on coronavirus (COVID-19) and the AAC process

RCR position on coronavirus (COVID-19) for clinical oncology

RCR position on coronavirus (COVID-19) and RCR events

RCR position on the role of CT in patients suspected with COVID-19 infection

Coronavirus (COVID-19) resources

Related content

Coronavirus (COVID-19): what the RCR is doing

Coronavirus (COVID-19) resources

As coronavirus infections become identified increasingly worldwide and the number of cases increase in the UK, we have received a number of queries about the use of computed tomography (CT) scanning in the diagnosis of patients with possible COVID-19 infection. Reports from other countries with greater disease prevalence state that CT has been used as a diagnostic tool, particularly where access to viral testing kits is or becomes limited.

As of 12 March 2020, our view is that there is no current role for CT in the diagnostic assessment of patients with suspected coronavirus infection in the UK. We do not believe that current evidence demonstrates a clear benefit in producing a definitive and positive management change on the basis of CT information.

March 11, 2020

ACR Recommendations for the use of Chest Radiography and Computed Tomography (CT) for Suspected COVID-19 Infection

UPDATED MARCH 19, 2020

As COVID-19 spreads in the U.S., there is growing interest in the role and appropriateness of chest radiographs (CXR) and computed tomography (CT) for the screening, diagnosis and management of patients with suspected or known COVID-19 infection. Contributing to this interest are limited availability of viral testing kits to date, concern for test sensitivity from earlier reports in China, and the growing number of publications describing the CXR and CT appearance in the setting of known or suspected COVID-19 infection.

To date, most of the radiologic data comes from China. Some studies suggest that chest CT in particular may be positive in the setting of a negative test. **We want to emphasize that knowledge of this new condition is rapidly evolving, and not all of the published and publicly available information is complete or up-to-date.**

Key goals for the U.S. health care system in response to the COVID-19 outbreak are to reduce morbidity and mortality, minimize disease transmission, protect health care personnel, and preserve health care system functioning.

The ACR believes that the following factors should be considered regarding the use of imaging for suspected or known COVID-19 infection:

- The Centers for Disease Control (CDC) does not currently recommend CXR or CT to diagnose COVID-19. Viral testing remains the only specific method of diagnosis. Confirmation with the viral test is required, even if radiologic findings are suggestive of COVID-19 on CXR or CT.
- For the initial diagnostic testing for suspected COVID-19 infection, the CDC recommends collecting and testing specimens from the upper respiratory tract (nasopharyngeal AND oropharyngeal swabs) or from the lower respiratory tract when available for viral testing.

Preconditions to use CT as a diagnostic tool with reasonable sensitivity and specificity

- Make use of the high pretest probability of the disease during the pandemia
- Select patients properly
- Acknowledge the shape and distribution of CT imaging features

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Preconditions to use CT as a diagnostic tool with reasonable sensitivity and specificity

- **Make use of the high pretest probability of the disease during the pandemia**
- Select patients properly
- Acknowledge the shape and distribution of CT imaging features

1/3	1/3	1/3
Covid-19	**Pneumonia from infectious agents other than SARS-Cov-2**	**Other diseases**

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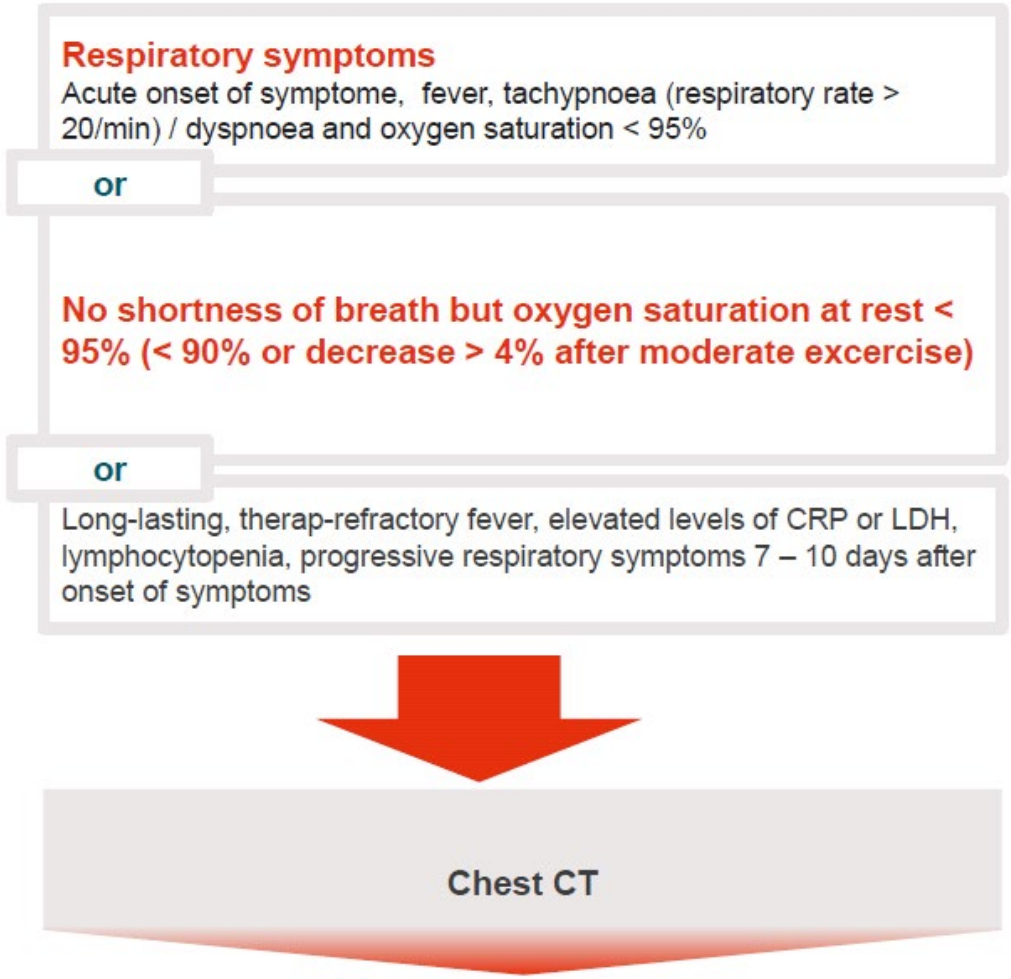
Select patients properly



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Preconditions to use CT as a diagnostic tool with reasonable sensitivity and specificity

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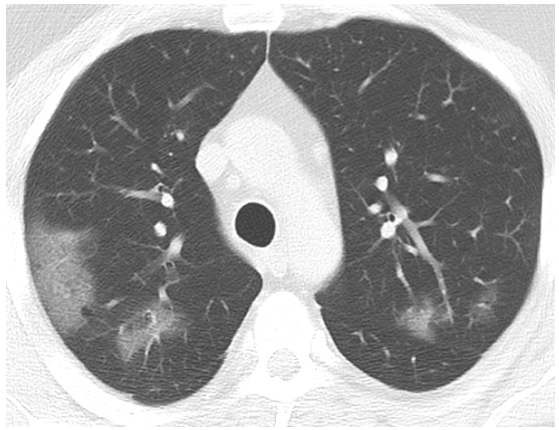
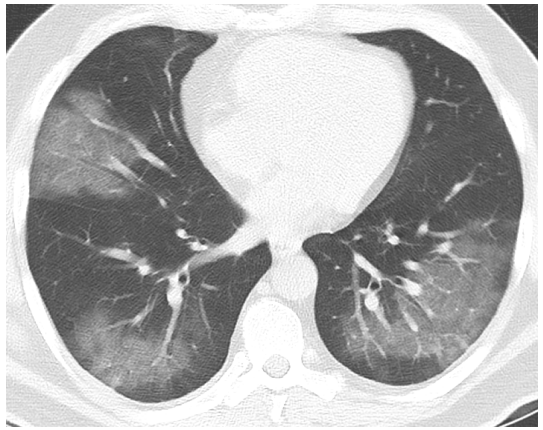
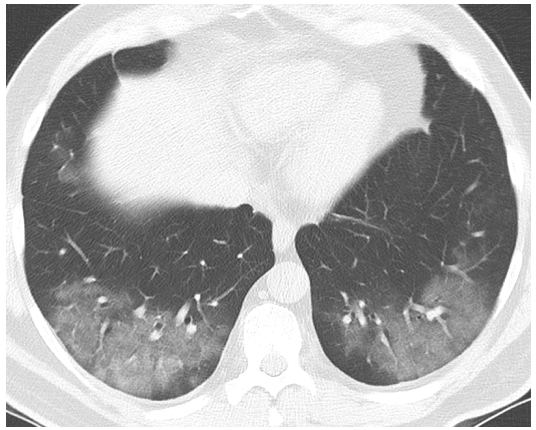

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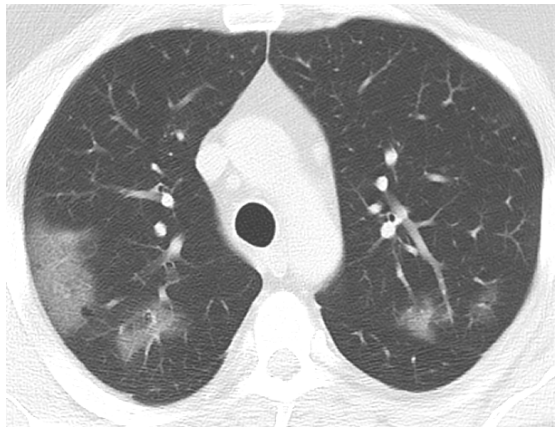
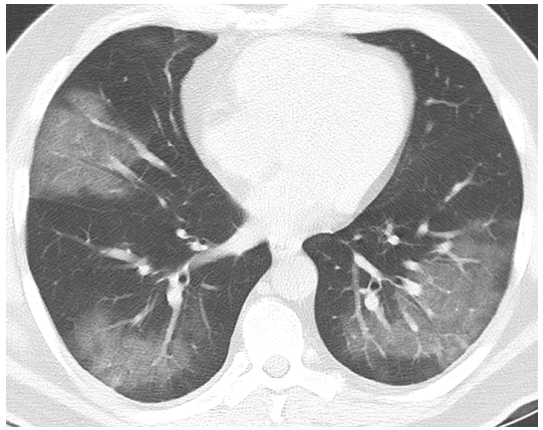
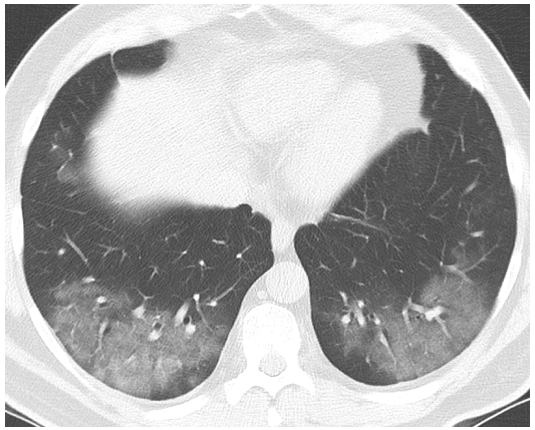
Acknowledge the shape and distribution of CT imaging features

- Bilateral
- Peripheral crescent shaped
- Ground glass with/without septal thickening
- No or minimal pleural effusion
- No or minimal lymphadenopathy

Definite COVID pattern

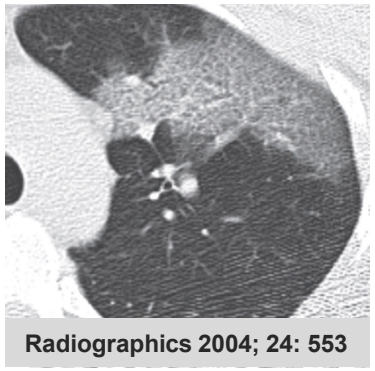




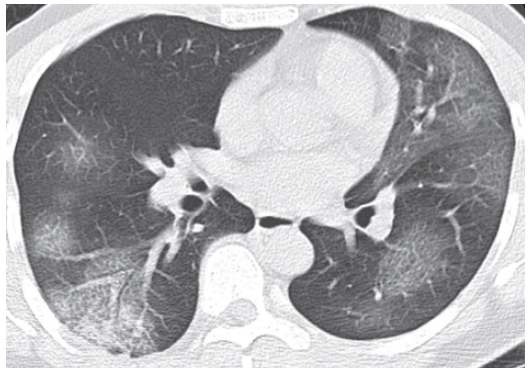


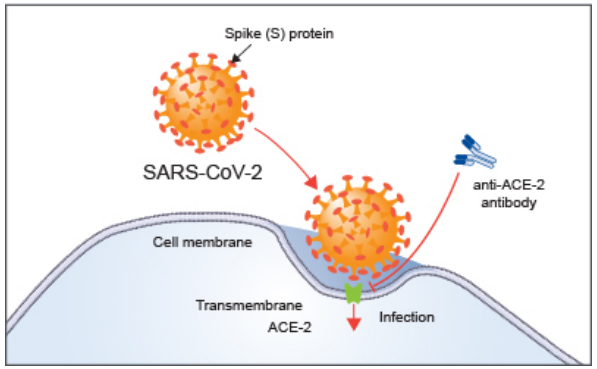
Acknowledge the shape and distribution of CT imaging features

SARS

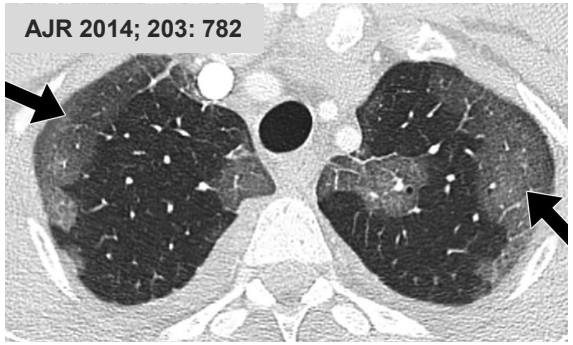


Radiographics 2004; 24: 553

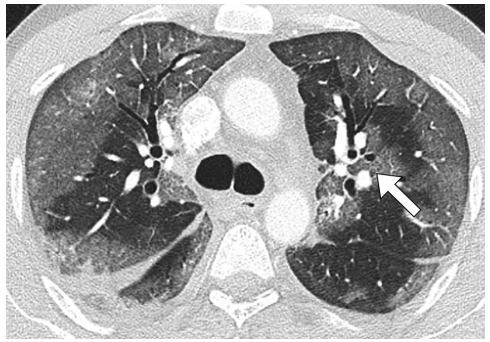




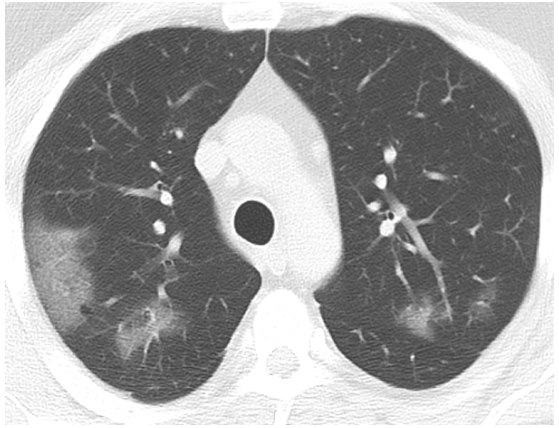
MERS

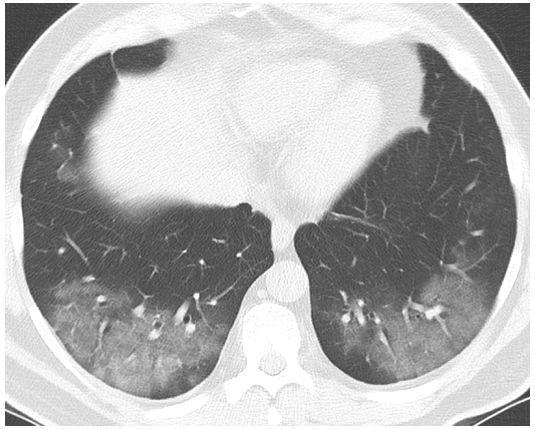


AJR 2014; 203: 782



COVID-19





MÜNCHEN KLINIK

Conclusions (1)

- The sensitivity of CT for COVID-19 is lower than 100%
- The specificity of CT for COVID-19 is lower than 100%
- That does ***not*** mean, that CT is useless for patients suspected to have COVID-19!
- The consequence is to establish a clinical algorithm that adresses the imperfection of the CT

MÜNCHEN KLINIK

Conclusions (1)

- The sensitivity of CT for COVID-19 is lower than 100%
- The specificity of CT for COVID-19 is lower than 100%
- That does ***not*** mean, that CT is useless for patients suspected to have COVID-19!
- The consequence is to establish a clinical algorithm that adresses the imperfection of the CT

…….. like always in medicine …..☺

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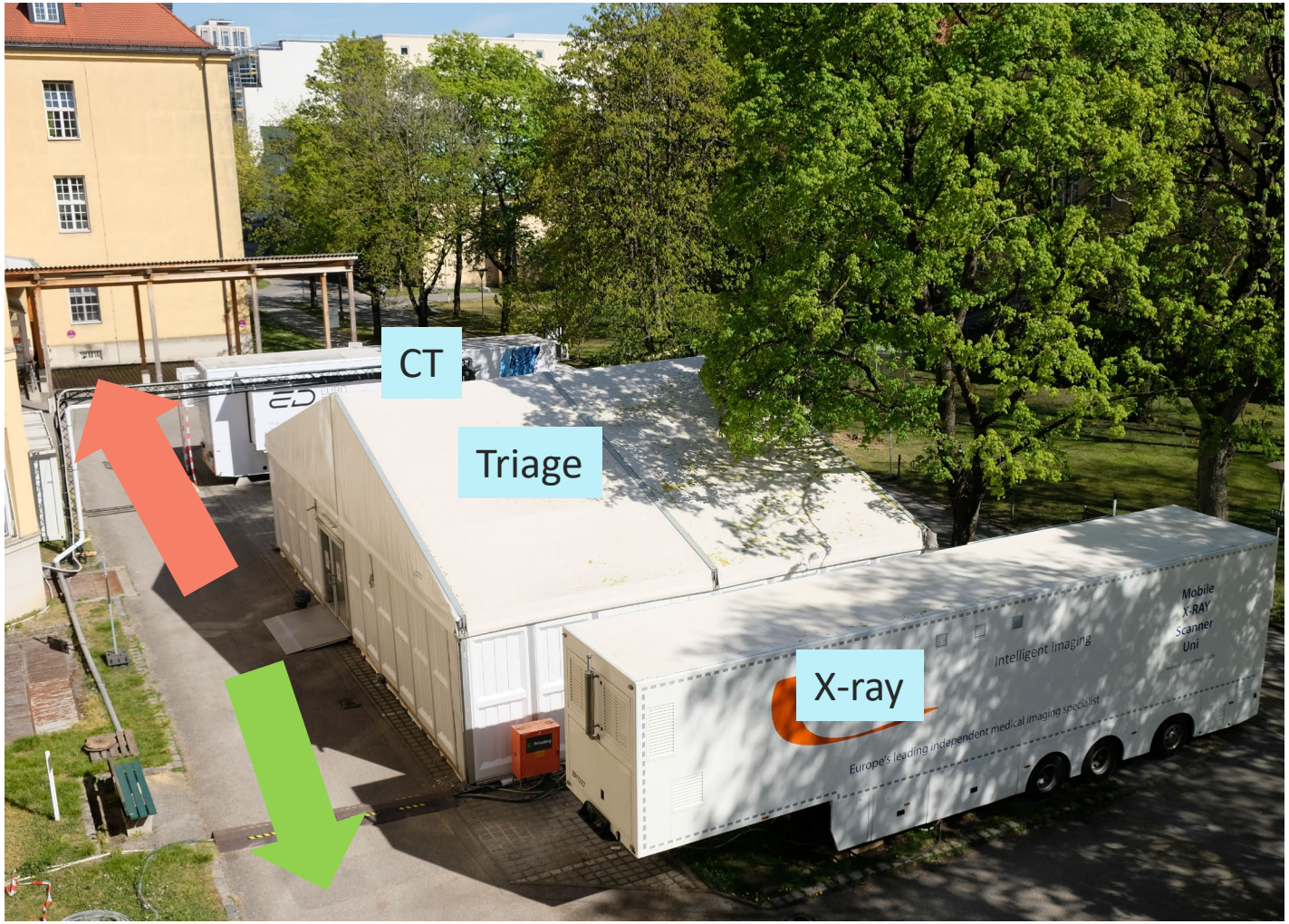
Where do the patients go …

COVID ward

Evaluation ward

Regular ward



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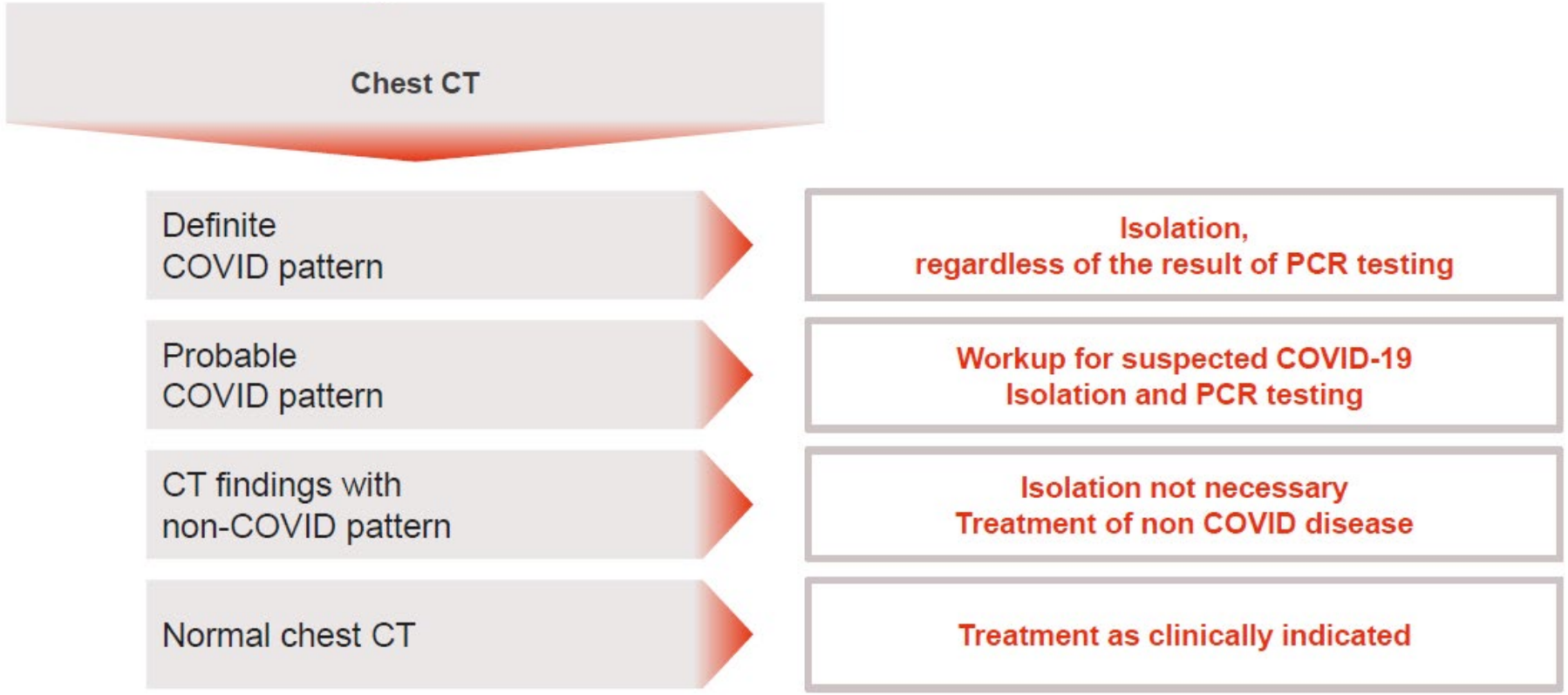
Where do the patients go …



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Four cases from April 17, 2020

Each case comes with three slides

- 1st: history, clinical signs and lab

  How would you have decided?

- 2nd: CT

  How would you decide?

- 3rd:

  Decision and follow-up

MÜNCHEN KLINIK

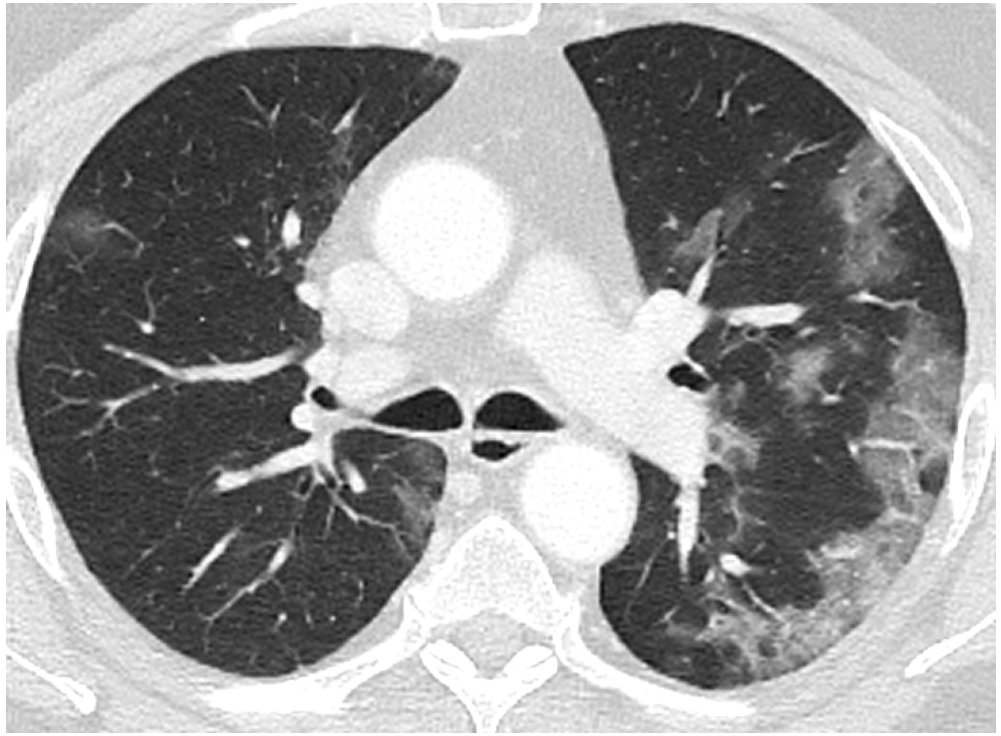
65-year old man, referral by GP, result of RT-PCR pending

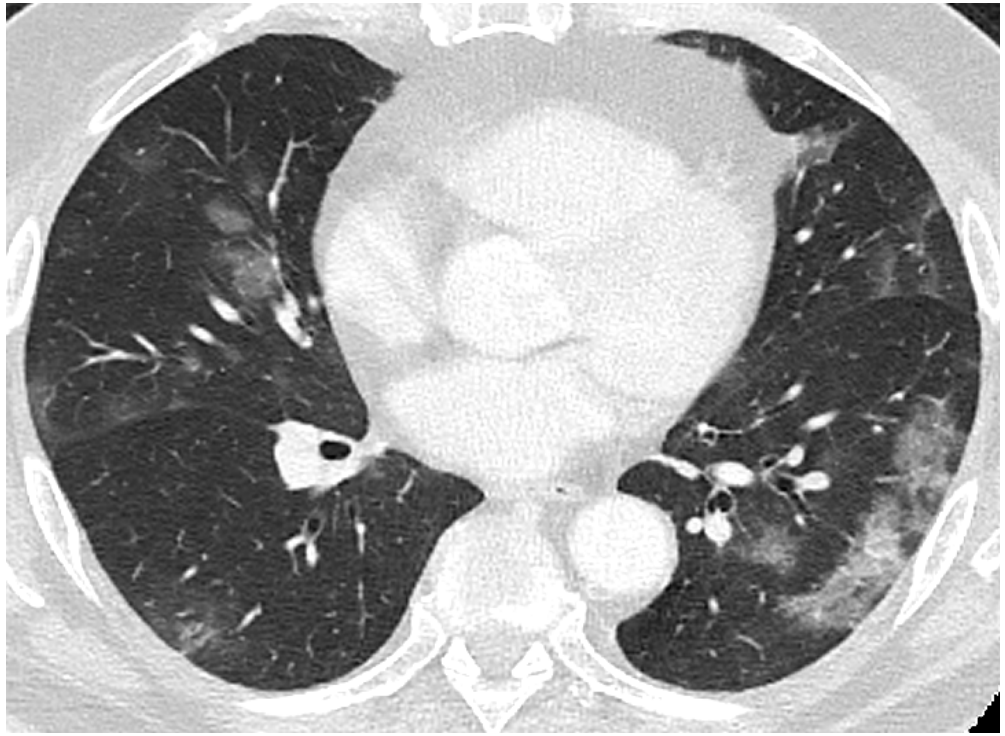
- History of oropharyngeal cancer (2007)
- Productive cough since 4 weeks
- Ageusia since 8 days
- No subjective dyspnea, but O_2-saturation 90%
- No fever, no diarrhea

- WBC and ANC normal
- Lymphocytopenia and eosinopenia
- CRP 72,8 mg/l
- PCT not elevated

MÜNCHEN KLINIK

65-year old man, referral by GP, result of RT-PCR pending





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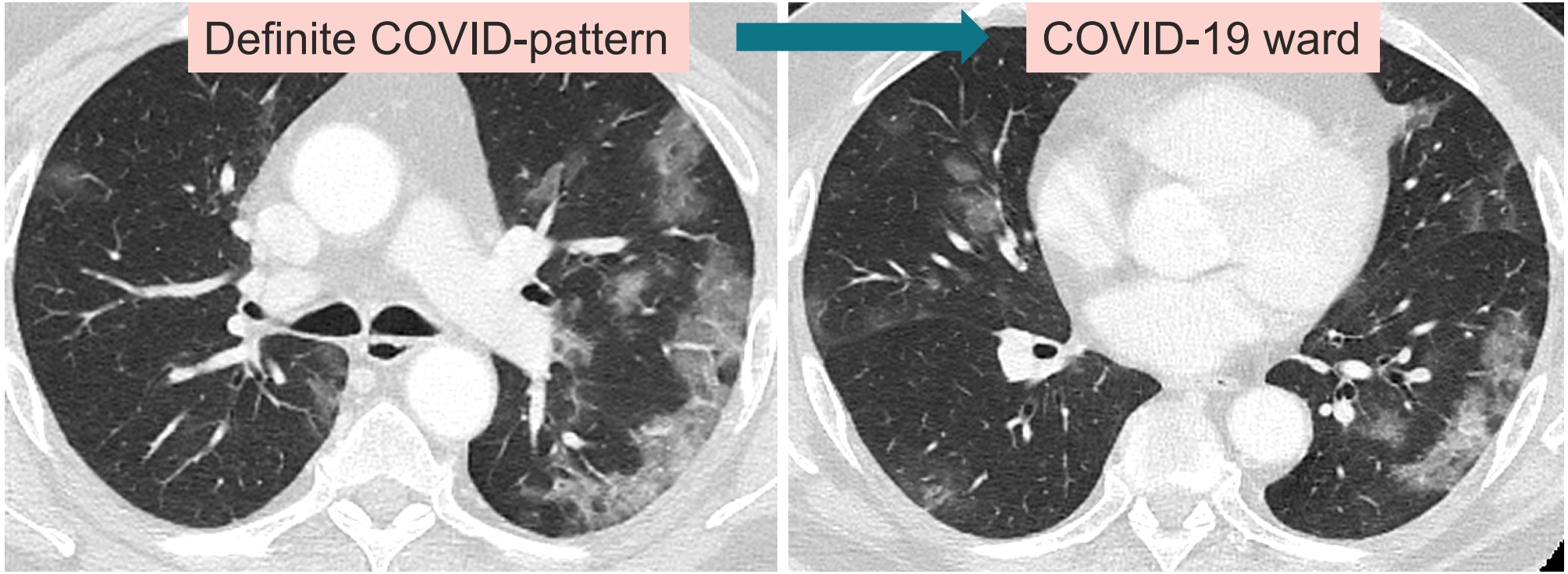

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MÜNCHEN KLINIK

45-year old man, RT-PCR (nasopharyngeal swab) negative

- Fever (39,5°C) since 9 days
- Dry cough
- Dysgeusia
- O_2-saturation 93%
- No diarrhea

- WBC, ANC and ALC normal
- Eosinopenia
- CRP 8,2 mg/l
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MÜNCHEN KLINIK

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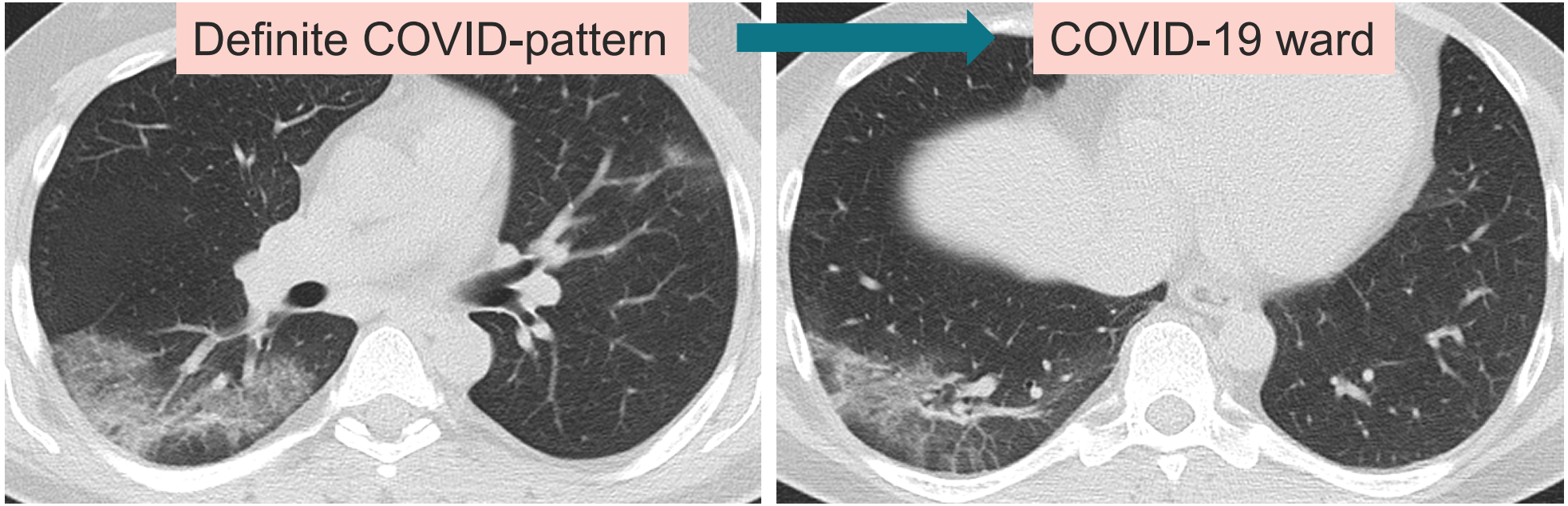

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MÜNCHEN KLINIK

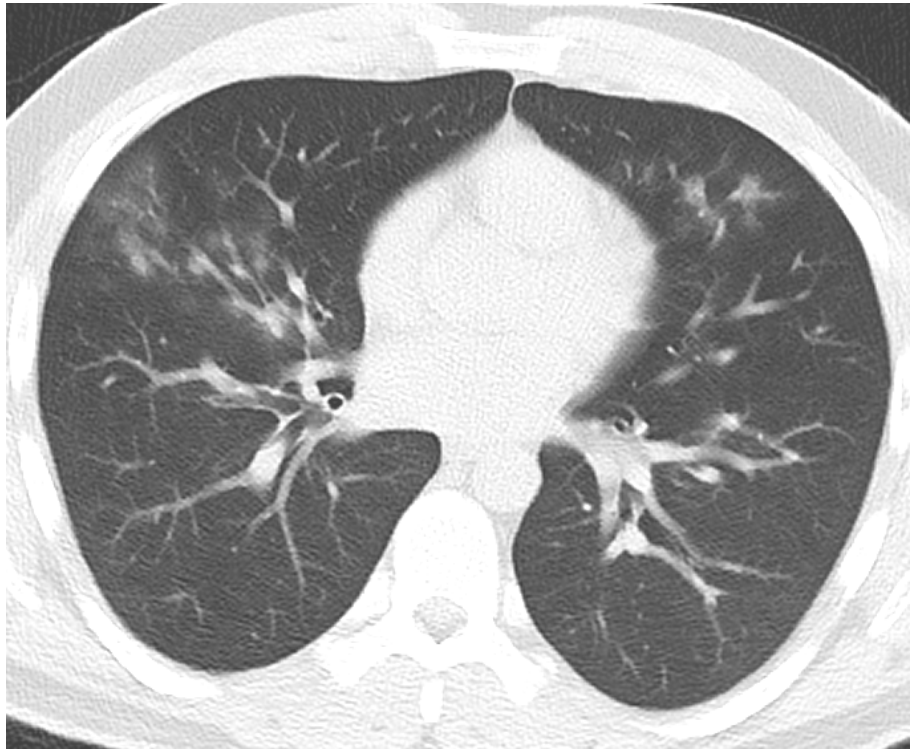
25-year old man, RT-PCR (nasopharyngeal swab) 2 x negative

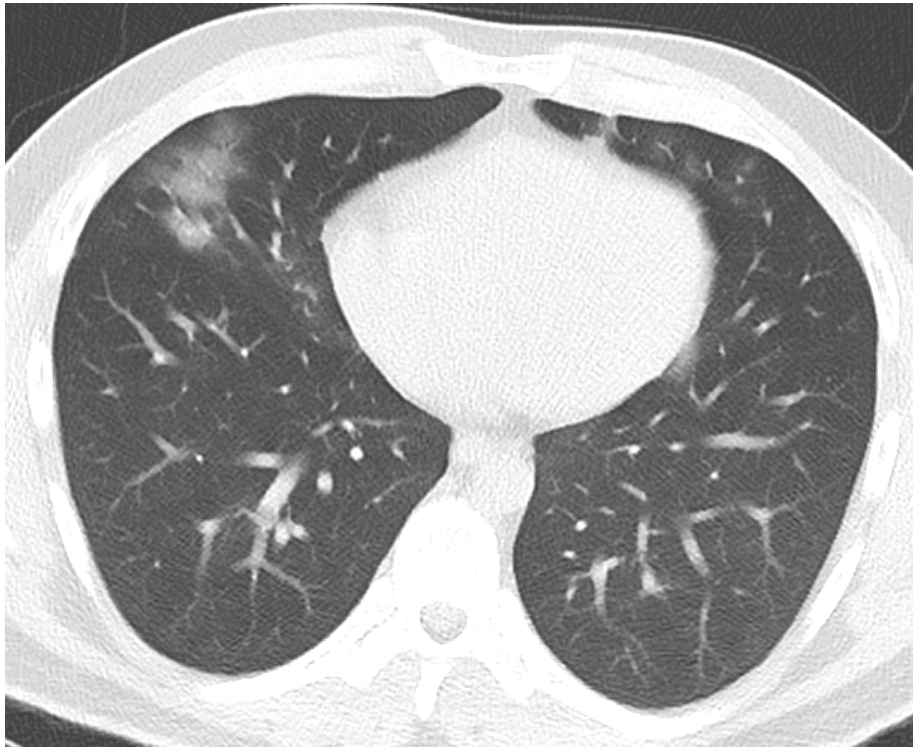
- Fever and headache since 4 days
- Sore throat, weakness
- Dysosmia and dysgeusia
- Diarrhea
- No dyspnoea, no cough

- WBC and ANC normal
- Lymphocytopenia and eosinopenia
- CRP 20,0 mg/l
- PCT not elevated

MÜNCHEN KLINIK

25-year old man, RT-PCR (nasopharyngeal swab) 2 x negative





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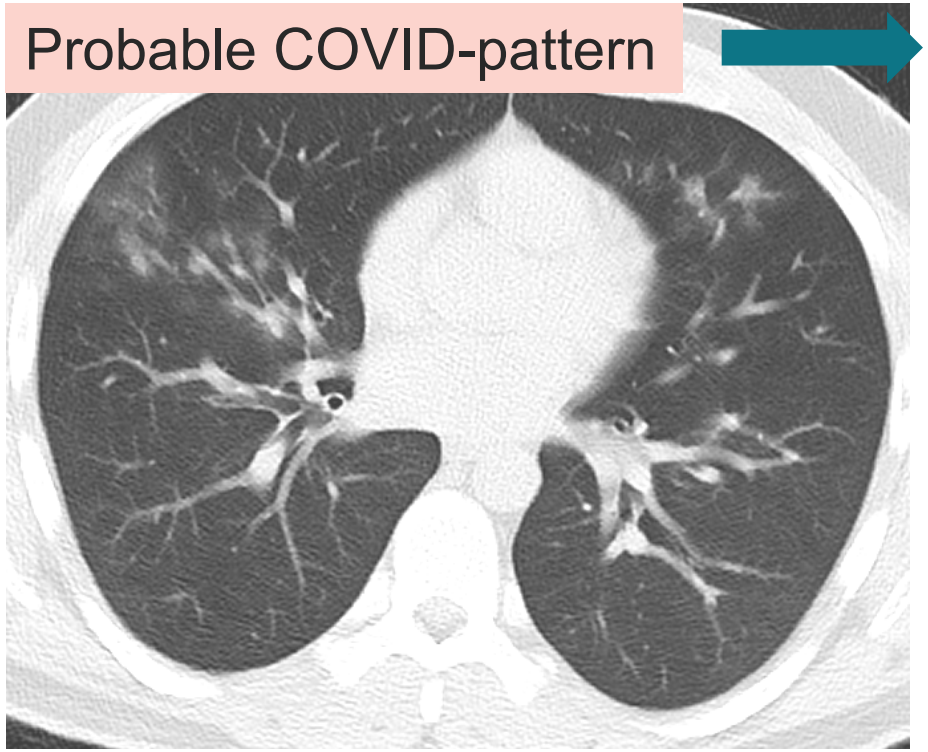
MÜNCHEN KLINIK

25-year old man, RT-PCR (nasopharyngeal swab) 2 x negative

Probable COVID-pattern



Isolation, repeat RT-PCR positive

- Fever and headache since 4 days
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- No dyspnoea, no cough

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MÜNCHEN KLINIK

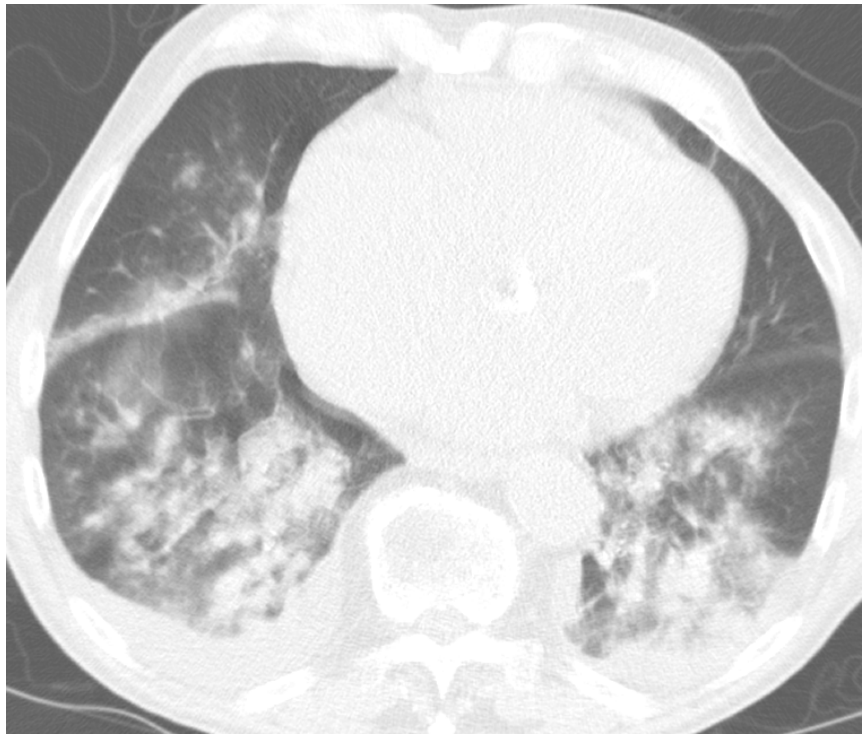
89-year old man, result of RT-PCR pending

- Fever and weakness
- No dyspnoea, no cough
- O_2-saturation 94%

- WBC 12,5/nl
- ANC elevated
- ALC normal, eosinophilia
- CRP 25,7 mg/l
- PCT not elevated

MÜNCHEN KLINIK

89-year old man, result of RT-PCR pending



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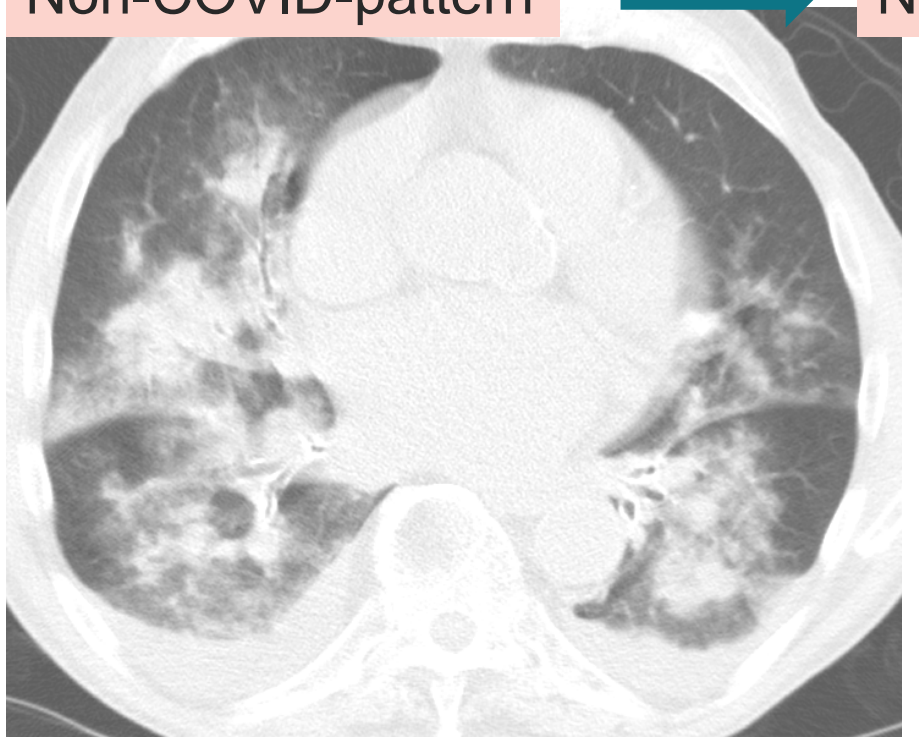
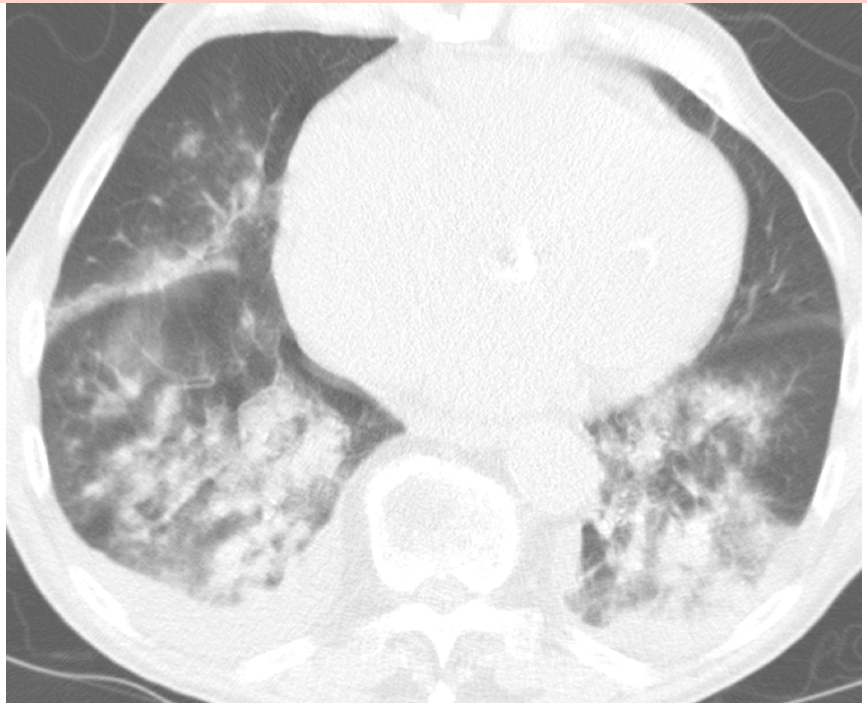
MÜNCHEN KLINIK

89-year old man, result of RT-PCR pending

Non-COVID-pattern → Normal ward, RT-PCR 3 x negative





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- CRP 25,7 mg/l
- PCT not elevated

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Conclusions (2)

- CT is ***not*** a tool to diagnose SARS-Cov-2 infection
- CT is a tool to diagnose severe COVID-19 pneumonia

- CT is ***not*** a screening tool
- CT is a tool that helps to triage severely ill patients with acute respiratory symptoms

- CT is ***not*** an alternative or substitute for RT-PCR testing
- CT is a supplement to clinical findings and laboratory findings

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Vielen Thank you for your attention!

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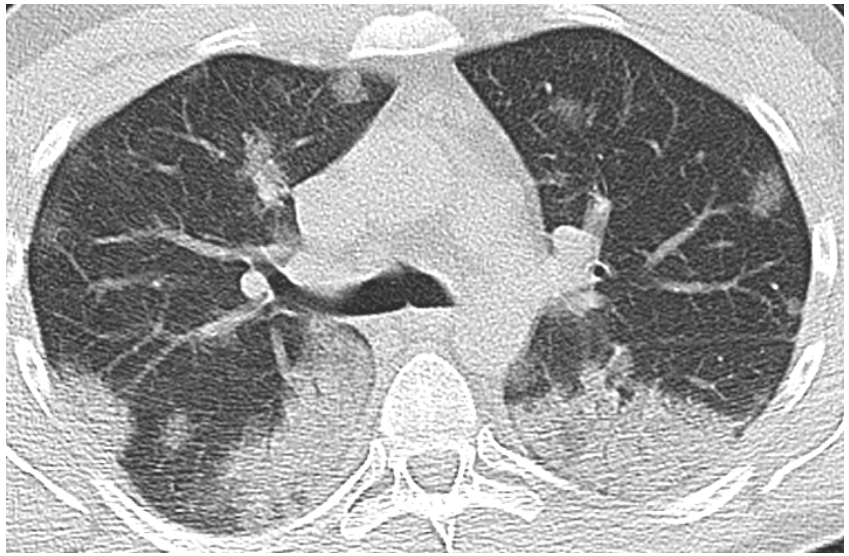
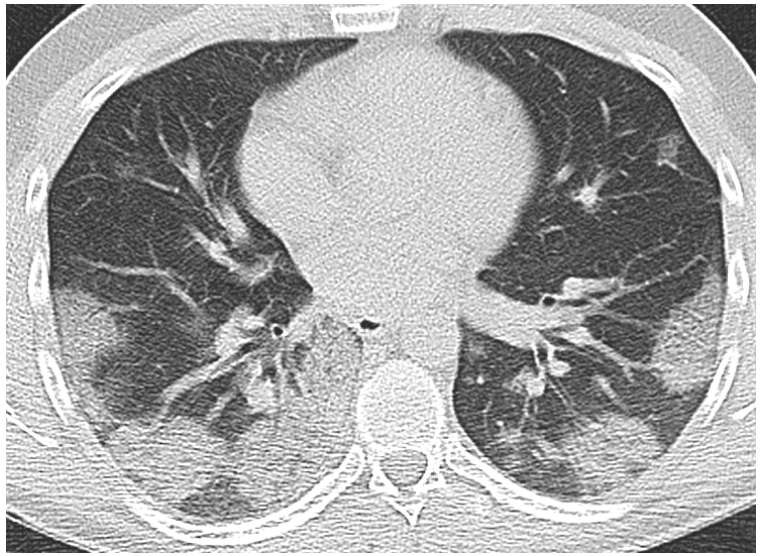
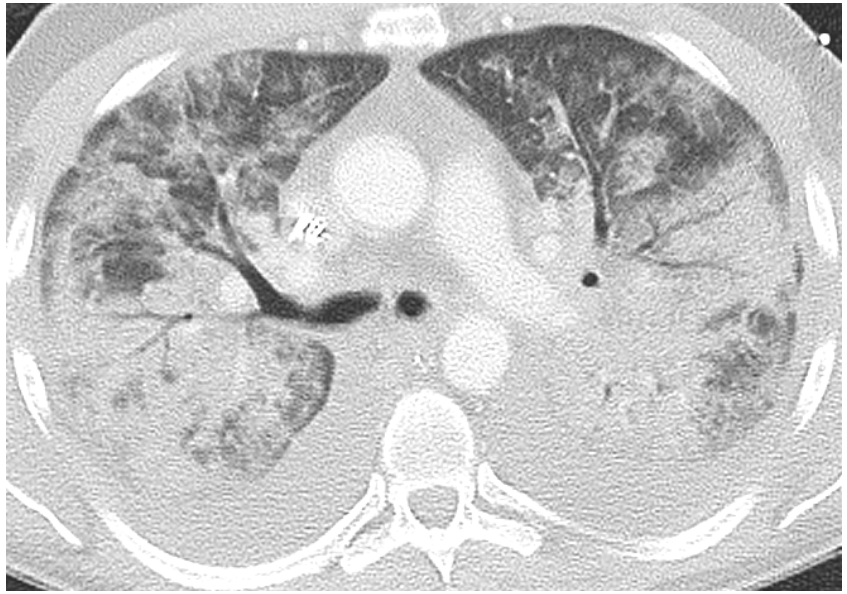
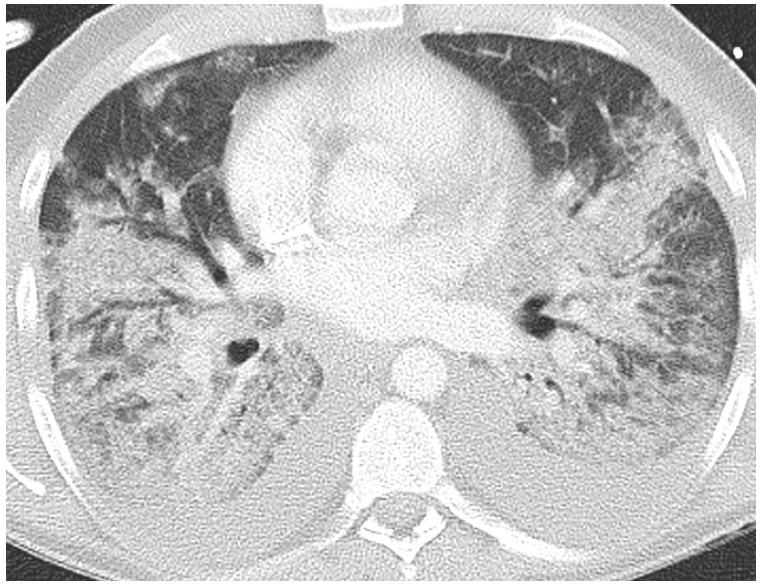




Day 7





Day 30

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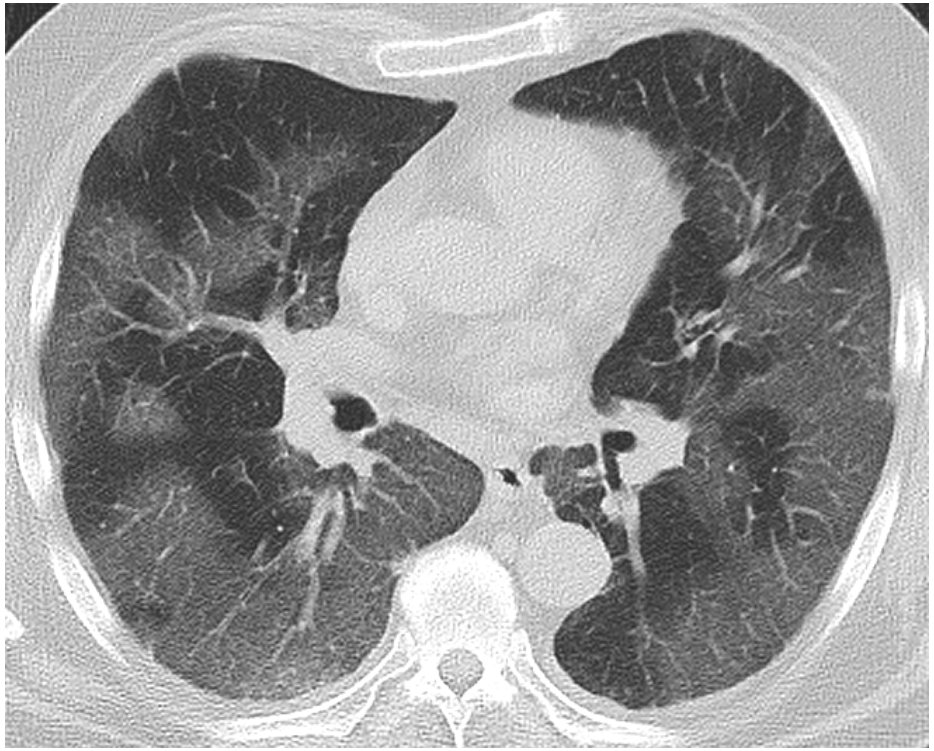
Day 9



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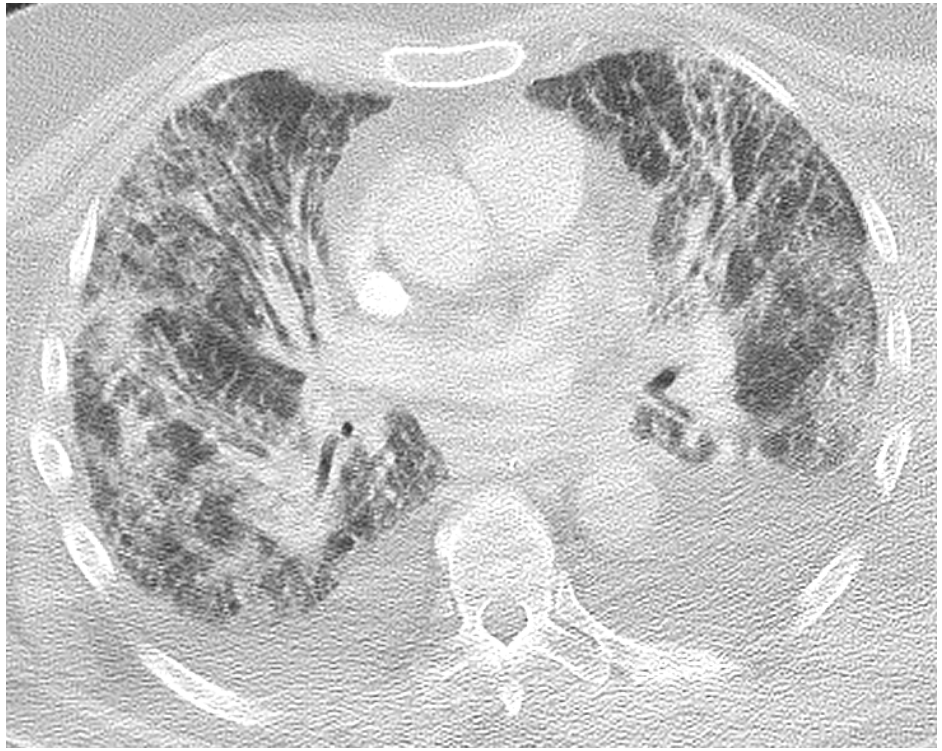

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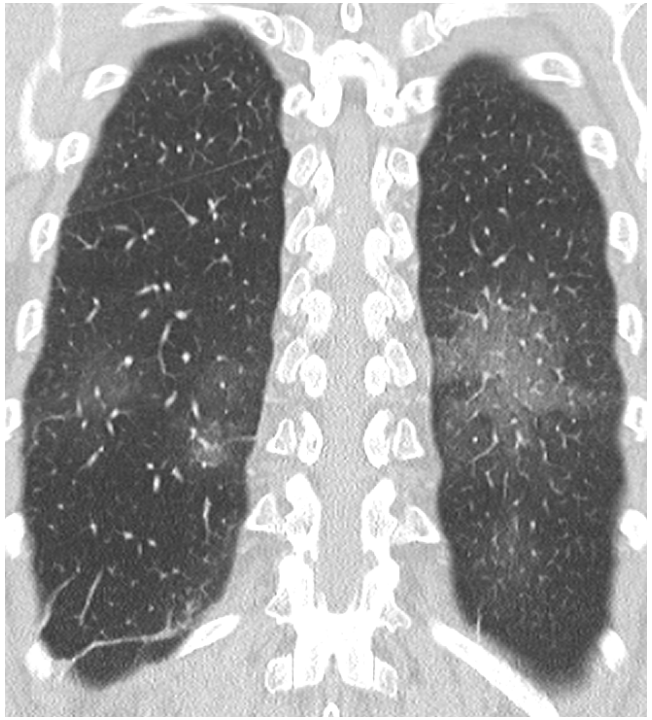
Day 7



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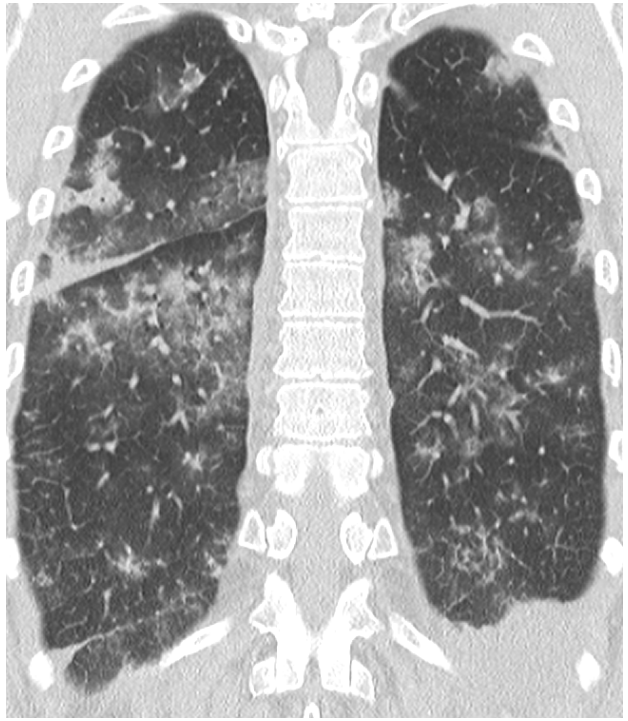

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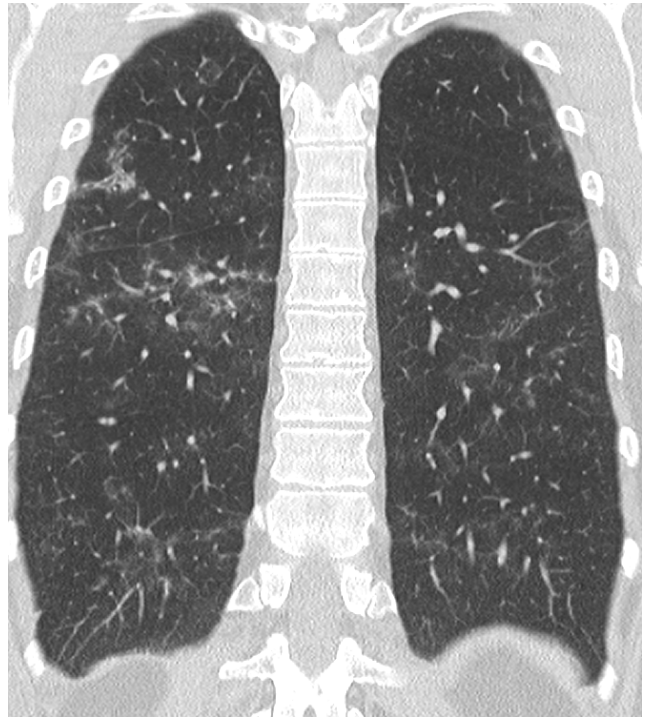

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