

## Review Article

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# The Role of Chest CT Scan in Diagnosis of COVID-19

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## Abstract

As the number of patients infected by COVID-19 increases worldwide, and in the absence of appropriate therapeutic drugs or vaccines, it is essential to detect patients with COVID-19 pneumonia at its early stages, in order to isolate the patients from healthy population. Computed tomography (CT) scan seems to be promising in detection of COVID-19 as shown in some studies.

**Key words:** COVID-19; Diagnosis; Pandemics; Tomography, X-Ray Computed

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## INTRODUCTION

As the number of patients infected by COVID-19 increases worldwide, and in the absence of appropriate therapeutic drugs or vaccines, it is essential to detect patients with COVID-19 pneumonia at its early stages, in order to isolate the patients from healthy population. Computed tomography (CT) scan seems to be promising in detection of COVID-19 as shown in some studies. Ai et al. evaluated 1014 patients in Wuhan, China, for whom chest CT scan and reverse transcriptase-polymerase chain reaction (RT-PCR) was performed. The sensitivity of chest CT in detection of COVID-19 was 97% in patients with positive RT-PCR results. Sixty to 93% of patients had positive chest CT findings for COVID-19 before or at the same time as the initial positive RT-PCR results. On the other hand, typical CT scan findings were found in more than 70% of patients with negative RT-PCR tests, which could be due to overlap of CT imaging features of COVID-19 and other viral pneumonias or the high false-negative rate of the RT-PCR tests<sup>(1)</sup>. In a recently performed meta-analysis, the pooled sensitivity and specificity of chest CT for detection of COVID-19 were 94% and 37%, respectively, whereas the pooled sensitivity of RT-PCR was 89%<sup>(2)</sup>.

## SHOULD A CHEST CT SCAN BE USED FOR DIAGNOSIS OF COVID-19?

Some patients had a negative chest CT scan during the first two days after the initial symptom, with ground-glass opacity (GGO) appearing between days 0 and 4 after symptom onset and peaking at 6-13 days<sup>(3-7)</sup>. Therefore, a negative chest CT does not rule out the possibility of COVID-19 infection,

particularly in the early phase. Chest CT scan findings may become apparent prior to the positive RT-PCR test. An initially negative RT-PCR may take up to 4 days to convert in a patient with COVID-19<sup>(1)</sup>. CT scan has been reported to be more sensitive than RT-PCR earlier in the course of the disease<sup>(8)</sup>. In a population with a high pretest probability for the disease, the positive and negative predictive values of chest CT for COVID-19 were estimated as 92% and 42%, respectively<sup>(9)</sup>.

This relatively low negative predictive value suggests that at least in earlier stages of the disease, CT may not be valuable as a screening test for COVID-19. Considering the fact that chest CT scan findings are not specific for COVID-19 and overlap with other infections, the American College of Radiology (ACR) recommends that CT should not be used for screening or as a first-line test to diagnose COVID-19 and should be used for hospitalized, symptomatic patients with specific clinical indications. Viral testing is considered as the only specific method of diagnosis. A normal chest CT does not rule out COVID-19 infection and an abnormal CT is not specific for COVID-19 diagnosis<sup>(10)</sup>.

In another statement, the Royal College of Radiology (RCR) announced that "as the current evidence does not demonstrate a clear benefit in producing a definitive and positive management change on the basis of CT information, there is no current role for CT in the diagnostic assessment of patients with suspected coronavirus infection in the UK. The CT request should be based on clinical need and management plan. The CT appearances alone will not obviate the need for viral testing and should not be viewed as equivalent to or replacing this"<sup>(11)</sup>.

**Table 1:** The CT scan imaging features of COVID-19 patients**The typical features**

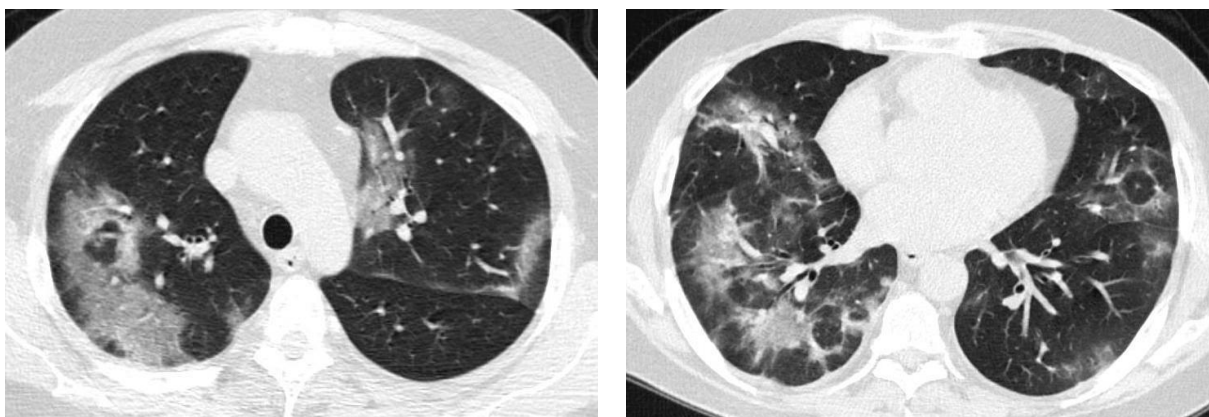
Peripheral bilateral or multifocal GGO of rounded morphology with or without consolidation  
 Visible “crazy paving”  
 Reverse halo sign  
 Other findings of organizing pneumonia

**The indeterminate features**

Non-rounded, non-peripheral, multifocal, diffuse, perihilar, or unilateral GGO with or without consolidation lacking a specific distribution  
 Few very small GGOs with a non-rounded and non-peripheral distribution

**The atypical features**

Isolated lobar or segmental consolidation without GGO  
 Discrete small nodules (centrilobular, “tree in- bud”)  
 Lung cavitation  
 Smooth interlobular septal thickening with pleural effusion

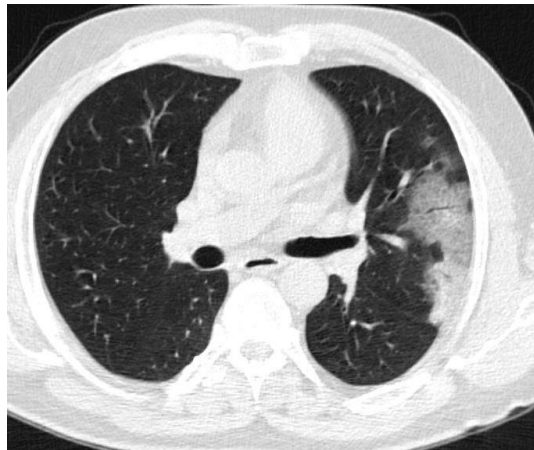
**Figure 1:** Typical imaging findings of COVID-19 pneumonia. Bilateral peripheral ground glass opacities in a 52-year-old man with cough and dyspnea**CHEST CT SCAN FINDINGS OF COVID-19 PNEUMONIA**

Several recently published papers have described CT imaging features of COVID-19, and the evolution of these features over time (3, 4, 12-14). The most common imaging features were peripheral GGO with or without consolidation, especially in the posterior or lower lung zone (3, 4, 12-15). GGO has also been frequently reported to have round morphology or be associated with interlobular septal thickening (“crazy paving”), which are often bilateral and multilobar (3, 12). However, a significant portion of cases have opacities with nonspecific distribution (3). Linear, curvilinear or perilobular opacities, and diffuse GGO are also reported. They can mimic several disease processes including other infections, inhalational injuries, and drug toxicities (16-19). In most cases, perihilar involvement was not reported (3).

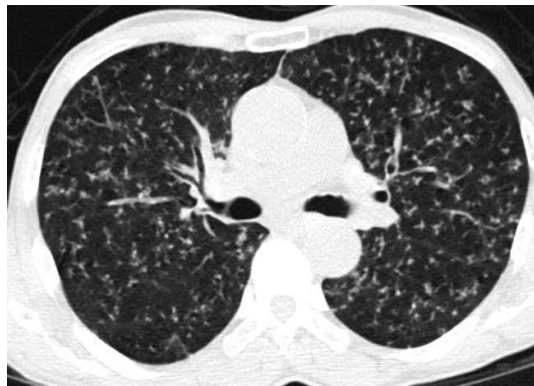
Mucoid impactions, Bronchial wall thickening, and nodules (“tree-in-bud” and centrilobular), which are common in some infections, are not typical findings of COVID-19 pneumonia (3). Pleural effusion and lymphadenopathy were rarely reported (12, 20). Radiological Society of North America Expert Consensus suggested using a standardized language

for reporting chest CT scan findings in patients with suspected COVID-19 infection. They categorized commonly reported imaging features of COVID-19 including peripheral bilateral GGO or multifocal GGO of rounded morphology with or without consolidation or visible “crazy paving”, Reverse halo sign, or other findings of organizing pneumonia as typical features.

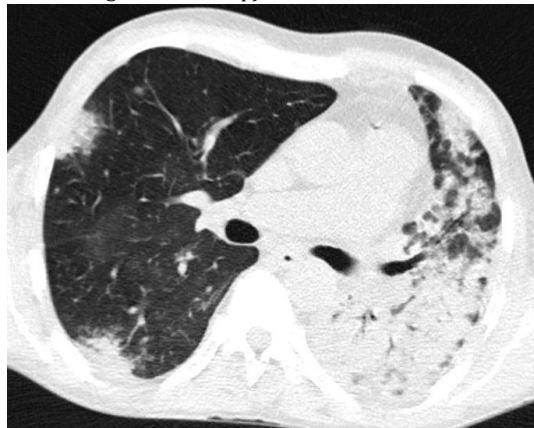
The indeterminate group included findings that have been reported in COVID-19 pneumonia but are not specific, including non-rounded, non-peripheral, multifocal, diffuse, perihilar, or unilateral GGO with or without consolidation lacking a specific distribution or few very small GGOs with a non-rounded and non-peripheral distribution. Atypical features included isolated lobar or segmental consolidation without GGO, discrete small nodules (centrilobular, “tree in-bud”), lung cavitation, and smooth interlobular septal thickening with pleural effusion. They are reported to be uncommon or not occurring in COVID-19 pneumonia and are more typical of other diseases. The CT scan imaging features of COVID-19 patients are reported in table 1, and illustrated in figures 1-3 (21).



**Figure 2:** Typical imaging findings of COVID-19 pneumonia. Peripheral ground glass opacity with interlobular septal thickening (crazy paving pattern)



**Figure 3:** Atypical imaging features for COVID-19 pneumonia. Bilateral diffuse tree in bud opacities (the patient was a 60-year-old man with positive tuberculosis tests in diagnostic work up)



**Figure 4:** Diffuse consolidation in the left lung and patchy peripheral consolidations in the peak phase of COVID-19 pneumonia

#### IMAGING FEATURES INDICATIVE OF DISEASE SEVERITY

Patients with COVID-19 pneumonia could have various degrees of lung involvement, ranging from mild with small patches of GGO to severe forms with

diffuse bilateral consolidation. Li et al. concluded that the incidence of consolidation, linear opacities, and crazy-paving pattern in severe or critically ill patients was significantly higher than that observed in other patients. These severely/critically ill patients were older and had more co-morbidities<sup>(22)</sup>.

Yuan et al. scored CT attenuation of pulmonary opacities (1 for normal attenuation, 2 for ground glass and 3 for consolidation) and degree of lung involvement in upper, middle and lower zones on each side using a 5-point scale (0 no involvement, 1 less than 25%, 2: 25–50%, 3: 50–75% and 4: >75%), and calculated CT score. The maximal CT score was 72. The cut-off value of 24.5 for the CT score, predicted mortality with 85.6% sensitivity and 84.5% specificity. The frequency of consolidations was also higher in the mortality group<sup>(23)</sup>.

#### TEMPORAL CHANGES OF IMAGING FINDINGS

In a study performed by Pan et al., they retrospectively evaluated twenty-one patients who had recovered from COVID-19 pneumonia and defined 4 stages of lung involvement on CT. In the early stage (0-4 days after onset of the initial symptom), unilateral or bilateral subpleural GGO in the lower lobes was the main imaging finding. Four patients had negative chest CT; however, they showed lung abnormalities in follow up CT scans<sup>(4)</sup>. In the progressive stage (5-8 days after the onset of the initial symptom), the opacities increased in number and size and led to bilateral multi-lobar diffuse GGO, crazy-paving pattern, and consolidation. In the Peak stage (9-13 days after the onset of the initial symptom), the involved areas were slowly reaching the peak involvement and dense consolidation became more prevalent. Typical findings at this stage were diffuse GGO, crazy-paving pattern, consolidation, and residual parenchymal bands<sup>(4)</sup>.

Lung abnormalities on chest imaging were most severe approximately 10 days after symptom onset. In the last stage, which was called the absorption stage ( $\geq 14$  days after the onset of the initial symptom), consolidations had gradually diminished and no crazy-paving pattern was present anymore. However, in this stage, extensive GGO could be observed as the result of the consolidation absorption. Figure 4 shows one example in this regard<sup>(4)</sup>.

In another study, among patients who clinically improved, resolutions of radiographic abnormalities were reported to happen after improvements in fever and hypoxia<sup>(24)</sup>.

**CONCLUSION**

Although CT scan has high sensitivity in detecting COVID-19 pneumonia, according to the published statements, it should not be used as a diagnostic or screening method. The most common chest CT scan finding of COVID-19 pneumonia is peripheral GGO with or without consolidations, especially in posterior and lower regions of lungs. Crazy paving, reverse halo sign and other imaging findings of organizing pneumonia are also considered typical. As time passes, opacities increase in number and size to reach the most severe stage at about 10 days from initial symptoms. Opacities eventually start to diminish in the absorption phase.

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**AUTHORS' CONTRIBUTION**

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**CONFLICT OF INTEREST**

None declared.

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