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Radiological Manifestations of COVID-19

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ABSTRACT

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Corona virus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a strain of Coronaviruses a broad family of enveloped RNA viruses. Currently there is no treatment and vaccine for the disease. The most important measure to control the pandemic is by identifying positive cases, isolating them and quarantining their contacts during incubation and infectious phases.

Keywords: Corona, Virus, Radiography, CT scan

*See End Note for complete author details

INTRODUCTION

In December 2019, an outbreak of severe acute respiratory syndrome (SARS COV-2) coronavirus infection occurred in Wuhan, Hubei province China and now it had became a pandemic infecting more than 30 lakh people around the world. First case in India was reported in Kerala in 30th January and with strict preventive measures Kerala has successfully flattened the Corona virus curve.

Clinical Perspective

The typical presentation of COVID-19 pneumonia includes fever (in 98.6%), cough (76%) and myalgia or fatigue.

The definitive test for SARS-CoV-2 is the real-time reverse transcriptase-polymerase chain reaction (RT-PCR) test.

Imaging

According to a Fleischner Society consensus statement published on 7 April 2020:

- Imaging is NOT indicated in patients with suspected COVID-19 and mild clinical features unless they are at risk for disease progression.
- Imaging is indicated in a patient with COVID-19 and worsening respiratory status or for medical triage of patients with suspected COVID-19.

For imaging any two of the three following should be present

- Fever (without any apparent respiratory cause).
- Hypoxia (room air SpO2 < / =94%).
- Respiratory rate > / = 20.

Radiologic findings

Radiographic and computed tomography (CT) imaging may be initially normal in COVID infection. The primary findings of COVID-19 on chest radiograph and CT are those of atypical pneumonia or organizing pneumonia.

Plain radiography

Chest radiography is the first-line imaging modality because of the ease of availability, portability and decontamination. Of patients with COVID-19 requiring hospitalization, 69% had an abnormal chest radiograph at the initial time of admission. Findings are most extensive in about 10-12 days after symptom onset.[1,4]

FINDINGS

The distribution is most often bilateral, peripheral and lower zone predominant. Bilateral reticulo nodular opacities and ground-glass opacities are the most common findings. Consolidation was the most common finding on x-ray in 47% of patients, while ground-glass opacities were found in 33%. In contrast to parenchymal abnormalities, pleural effusion is rare (3%).[1,4]

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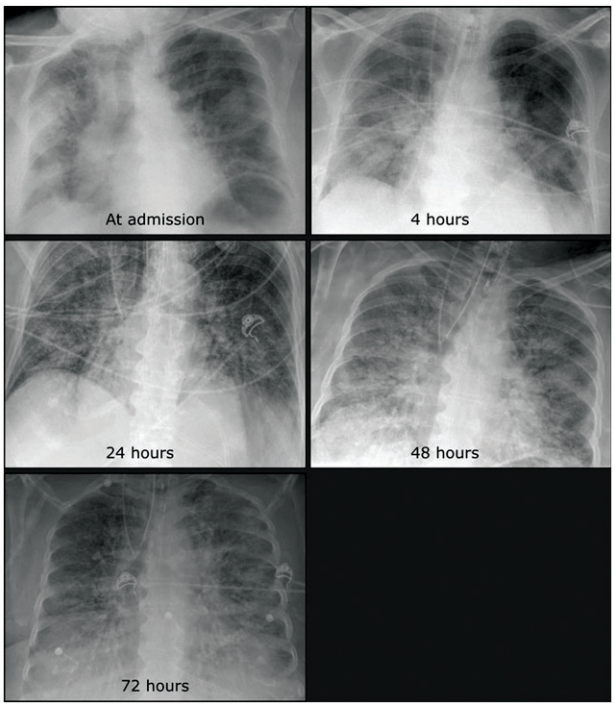

Figure 1. **Serial Chest Radiographs of COVID-19 Patients**

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At admission – Ill defined bilateral peripheral alveolar consolidation **(Figure 1).**

4 hours – Radiological worsening with bilateral lower lobe involvement.

24 hours – Bilateral alveolar consolidation.

48 hours – Bilateral alveolar consolidation with panlobar involvement.

72 hours - Bilateral panlobar consolidation with ARDS pattern. After 24 hours the patient passed away.

Italian researchers have developed a chest x-ray scoring system for quantifying and monitoring COVID-19 findings.

The scoring system included two steps. First, the lungs were divided into six zones on frontal chest projection (two upper zones, two middle, and two lower). Second, each zone was scored based on the following:

- 0: No lung abnormalities
- 1: Interstitial infiltrates
- 2: Interstitial and alveolar infiltrates (interstitial predominance)
- 3: Interstitial and alveolar infiltrates (alveolar predominance)

The researchers added the scores of the six lung zones for an overall score between 0 and 18.

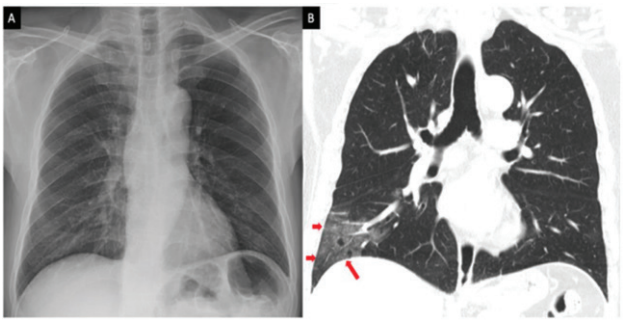

Figure 2. **Normal CXR but obvious peripheral changes in CT (Study done 1 hour apart)**

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CT study

- Indicated in seriously ill patients or if PCR unavailable.
- CT is having high sensitivity (97%), relatively good NPV (83%) and low specificity (25%)[1,2] **(Figure 2).**

HRCT – PCR a comparison

HRCT to be positive in 88% of cases compared to RT-PCR which was positive in 59% of cases.[7] There are more than 3000 CT scanners in India. Nearly every district has one or multiple CT scanners. There are only 52 RT PCR centres in India at this time. Time taken to obtain nasal swab and HRCT is relatively similar. Turn around time of result HRCT instantaneous, RT PCR is 5 hours at present. Number of HRCT that can be done in a day could be 200 or much more per machine or more.[9] HRCT also has additional advantages as it helps assess the extent of pulmonary involvement, disease severity, thus helping to guide clinical management. However ACR- American college of radiology has advised against utilization of HRCT as a first line tool with a logic that RT PCR testing is the definitive diagnosis and will be required to establish the diagnosis.[3] There is overlap of findings with other viral pneumonia and CT is normal in up to 50% of patients within the first two days of symptom onset.

Patients requiring CT should receive a non-contrast chest CT with reconstructions of the volume at 0.625-mm to 1.5-mm slice thickness. If iodinated contrast medium is indicated (for example a CT pulmonary angiogram) a non-contrast scan should be considered prior to contrast administration, as contrast may impact the interpretation of ground-glass opacification (GGO) patterns **(Figure 3)**.

The primary findings on CT in adults:

- Ground-glass opacities (GGO): bilateral, subpleural, peripheral 3(a)
- Crazy paving appearance (GGOs and inter-/intra-lobular septal thickening) 3(b)

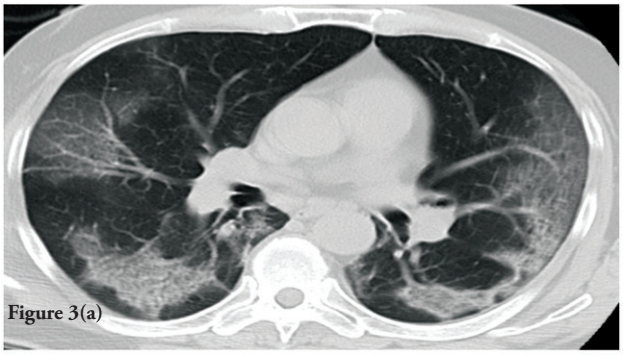
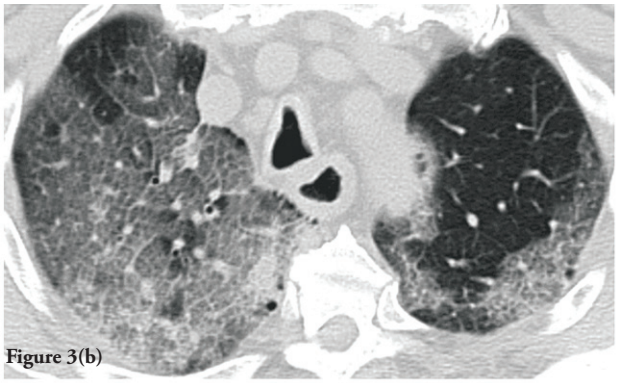


Figure 3(a)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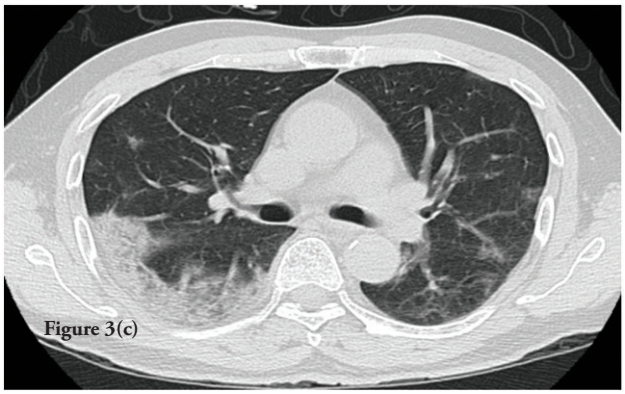
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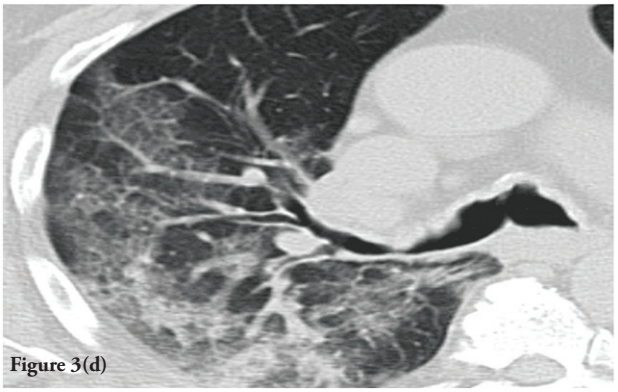
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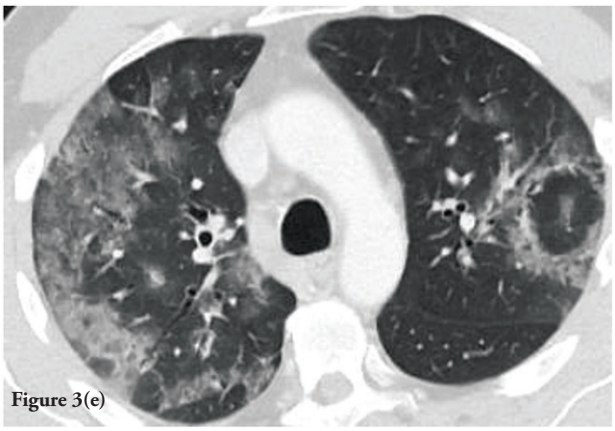
Figure 3(e)

Figure 3. **The primary findings on CT in adults**[1,3,4,6]

Figure 3(a). **Ground-glass opacities (GGO): Bilateral, subpleural and peripheral**

Figure 3(b). **Crazy paving appearance (GGOs and inter-/intra-lobular septal thickening)**

Figure 3(c). **Air space consolidation**

Figure 3(d). **Bronchovascular thickening**

Figure 3(e). **Reverse halo and Perilobularopacities**

©Radiological Findings of 2019-nCoV Pneumonia PMH Experience Dr SK Li and & Dr YC Lee

- Air space consolidation 3(c)
- Bronchovascular thickening 3(d)
- Reverse halo and Perilobular opacities 3(e)

Atypical CT findings: These findings only seen in a small minority of patients should raise concern for superadded bacterial pneumonia or other diagnoses.

Mediastinal lymphadenopathy, Pleural effusions, Multiple tiny pulmonary nodules, Tree-in-bud appearance, Pneumothorax, Cavitation.

CT FINDINGS ACCORDING TO THE STAGE OF THE DISEASE

Five temporal stages as ultra-early, early, rapid progression, consolidation and Dissipation stage **(Figure 4).**

Ultra-early stage (asymptomatic, 1–2 weeks after exposure) - single or multiple focal GGO, patchy consolidative opacities, pulmonary nodules encircled by GGO and air bronchograms.

Early stage (early symptomatic presentation, 54% of their cases) - single or multiple GGOs, or GGO combined with interlobular septal thickening.

Rapid progression stage (days 3–7 of symptomatic presentation) - large, light consolidative opacities and air bronchograms

Consolidation stage (second week of symptomatic presentation) - reductions in density and size of the consolidative opacities may be seen.

Dissipation stage - About 2–3 weeks after the onset, CT may show dispersed patchy consolidative opacities,

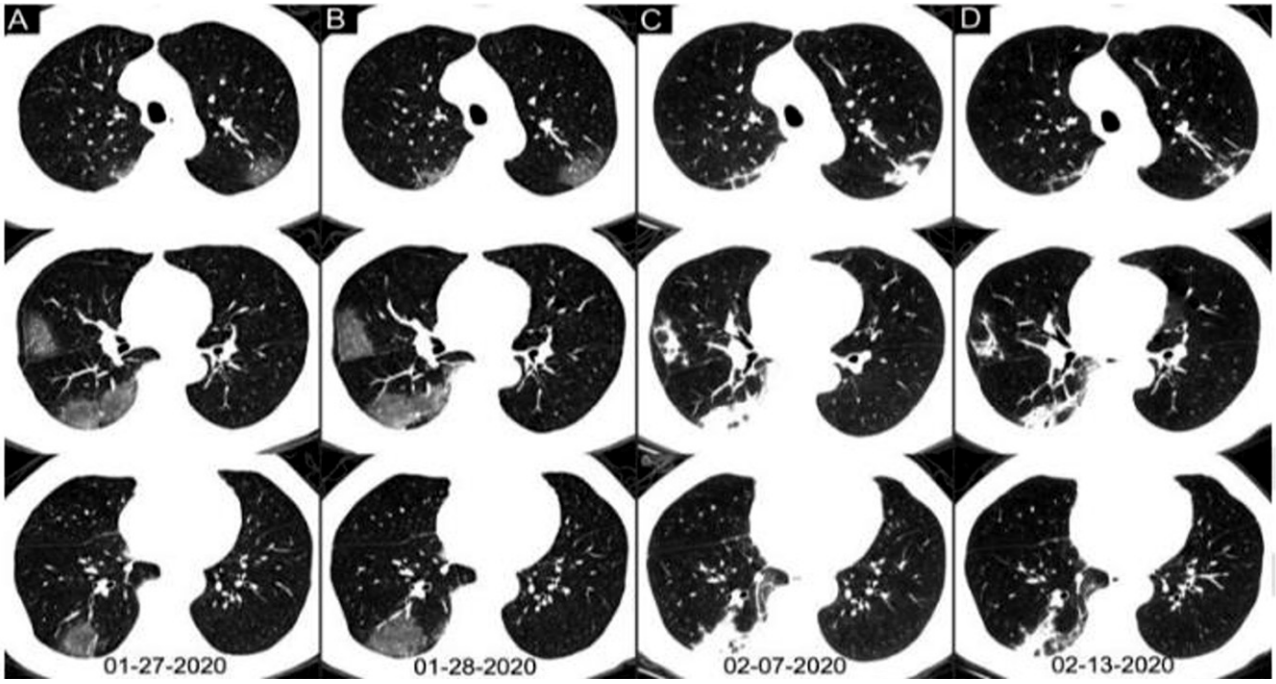

Figure 4. **CT Serial changes**[7]

©Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases Tao Ai MD, PhD1*, Zhenlu Yang MD, PhD1*, Hongyan Hou, MD2, Chenao Zhan MD1,Chong Chen MD1, Wenzhi Lv3, Qian Tao, PhD4, Ziyong Sun MD2, Liming Xia MD, PhD1

reticular opacities (referred to as "strip-like opacities"), bronchial wall thickening, and interlobular septal thickening.

CT findings were most prominent on day 10 of the disease. After day 14, improvement in imaging findings was reported in 75% of the patients, including decreased number of involved lobes and resolution of crazy paving pattern and consolidative opacities.

CT Severity score

Scoring based on percentage of each lobe involvement:

1 - < 5% involvement, **2** - 5%-25% involvement, **3** - 26%-49% involvement, **4** - 50%-75% involvement, **5** - > 75% involvement

The total CT score is the sum of the individual lobar scores and can range from 0 (no involvement) to 25

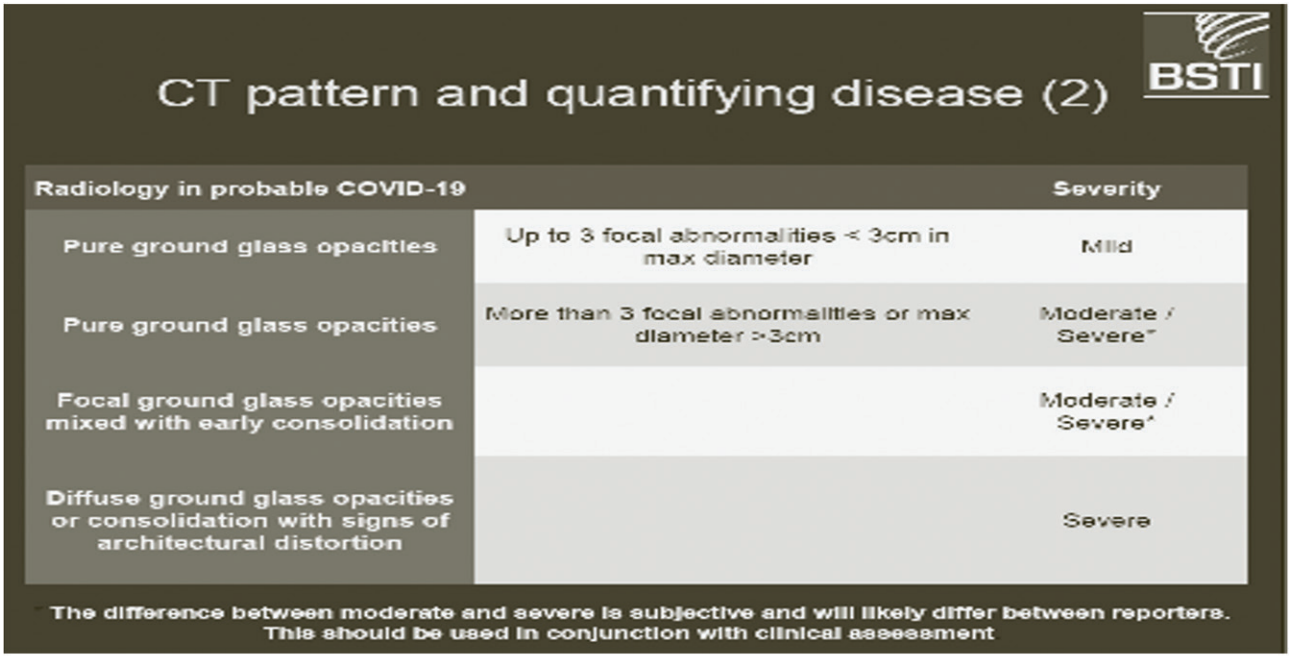

Figure 5. **Disease quantification according to CT pattern into mild, moderate and severe by British Society of Thoracic Imaging**

(maximum involvement), when all the five lobes show more than 75% involvement. Disease quantification into mild, moderate and severe by British Society of Thoracic Imaging has been done based on the lung parenchymal involvement pattern **(Figure 5).**

Paediatric CT: Primary finding is bilateral patchy ground-glass opacities, similar to the appearances in adults, but less florid and the opacities resolved with the clinical improvement.

PET-CT: FDG uptake is increased in ground-glass opacities

Differential diagnoses and radiological differentiating points

- Influenza pneumonia A and B (distribution more along the bronchovascular bundles)
- Cytomegalovirus (CMV) pneumonia (small symmetrical distribution of nodules)
- MERS coronavirus (Pneumothorax and pleural effusion)
- SARS (focal opacity in middle and lower zones)
- Acute respiratory distress syndrome (ARDS): a complication of COVID-19 infection in 17-29% of the patients (Ill-defined alveolar consolidations to bilateral panlobar consolidations)
- Atypical bacterial pneumonia: Mycoplasma pneumonia (Bronchial wall thickening, Centrilobular nodules)
- Pulmonary oedema: (PVHTN, perihilar fluffy opacities, septal thickening, lymphadenopathy)
- Interstitial lung diseases - Cryptogenic organising pneumonia (mid or lower zone, peribronchovascular consolidation, random ggo and nodules)
- Chronic eosinophilic pneumonia (Upper zone, reticular pattern)
- Rheumatoid arthritis-associated pneumonia (Nodules, pleural effusion)
- Pulmonary alveolar proteinosis (No particular zonal distribution
- Pulmonary mucinous adenocarcinoma (Bulging fissures, small peripheral nodules, lymphadenopathy)

Ultrasound

Findings **(Figure 6)**

- Multiple B-lines - focal to diffuse, representing thickened subpleural interlobular septa.
- Irregular, thickened pleural line with scattered discontinuities.

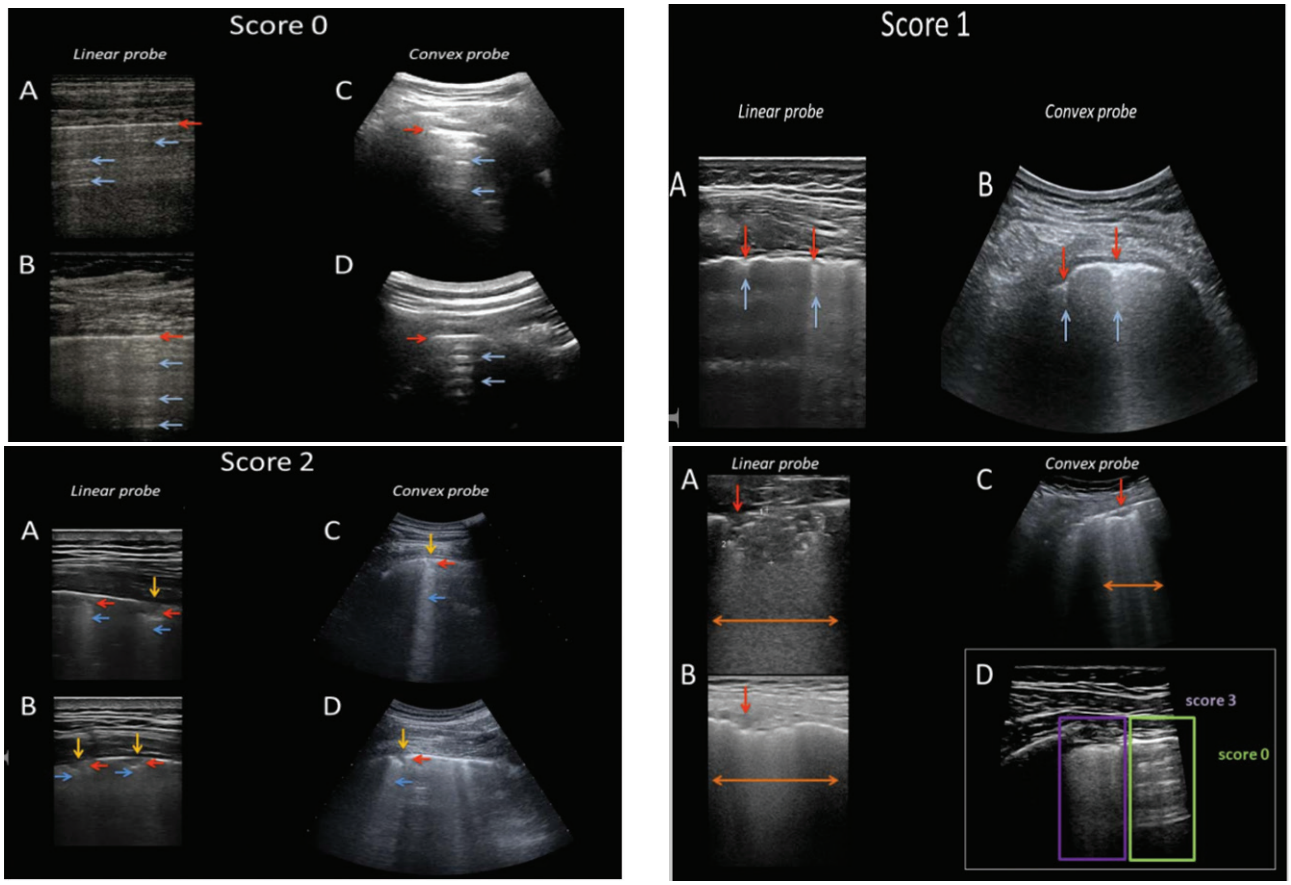

Figure 6. **Ultrasound based scoring**[8]

0 - Continuous regular pleural line. A lines present
1 - Irregular continuous pleural line. A lines absent
2 - Broken pleural line. Small to large consolidations. Scattered B lines
3 - Multiple confluent B lines. Consolidations

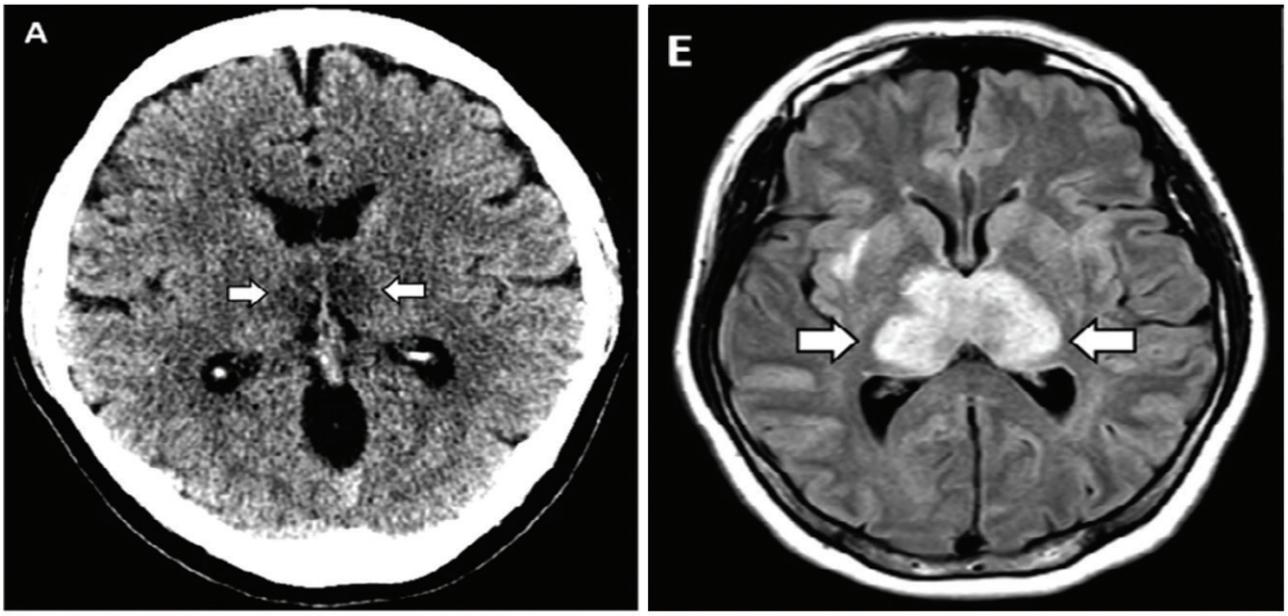

Figure 7. **COVID-19–associated Acute Hemorrhagic Necrotizing Encephalopathy**

- Subpleural consolidation
- Alveolar consolidation
- Reappearance of bilateral A-lines - Restitution of aeration during recovery

COVID-19–associated Acute Hemorrhagic Necrotizing Encephalopathy: CT and MRI Features

Acute necrotizing encephalopathy (ANE) is related to intracranial cytokine storms, which result in blood-brain-barrier breakdown, but without direct viral invasion or parainfectious demyelination. Noncontrast head CT images demonstrated symmetric hypoattenuation within the bilateral medial thalami with a normal CT angiogram and CT venogram[5] **(Figure 7).**

MRI demonstrated symmetric, multifocal T2 FLAIR hyperintense, hemorrhagic, rim enhancing lesions within the bilateral thalami, medial temporal lobes and subinsular regions. Other commonly involved locations include the brain stem, cerebral white matter, and cerebellum.[5]

Patient Management Protocol based on Radiology

A low-dose thoracic CT scan protocol for screening and/or diagnosis of patients suspected of 19-COVID based on a modified version of the existing lung cancer screening CT protocol, version 5.1, originally provided by American Association of Physicists in Medicine (AAPM)[10] can be done for immediate action in case of lack of access to the COVID-19 RT-PCR diagnostic kit.

Based on radiologic findings patients can be grouped as Highly suggestive of COVID-19, Inconsistent and indeterminate for triage and further management.[11]

Highly suggestive of COVID-19 - Ground glass opacities/consolidation, bilateral multilobar involvement, peripheral distribution, crazy paving, round and linear opacities and reverse halo sign.

Inconsistent – Centrilobular distribution, nodules, Tree in bud appearance, cavitation, lymphadenopathy and pleural effusion.

Indeterminate – Findings of both categories and fibrotic changes.

END NOTE

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Conflict of Interest: None declared

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