Suspected COVID 19 Patients in Emergency Department: HRCT Chest and CO-RADS Classification System, A Pictorial Review

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ABSTRACT
Coronavirus Disease 2019 (COVID-19) pandemic has rapidly resulted in global health emergency. Because of limitations of RT-PCR assay and other rapid detection tests, chest CT can aid in early diagnosis and management of patients with suspected COVID-19 presenting in emergency department. This pictorial review provides radiologists with an overview of various High Resolution CT scan chest manifestations of COVID 19 and also the CO-RADS reporting system which can help in making accurate diagnosis and better communication to referring physician.

Keywords: COVID-19, CO-RADS, HRCT Chest

INTRODUCTION
With the increasing prevalence of coronavirus disease-19 (COVID-19) worldwide, timely detection of COVID-19 infection in patients presenting to emergency department with SARI and distinguishing them from other causes has become crucial to ensure rapid prevention and early treatment.¹

As of now, methods for detection of COVID-19 such as real-time reverse-transcriptase polymerase chain reaction (RT-PCR) tests or rapid antigens tests are either not readily available, or have high relative false negative rate or require several hours for the result.² Performing chest CT for detecting COVID-19 related pulmonary lesions may be a helpful test for patients suspected of COVID-19 infection at the beginning of admission in the emergency department.¹

With almost similar time taken to obtain nasal swab and HRCT, the turn around time of result of HRCT is instantaneous as compared to 4-5 hours for RT-PCR at present.³ Therefore, radiologist needs to be familiar with the imaging findings of COVID-19 to make accurate diagnosis, clinical suggestions and help in limiting the spread of disease.³

CO-RADS, (COVID-19 Reporting and Data System), is non enhanced chest CT scan based assessment scheme for pulmonary involvement in patients suspected of COVID-19 and has very good predictive value for COVID-19 patients.⁴ CO-RADS categorical system assesses the suspicion of lung involvement, providing standardized communication to clinicians for better and early decision making. However to build a clinical diagnosis of COVID-19 before availability of RT-PCR test results, it has to be interpreted together with clinical and laboratory findings.⁴ Also Final diagnosis however relies on RT-PCR positivity for the presence of coronavirus.⁴

Through this pictorial review, we aim to illustrate the various HRCT CHEST manifestations of suspected COVID-19 patients who present to the emergency department and categorize them according to CO-RADS. Various CT manifestations of COVID-19 are shown in a pictorial fashion to help radiologists familiarize these possible imaging features.

Ground glass opacity, Fig 1
The earliest and most common CT manifestation of COVID 19 is unifocal or multifocal, unilateral or bilateral, Ground glass opacities (GGOs) with predominant peripheral and subpleural distribution. GGOs together with small areas of consolidation may suggest an organizing pneumonia pattern of lung injury.⁶

Crazy paving pattern, Fig 2
Crazy paving pattern of thickened interlobular septa and intralobular lines superimposed on a GGOs background, resembling irregular paving stones is another common finding of COVID-19.⁷

Consolidation, Fig 3
Multifocal, patchy, or segmental consolidation, with subpleural or peribronchovascular distribution, is usually present in COVID-19 patients and is an indicator of disease progression.⁵

Reticular pattern, Fig 4, Fig 5
Reticular pattern seen as coarse linear opacities or fine sub-pleural reticulation due to thickened interlobular and intralobular septa is relatively late but common chest CT manifestation of COVID-19.⁹

Subpleural curvilinear line, Fig 6
It manifests as a thin curvilinear opacity with 1–3 mm thickness, lying less than 1 cm from and parallel to the pleural surface.⁸

Air bronchogram, Fig 7
Air bronchogram seen as air-filled bronchi on a

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background of high attenuation airless lung is another CT manifestation of COVID-19. Moreover, this can often be accompanied by slight bronchiolar dilatation termed as bronchiolectasis. 7

**Bronchial Wall Thickening and Bronchiectasis, Fig 8**
Bronchial wall thickening and bronchiectasis are seen less commonly in COVID-19 pneumonia and are more frequent in later stages and in critical patients. 10

**Vascular Dilation or Thickening, Fig 7**
Vascular enlargement often occurs as the dilatation of small pulmonary vessels around and within lung parenchymal lesion like ground glass opacity or consolidation. 11

**Pleural changes, Fig 9**
Pleural thickening is more prevalent than pleural effusion. Presence of pleural effusion can be due to underlying co-morbid condition or may suggest a poor prognosis in COVID-19. 10

**Halo sign, Fig 10**
Halo sign, though an uncommon finding in COVID-19, is seen as a nodule or mass surrounded by ground glass haze. 6

**Reversed Halo Sign, Fig 10**
The reversed halo or atoll sign is seen as a central focal area of ground glass opacity surrounded more or less complete ring-like consolidation. 12

**Fibrosis, Fig 11, 12**
Fibrous lesions may form during the healing of chronic pulmonary inflammation. CT manifestations of fibrosis in COVID-19 suggest disease stabilization. However, some reports argue that fibrosis may progress to pulmonary interstitial fibrosing disease. 13

**Lymphadenopathy**
Mediastinal and hilar lymphadenopathy is very uncommon finding and is considered as risk factor of severe pneumonia or bacterial superinfection. 10,14 Based on the CT findings, the level of suspicion of COVID-19 infection is graded from very low or CO-RADS 1 to very high or CO-RADS 5 and the severity and stage of the disease is determined. An overview of CO-RADS is given in Table 1 and a pictorial overview is presented in subsequent section. 5

**CO-RADS 1**
CO-RADS 1 signifies very low level of suspicion for pulmonary involvement and COVID-19 is highly unlikely, eg. normal CT scan or CT findings of non-infectious etiology like emphysema, congestive heart failure (Fig 13 a), interstitial lung disease, lung tumors etc.

<table>
<thead>
<tr>
<th>CO-RADS Category</th>
<th>Level of Suspicion</th>
<th>HRCT features</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Very low</td>
<td>Normal or non infectious cause</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
<td>Consistent with Infections other than COVID-19</td>
</tr>
<tr>
<td>3</td>
<td>Indeterminate</td>
<td>Overlapping features seen in COVID-19 as well as other diseases</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>Abnormalities Suspicious for COVID-19</td>
</tr>
<tr>
<td>5</td>
<td>Very high</td>
<td>Typical COVID-19 abnormalities</td>
</tr>
<tr>
<td>6</td>
<td>RT-PCR Positive</td>
<td></td>
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**Table-1:** CO-RADS Categories and the Level of Suspicion of COVID-19 infection
Figure 5a and 5b: HRCT scan images of two different patients shows subpleural curvilinear lines (arrows).

Figure 6: HRCT scan shows bilateral GGOs and thick linear fibrous stripes in both lower lobes.

Figure 7: HRCT scan images of same patient at two different levels show small vascular enlargement and air bronchograms within patches of GGOs in right upper (fig a) and right lower lobes (fig b).

Figure 8: HRCT scan image shows area of GGO, consolidation with air bronchogram, bronchial wall thickening and bronchiectatic changes in right middle lobe (black frame)

Figure 9: HRCT scan shows left pleural thickening (arrow).

Figure 10: HRCT scan shows small nodules surrounded by a ground glass halo in both upper lobes (Halo sign, fig a). HRCT scan shows a reversed halo sign in subpleural region of right lower lobe (arrow in fig b).

Figure 11: HRCT scan shows extensive predominantly peripheral areas of fibrosis, consolidation with pleural thickening and mild traction bronchiectasis suggesting relatively late phase of disease.

Figure 12: HRCT scan image of patient recovered from COVID-19 shows residual extensive fibrotic changes with interstitial thickening and architectural distortion in both lungs.

Figure 13: CO-RADS 1, interstitial pulmonary edema with pleural effusion (fig a). CO-RADS 2, Lobar consolidation along with centrilobular nodules and tree-in-bud pattern (fig b).

CO-RADS 2
CO-RADS 2 signifies low level of suspicion of COVID-19 infection in which CT findings are typical of other infectious etiology like bronchopneumonia, lobar pneumonia, pulmonary abscess. Features include centrilobular nodules, tree-in-bud appearance, lobar or segmental consolidation (Fig 13 b) and cavitation.
CO-RADS 3
CO-RADS 3 signifies equivocal findings and COVID-19 infection is indeterminate based on CT features alone, that can also be found in other etiologies like widespread bronchopneumonia, perihilar or homogenous extensive ground glass opacities (Fig 14 a, b) with or without pleural effusion. Single unilateral ground glass opacity is also considered in this category (Fig 15).

CO-RADS 4
CO-RADS 4 signifies a high level of suspicion for COVID-19 infection. CT findings are typical for COVID-19 but may not be located in contact with the visceral pleura, may be strictly unilateral (Fig 16) or superimposed on pre-existing pulmonary abnormalities (Fig 17) or showing some overlap with other (viral) pneumonias.

CO-RADS 5
CO-RADS 5 signifies a very high level of suspicion for COVID-19 infection. Obligatory features include ground-glass opacities, with or without consolidations, close to visceral pleural surfaces, multifocal and bilateral distribution. In Early phase of disease dominant pattern is multiple ground-glass areas (Fig 18a). With disease progression these areas evolve into crazy paving pattern and increasing consolidations appear (Fig 18 b). Eventually organizing pneumonia like pattern (Fig 18 c) and fibrosis (Fig 18 d) occurs. Subpleural curvilinear bands and thickened vessels within lung abnormalities are associated frequent and typical findings.

CO-RADS 6
CO-RADS 6, indicates RT-PCR proven COVID-19.

CONCLUSION
In conclusion, with surge in COVID-19 pandemic cases and many patients presenting to emergency department with acute respiratory symptoms, HRCT scan of chest is a rapid and reliable tool to triage patients suspected of infected with COVID-19. Familiarity with imaging findings of COVID 19 and further communicating the results to referring physician through structured and fast reporting system like CO-RADS,
as presented in this review article, radiologist can play a crucial role in management of this global outbreak.

**Ethical Approval:**
As this is retrospective and observational/pictorial review of the patients for whom chest CT scan was indicated to diagnose the infection, ethical approval is not required.

**REFERENCES**