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

Hoda Asefi[1], Arash Safaie[2]*

1. Department of Radiology, Tehran University of Medical Sciences, Tehran, Iran.
2. Department of Emergency Medicine, Tehran University of Medical Sciences, Tehran, Iran.

***Corresponding author:** Arash Safaie; **Email:** a-safaie@sina.tums.ac.ir

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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 [1]. 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% [2].

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 [3-7]. 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 [1]. CT scan has been reported to be more sensitive than RT-PCR earlier in the course of the disease [8]. 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 [9].

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 [10].

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" [11].

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

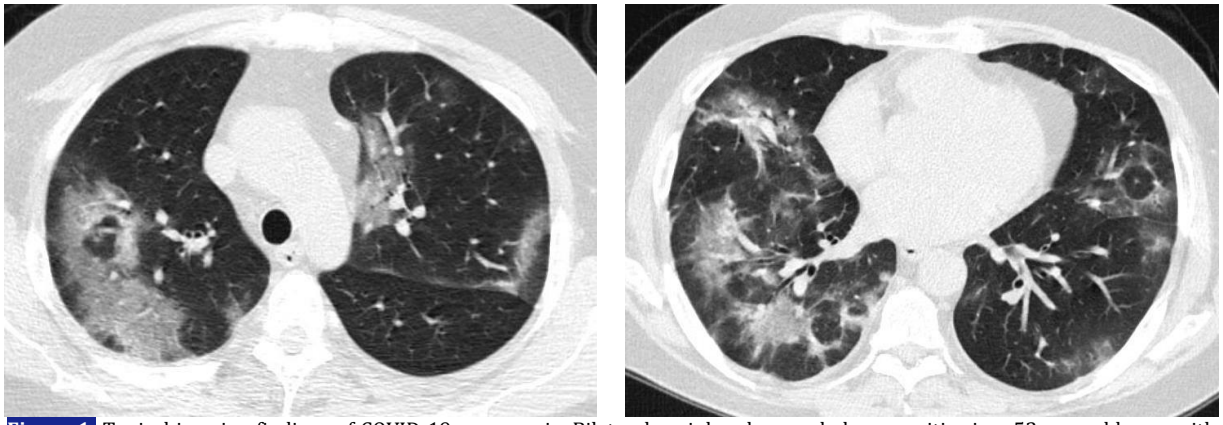

Figure 1: Typical imaging findings of COVID-19 pneumonia. Bilateral peripheral ground glass opacities in a 52-year-old man with cough and dyspnea

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].

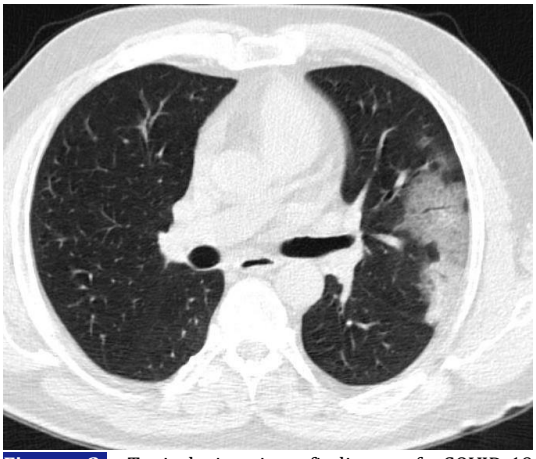

Figure 2: Typical imaging findings of COVID-19 pneumonia. Peripheral ground glass opacity with interlobular septal thickening (crazy paving pattern)

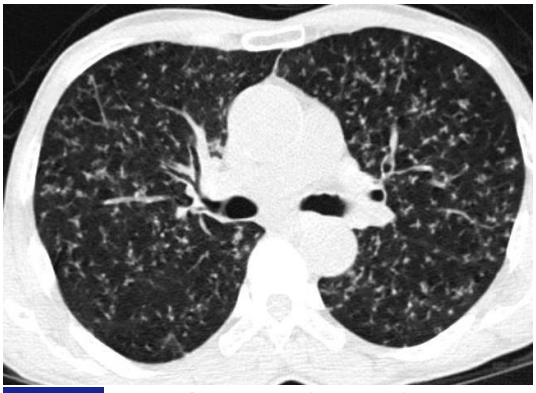

Figure 3: Atypical imaging features for COVID-19 pneumonia. Bilateral diffuse tree in bud opacities (the patient was a 60-year-old man with positive tuberculosis tests in diagnostic work up)

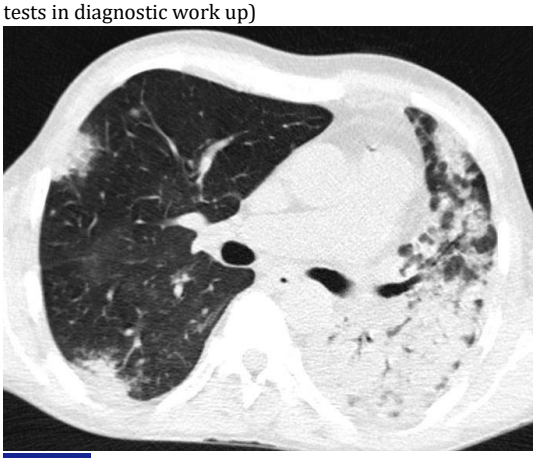

Figure 4: Diffuse consolidation in the left lung and patchy peripheral consolidations in the peak phase of COVID-19 pneumonia

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 [22].

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 [23].

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 [4]. 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 [4].

Lung abnormalities on chest imaging were most severe approximately 10 days after symptom onset. In the last stage, which was called the absorption stage (≥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 [4].

In another study, among patients who clinically improved, resolutions of radiographic abnormalities were reported to happen after improvements in fever and hypoxia [24].

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

All the authors met the standards of authorship based on the recommendations of the International Committee of Medical Journal Editors.

Conflict of interest

None declared.

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References

1. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, et al. Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. Radiology. 2020:200642.
2. Kim H, Hong H, Yoon SH. Diagnostic Performance of CT and Reverse Transcriptase-Polymerase Chain Reaction for Coronavirus Disease 2019: A Meta-Analysis. Radiology. 2020:201343.
3. Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, et al. Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection. Radiology. 2020:200463.
4. 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 2019 Novel Coronavirus (COVID-19) Pneumonia. Radiology. 2020:200370.
5. 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. 2020:200843.
6. Huang L, Han R, Ai T, Yu P, Kang H, Tao Q, et al. Serial quantitative chest ct assessment of covid-19: Deep-learning approach. Radiology. 2020;2(2):e200075.
7. Song F, Shi N, Shan F, Zhang Z, Shen J, Lu H, Ling Y, Jiang Y, Shi Y. Emerging 2019 Novel Coronavirus (2019-nCoV) Pneumonia. Radiology. 2020;295(1):210-7.
8. Fang Y, Zhang H, Xie J, Lin M, Ying L, Pang P, et al. Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR. Radiology. 2020:200432.
9. Wen Z, Chi Y, Zhang L, Liu H, Du K, Li Z, et al. Coronavirus Disease 2019: Initial Detection on Chest CT in a Retrospective Multicenter Study of 103 Chinese Subjects. Radiology. 2020;2(2):e200092.
10. American College of Radiology. ACR recommendations for the use of chest radiography and computed tomography (CT) for suspected COVID-19 infection. March 11, 2020. [Available from: https://www.acr.org/ Advocacy-and-Economics/ACR-Position- Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19- Infection].
11. Royal College of Radiology. RCR position on the role of CT in patients suspected with COVID-19 infection. [Available from: https://www.rcr.ac.uk/college/coronavirus-covid-19-what-rcr-doing/clinical-information/rcr-position-role-ct-patients].
12. Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, et al. CT Imaging Features of 2019 Novel Coronavirus (2019-nCoV). Radiology. 2020;295(1):202-7.
13. Kong W, Agarwal PP. Chest imaging appearance of COVID-19 infection. Radiology. 2020;2(1):e200028.
14. Bai HX, Hsieh B, Xiong Z, Halsey K, Choi JW, Tran TML, et al. Performance of radiologists in differentiating COVID-19 from viral pneumonia on chest CT. Radiology. 2020:200823.
15. Salehi S, Abedi A, Balakrishnan S, Gholamrezanezhad A. Coronavirus Disease 2019 (COVID-19): A Systematic Review of Imaging Findings in 919 Patients. AJR Am J Roentgenol. 2020:1-7.
16. Franquet T. Imaging of pulmonary viral pneumonia. Radiology. 2011;260(1):18-39.

17. Kligerman S, Raptis C, Larsen B, Henry TS, Caporale A, Tazelaar H, et al. Radiologic, Pathologic, Clinical, and Physiologic Findings of Electronic Cigarette or Vaping Product Use-associated Lung Injury (EVALI): Evolving Knowledge and Remaining Questions. Radiology. 2020;294(3):491-505.
18. Ellis SJ, Cleverley JR, Müller NL. Drug-induced lung disease: high-resolution CT findings. AJR Am J Roentgenol. 2000;175(4):1019-24.
19. Nishino M, Hatabu H, Hodi FS. Imaging of Cancer Immunotherapy: Current Approaches and Future Directions. Radiology. 2019;290(1):9-22.
20. Ng MY, Lee EY, Yang J, Yang F, Li X, Wang H, et al. Imaging profile of the COVID-19 infection: radiologic findings and literature review. Radiology. 2020;2(1):e200034.
21. Simpson S, Kay FU, Abbara S, Bhalla S, Chung JH, Chung M, et al. Radiological Society of North America Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA. Radiology. 2020 25;2(2):e200152.
22. Li K, Wu J, Wu F, Guo D, Chen L, Fang Z, et al. The Clinical and Chest CT Features Associated with Severe and Critical COVID-19 Pneumonia. Invest Radiol. 2020; Epub ehead of print.
23. 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(3):e0230548.
24. Han X, Cao Y, Jiang N, Chen Y, Alwalid O, Zhang X, et al. Novel Coronavirus Pneumonia (COVID-19) Progression Course in 17 Discharged Patients: Comparison of Clinical and Thin-Section CT Features During Recovery. Clin Infect Dis. 2020; Epub ahead of print.