Review Article

Role of HRCT Scan of Chest in the Evaluation of COVID-19 Pneumonia

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Abstract

Coronavirus disease (COVID-19) pneumonia emerged in Wuhan, China, in December 2019. It is a highly contagious viral disease spreading worldwide, with a rapid increase in the number of cases & deaths. COVID-19 pneumonia is characterized by fever, fatigue, dry cough, and dyspnea with other systemic features such as diarrhea, altered sensorium, stroke & multi-organ failure. HRCT chest is one of the most sensitive modalities for early detection of COVID-19 pneumonia & monitor the outcome of these patients. It is an important complement to the reverse transcriptase polymerase chain reaction (RT-PCR) tests. HRCT shows high specificity & sensitivity in detection of COVID-19 pneumonia being 90.7% & 70.8% respectively. In this pandemic situation, proper diagnosis & management of COVID-19 positive cases largely depends on HRCT findings & severity scoring.

Keywords: HRCT Chest, COVID-19 pneumonia, Ground glass opacities, Consolidation, Crazy paving, organizing pneumonia

Introduction

The emergence of the novel coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) has created an international outbreak of respiratory illness that ranges from mild, self-limited disease to severe pneumonia and death. The initial cases were reported by the World Health Organization (WHO) on December 31, 2019, as "pneumonia of unknown origin" from Wuhan city of Hubei province of China. Since then, the rapid spread of the virus outside China despite local and global attempts to restrain dissemination has garnered international attention, and the WHO declared this outbreak a global pandemic in early March 2020. So far, 14th November 2020, there have been 52.6 million confirmed cases, 34.1 million cases of recovery & 1.29 million deaths were reported by WHO. But these numbers are underestimated as many infected individuals are asymptomatic or have only mild symptoms not requiring tests.[1]

The standard method of confirming COVID -19 infection relies on molecular tests such as real-time polymerase chain reaction (RT-PCR) or sequencing. However, RT-PCR is a costly, time-consuming test that might not be available to all. When the viral load is insufficient, there is a

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strong chance of false-negative results. HRCT scan of chest is an excellent radiological modality that is rapid, non-invasive, and can detect very early pulmonary changes even when RT-PCR remains negative. Thus, CT can play a pivotal role in the early detection and management of COVID-19 pneumonia, at least for patients who have been symptomatic for more than three days.[2] Similar to other viral infectious diseases, COVID-19 infection is not restricted to the pulmonary parenchyma, with reports of myocarditis, hypercoagulability status, acute renal failure, gastroenteritis-like symptoms, mesenteric lymphadenitis, stroke, leukoencephalopathy, and encephalitis.

In this article, we are going to discuss CT scan evaluation of pulmonary involvement of COVID-19.

Role of imaging in COID -19 Pneumonia:

Chest imaging needs to be carefully indicated in suspected COVID-19 infection patients not only to reduce the patients' radiation exposure but also to reduce unnecessary exposure of other patients and healthcare workers and to rationalize the use of personal protective equipment and resources for disinfecting the patient care equipment.

Imaging should be reserved for patients with moderate to severe disease, with comorbidities, and in patients with a high prediction of clinical worsening. Asymptomatic and mild cases do not need imaging. Abnormalities in chest imaging may persist up to a month even after clinical improvement and a negative RT-PCR, so it should not negate patient released from the hospital.[3]

The first imaging modality is a Chest X-ray, which can be done at the radiology department or at the bedside by a portable unit in the severely ill patient. Typical X-ray features include bilateral peripheral patchy ground-glass opacities in the mid and lower zone. Chest X-ray often underestimates the disease severity as it has low sensitivity, around 25%. As such, a chest X-ray should not be used as a screening tool; rather, it should be reserved to see disease progression. It is

again an excellent method to detect complications such as ventilation-associated pneumonia, pneumothorax, pleural effusion at the bedside in an ICU setting.

The role of ultrasonography is limited. It can detect pleural effusions and pneumothorax. COVID -19 pneumonia typically affects peripheral subpleural lung parenchyma, so these peripheral areas of consolidation can be detected by USG. ARDS can also be diagnosed by USG by artifactual lines, which is especially useful in ICU patients when performing a CT scan is not possible. USG also requires less health personnel involvement and can be done at the bedside.[4]

Role of CT scan:

CT scan plays a crucial role in the detection and prognostication of COVID –19 pneumonia. The predominant patterns on CT scan as ground-glass opacification (GGO, hazy areas of increased attenuation without obscuration of the underlying vessels), crazy-paving pattern (GGO with

interlobular and intralobular septal thickening), consolidation (homogeneous opacification of the parenchyma with obscuration of the underlying vessels), and linear opacities (disordered arrangement of coarse linear or curvilinear opacities or fine subpleural reticulation). On the scans, some other minor signs such as air bronchogram, cavitation, bronchiectasis, pleural effusion, pericardial effusion, pneumothorax and mediastinal lymphadenopathy (defined as a lymph node greater than 1 cm in short-axis diameter) were also noted. The distribution of pulmonary lesions was noted as peripheral (predominantly subpleural, involving mainly the peripheral one-third of the lung), central (predominantly lung hilum, involving mainly the central two-thirds of the lung), and diffuse (both subpleural and central regions). The involvement of pulmonary lesions was also noted as single lobe, unilateral multilobe, and bilateral multilobe. Indeed, 56% of patients imaged during the first two days following symptom onset may have normal CT findings.[5]

Adapted Reporting Language for CT Findings Related to COVID-19 Pneumonia:[6]

Among available classifications, the proposal by the consensus of specialists of the Radiological Society of North America (8) has been widely used. They propose four groups of CT findings: typical, indeterminate, atypical, and negative for COVID-19.

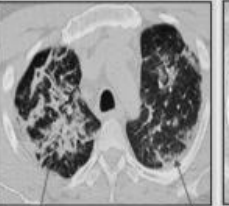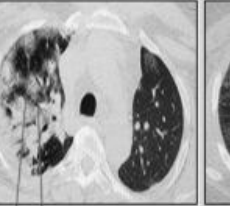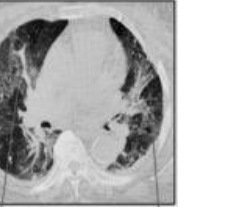| Appearance	Suggested reporting language
Typical	1) Peripheral, bilateral GGO with or without consolidation or visible intralobular lines (crazy-paving pattern). (2) multifocal GGO of rounded morphology with or without consolidation or visible intralobular lines (crazy-paving pattern) or (3) reversed halo sign or other findings of organizing pneumonia. These imaging features are suggestive of pneumonia, and viral etiology must be included in the etiological differential diagnosis, particularly COVID-19.
Indeterminate	Diffuse, perihilar, or unilateral GGO with or without consolidation lacking a specific distribution. Patients with few very small GGOs with a non-rounded and non-peripheral distribution. These imaging features are nonspecific and can be found in a variety of infectious and non-infectious processes, including cases of viral pneumonia and COVID-19.
Atypical	isolated lobar or segmental consolidations, discrete small nodules (centrilobular and tree-in-bud appearance), lung cavitation, and smooth interlobular septal thickening with pleural effusion. These imaging features suggest pulmonary inflammation/infection, although its pattern is not usually reported in COVID-19 cases. Other etiological agents should be considered initially.
Negative for pneumonia	No CT findings are suggestive of pulmonary inflammation/infection. **Note: CT may be negative in some early stages of COVID-19**

Various forms of severity:

Patients with COVID-19 pneumonia present with variable disease extent, ranging from mild involvement of the lung parenchyma to severe disease extent with a "white lung" appearance on HRCT. Various forms of severity scoring systems have been adopted by radiologists worldwide, both in chest X-ray & HRCT. These scoring systems help categorize patients in need of hospitalization and also follow-up.

Each of the five lung lobes is assessed for the degree of involvement and classified as none (0%), less than 5% involvement score is 1, 5-25% score is 2, 25-50% scores 3, 50-75% scores 4 & 75-100% is a score of 5. An overall lung "total severity score" was reached by summing the five lobe scores; total severity scores range from 0–25.

Yuan et al. evaluated imaging findings associated with mortality and reported that the frequency of consolidations as well as the median CT score was both higher in the group of patients who died at the hospital, as compared to patients who could be discharged. A Median CT severity score can predict the patient's outcome as well as can monitor the prognosis of the patient. Other risk factors, patients various co-morbidities also play a vital role in the patients outcome.[7]

Evolution During Follow Up:

CT findings of COVID-19 can be classified in five temporal stages as ultra-early, early, rapid progression, consolidation, and dissipation stages.[8]

|	**Ultra-Early Stage**	**Early Stage**	**Rapid progression Stage**	**Consolidation Stage**	**Dissipation Stage**
Findings	• Prior to symptom onset. • Throat swab positive, laboratory negative • Usually within 1-2 weeks of exposure.	• Patients present with symptoms (within 1-3 days of symptoms like fever, dry cough). • On histopathology - There is congestion of alveolar capillaries resulting in alveolar and interlobular interstitial edema.	• This stage follows within 3-7 days of symptomatic presentation. • There is an escalation in the hyperinflammatory response. Fibrous extensions that connect the alveoli begin to develop.	• This phase coincides with 2nd week of clinical symptoms. • The vascular congestion diminishes and fibrosis predominates.	• It occurs about 2-3 weeks after initial symptomatic presentation. • There is more of a healing and repair response within the lungs.
Images	CT scan demonstrates Bilateral, subpleural, multiple scattered ground glass opacities.	CT scan shows multiple, bilateral ground glass opacities. Irregular, interlobular septa begin to develop.	CT findings include subpleural, posterior consolidations, dispersed air bronchograms along with superimposed irregular septa.	There is a decrease in size and density of consolidations.	CT scan shows patchy consolidation, reticular opacities (strip-like opacities), bronchial and interlobular septal thickening.

The transformation of GGO into linear consolidation is a typical feature for evolution towards organizing pneumonia, which is a nearly universal response to lung injury, whether it is focal or diffuse, due to infection, radiation therapy, or following drug-induced pneumonitis.

Wang et al. also evaluated longitudinal changes and confirmed that pure ground glass was the most common observation after symptoms onset, whereas a mixed pattern combining ground glass with irregular linear opacity peaked on illness days 6-11.

In patients with clinical worsening not explained by an increase in lung opacities on CT, pulmonary embolism should be suspected, and a contrast-enhanced CT examination should be performed, taking into consideration the clinical severity and the renal function. Patients with severe COVID-19 pneumonia have a marked elevation of D-dimers, so that these D-dimer levels do no help identify those who have superimposed pulmonary embolism.

Pictorial Review :
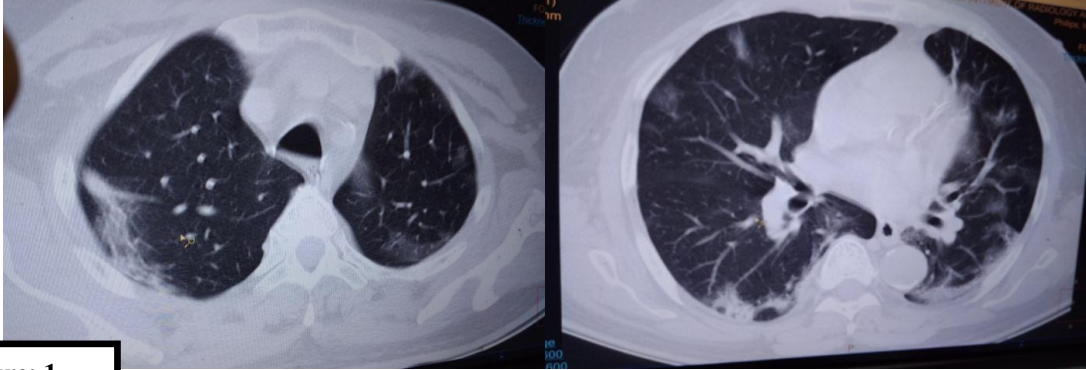
Figure: 1

Axial sections of HRCT Scan of chest of a 62 years male patient, scanned five days after onset of symptoms. Multifocal peripheral subpleural ground-glass opacities are seen involving all the lobes.
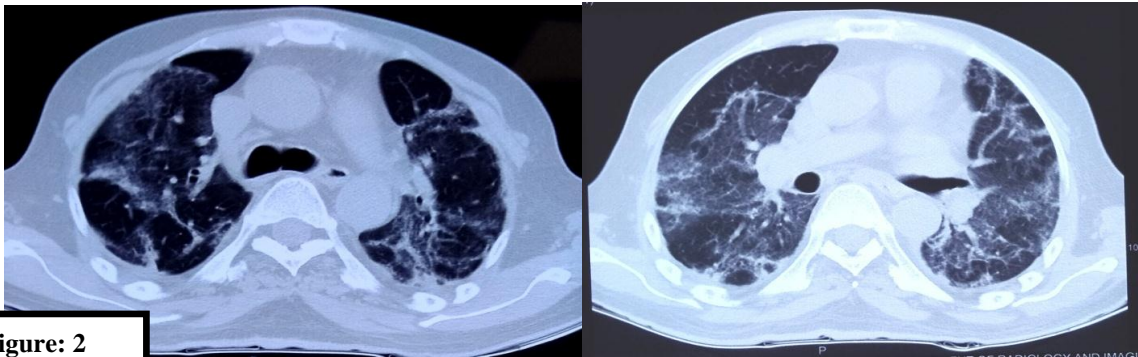
Figure: 2

Axial sections of HRCT Scan of chest of a 48 years female patient, scanned 14 days after onset of symptoms. Multifocal peripheral subpleural ground-glass opacities with fibrotic stripes & septal thickening are observed involving all the lobes.
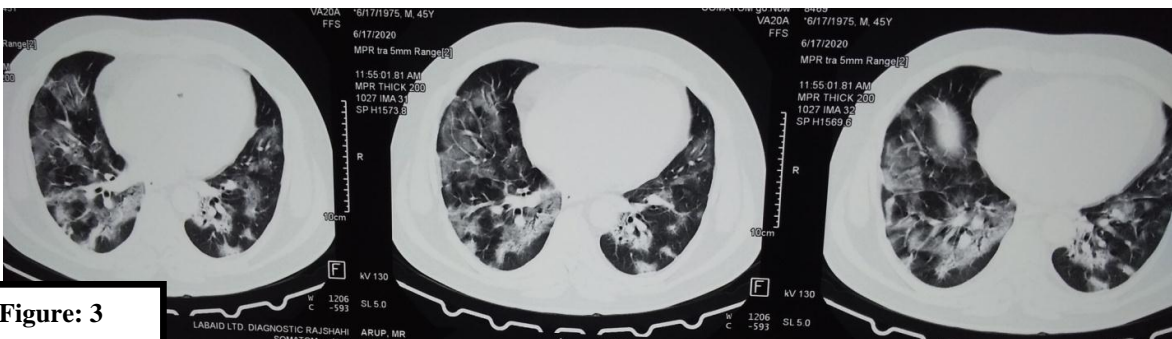
Figure: 3

Axial sections of HRCT Scan of chest of a 70 years male patient, scanned 9 days after onset of symptoms. Multifocal ground-glass opacities with septal thickening are observed involving all the lobes giving a typical crazy paving appearance. Mild vascular dilatations are also seen.

Figure: 4

Axial section of HRCT scan of chest mediastinal window of a 55 years old man showing peripheral wedge-shaped hypodense lesion in superomedial aspect of splenic parenchyma indicating splenic infarction in a COVID-19 positive case having hypercoagulable state.

Conclusion

Chest HRCT is the main imaging modality used in the evaluation of COVID-19 pneumonia. Typical findings include GGOs with or without consolidation, crazy-paving pattern with bilateral and multifocal distribution, peripheral and posterior predominance, multifocal GGOs of rounded morphology, and reversed halo sign. Moreover, HRCT can help evaluate the extent of pulmonary disease, presence of complications, evaluate the disease progression and exclude another differential diagnosis. Despite typical CT findings in COVID-19, RT-PCR remains the gold standard for the diagnosis. Chest imaging should be rationalized & reserved for patients with moderate to severe respiratory symptoms, risk of progression in patients with comorbidities, or worsening of the respiratory condition. Unnecessary radiation exposure and protection of health care personnel should always be taken into consideration.

Standardized & structured chest HRCT report documents the imaging findings and optimizes communication with the referring physician, thus being a useful tool in this pandemic scenario.

References

1. Farias LPG, Fonseca EKUN, Strabelli DG, Loureiro BMC, Neves YCS, and Rodrigues TP. Imaging findings in COVID-19 pneumonia. CLINICS 2020;75: e2027

2. Omar et al. High-resolution CT features of COVID-19 pneumonia in confirmed cases Egyptian Journal of Radiology and Nuclear Medicine (2020) 51:121

3. Wang Y, Dong C, Hu Y, Li C, Ren Q, Zhang X, et al. Temporal changes of CT findings in 90 patients with COVID-19 pneumonia: a longitudinal study. Radiology 2020,

4. Yuan M, Yin W, Tao Z, Tan W, Hu Y. Association of radiologic findings with mortality of patients infected with 2019 novel coronavirus in Wuhan, China. PLoS One 2020;15: e0230548.

5. WHO Director-General's opening remarks at the media briefing on COVID-19. Available from: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19--11-march-2020 [cited Mar 23th, 2020]

6. Ai T, Yang Z, Hou H. Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. Radiology 2020; 296(2): E32-40

7. Hani C, Trieu NH, Saab I, Dangeard S, Bennani S, Chassagnon G, Revel MP, COVID-19 pneumonia: A review of typical CT findings and differential diagnosis. Diagnostic and Interventional Imaging 101 2020; 263–268

8. Pan F, Ye T, Sun P, Gui S, Liang B, Li L, et al. Time Course of Lung Changes On Chest CT during Recovery from Coronavirus Disease (COVID-19). Radiology. 2020;295(3):715-21.

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