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# Imaging in COVID-19: A Review

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## ABSTRACT

The coronavirus disease 2019 (COVID-19) outbreak, which started in Wuhan, China, has rapidly spread worldwide. It is a highly infectious viral disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and diagnosed by real-time reverse transcription-polymerase chain reaction (RT-PCR) of the viral nucleic acid. COVID-19 usually presents with symptoms related to respiratory system; however, lately there have been number of reports with extrapulmonary manifestations. Some patients have shown severe cardiovascular damage, acute-onset hepatitis, acute renal failure, encephalitis and myositis. Although the role of imaging has been limited in diagnosis, it is becoming more and more central to supplementing diagnosis, assessing severity, progression and in the follow-up of these patients. This article is aimed to review the role of imaging in COVID-19.


**Keywords:** Coronavirus infection, pneumonia, COVID-19, extrapulmonary manifestation

In December 2019, several pneumonia cases with unknown etiology were reported in Wuhan, China[1] and were subsequently confirmed to be due to a novel coronavirus - severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease, in shorthand, was named COVID-19 from **Co**rona**vi**rus **D**isease-20**19**. Belonging to the family Coronaviridae, the novel coronavirus is a member of the family of viruses that cause diseases ranging from the common cold to severe acute respiratory syndrome (SARS) and the Middle East respiratory syndrome (MERS).[2] The virus has since then spread to 213 countries with more than 5.7 million worldwide cases reported as of the last week of May. The virus uses widely expressed angiotensin-converting enzyme 2 (ACE2) receptors to enter cells including pneumocytes, respiratory, renal, gastrointestinal epithelial cells and the vascular endothelial cells from nasal and oral pharyngeal mucosa. The average incubation period of the disease is 6.4 days. About 20% of cases are severe with mortality of about 2-3%.[3]

The common clinical presentation includes a lower respiratory tract illness with low-grade fever, headache, generalized weakness, dry cough, dyspnea and anosmia. Old age, obesity, comorbidities like diabetes, hypertension and immunocompromised status are known risk factors for severe disease. However, several patients have shown extrapulmonary manifestations involving the cardiovascular, musculoskeletal, hepatic, renal and the nervous systems.

With changes in the presentation patterns, as well as more and more patients getting extrapulmonary system involvement, the role of imaging is increasing. The present article is an attempt to review and describe the role of imaging in the various pulmonary and extrapulmonary manifestations of the disease.

## PULMONARY IMAGING IN COVID-19

### Chest X-ray

Chest X-ray is the initial and remains the most commonly performed imaging in these patients. It is indicated if the patient presents with respiratory symptoms as well as for assessing the patient in follow-up. Initially, the X-ray chest remains normal, but as the disease progresses, patchy opacities in the lung fields can be noted. As the disease progresses further, these opacities may coalesce to give white lung appearance. Other findings that may be seen on radiographs during the course of illness are consolidation and may be pleural effusion.

### Chest Computed Tomography Scan

Chest computed tomography (CT) scan is the most sensitive imaging modality for the evaluation of lung manifestations. Interestingly, there are studies with

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positive CT and false-negative reverse transcription-polymerase chain reaction (RT-PCR) results.[4,5] The available literature amply proves that imaging can play an important role in the evaluation of suspected COVID-19 infection. Additionally, CT imaging can help in assessing the severity, monitoring disease progression and evaluating treatment response. Due to increased incidence of deep venous thrombosis and pulmonary embolism, it is advised to go for contrast study in these cases.[6]

These patients may show varying spectrum on CT chest depending upon the time course and disease severity. There are certain CT findings which are typical for, and seen more frequently in COVID-19 patients, while there are others which are relatively uncommon. Certain findings, if present, almost rule out COVID-19 as per the disease understanding today.

| Typical findings | Atypical findings |
|---|---|
| • Ground-glass opacity | • Airway changes |
| • Consolidation | • Pleural changes and effusion |
| • Reticular pattern | • Fibrosis |
| • Crazy paving pattern | • Vascular enlargement |
| • Peripheral distribution | • Air bubble sign |
| | • Nodules and Halo sign |
| | • Lymphadenopathy |
| | • Pericardial effusion |

Lobar consolidation and lack of ground-glass opacity almost rules out COVID-19.

**Ground-glass opacity** is defined as a hazy area with slightly increased density with no obscuration of bronchial and vascular margins likely as a result of partial filling of air spaces or interstitial thickening. This may be unilateral or bilateral, and is usually peripheral and subpleural.[7-9] This is the earliest CT manifestation.

**Consolidation** is defined as alveolar air getting replaced with fluid, cells or tissues and is seen as an increase in pulmonary parenchymal density obscuring the margins of underlying vessels and airway walls.[10] The distribution is multifocal, patchy or segmental in the subpleural area or along the bronchovascular bundles. Consolidation is usually seen after 2 weeks of the onset of symptoms. It is as an indication of disease progression and should be taken as an alarming sign in management.

**Reticular pattern** is seen as thickening of pulmonary interstitial structures like interlobular septae and intralobular lines. These have been reported to be the most common CT finding after ground-glass opacity and consolidation in patients of COVID-19.[8] Its prevalence has been seen to have a direct correlation with duration of illness.[11]

**Crazy paving pattern** is seen as thickened interlobular septae and intralobular lines superimposed on a background of ground-glass opacity, giving it irregular paving stone appearance. This signals disease entering progressive or peak stage.[12]

**Airway changes** in the form of bronchiolectasis, bronchiectasis and bronchial wall thickening have been seen in severe disease but are not very common.[4,13,14]

**Pleural and subpleural changes:** Pleural thickening and pleural effusion, both have been reported, the former being relatively more prevalent; however, pleural effusion has been shown to be associated with a relatively poor prognosis.[11,15]

**Vascular enlargement** described as the dilatation of pulmonary vessels around and within the lesion, although not commonly reported, was seen in most of the cases reported by Ye et al.[16]

**Nodules and Halo sign:** A nodule refers to a rounded or irregular opacity with well or poorly defined edges measuring less than 3 cm in diameter.[10] The nodules have been associated with viral pneumonia.[17] About 3-13% of COVID-19 patients may have multifocal solid irregular nodules[12] or nodules with the Halo sign.[18] Halo sign is defined as nodules or masses surrounded by ground glass opacification.

**Lymphadenopathy and pericardial effusion:** Enlarged mediastinal lymph nodes (lymph node larger than 1.0 cm in short axis) have been reported in 4-8% of patients. This is considered to be a significant risk factor of severe/critical COVID-19 pneumonia. Along with pleural effusion and multiple nodules, it may suggest a superadded bacterial infection.[11,13,14]

Pericardial effusion is rare in COVID-19, but if present, it is essential to exclude infective/cardiac pathology.

## Correlation Between CT Findings and Severity

The commonest CT finding in asymptomatic, mildly symptomatic, as well as severe patients is the presence of ground-glass opacities. However, consolidation, air bronchograms, pleural effusions and white lung pattern are seen in severe patients. Bilateral diffuse involvement indicates severe disease. Asymptomatic and mildly symptomatic patients show predominant involvement of the peripheral and lower lung with no multifocal segmental involvement.

### Differential Diagnosis

Other viral and atypical infections including Influenza, Parainfluenza virus, Adenovirus, Respiratory Syncytial virus, Rhinovirus, SARS-CoV may show CT findings similar to COVID-19. Pulmonary edema, acute lung injury due to other causes, acute interstitial and acute eosinophilic pneumonia also may pose a diagnostic challenge on CT.

## IMAGING IN GASTROINTESTINAL MANIFESTATIONS

Although respiratory symptoms are the commonest presenting complaints, an increasing number of patients are also showing gastrointestinal symptoms such as diarrhea, abdominal pain, nausea and vomiting and loss of appetite. Liver function derangement is also seen in number of patients. Bhayana et al[19] analyzed 224 abdominal imaging studies in 412 patients. Ultrasonography (USG) was the modality used in patients with deranged liver function to assess the right upper abdominal quadrant/hepatobiliary system. CT abdomen was performed in all patients with abdominal pain or sepsis.

The CT findings observed were bowel wall abnormalities in the form of small bowel and/or large bowel thickening (>3 mm in distended and >5 mm in collapsed loop) being commonest followed by pneumatosis and portal venous gas. Other findings encountered were changes suggestive of hepatitis in the form of gallbladder (GB) wall thickening and lower attenuation of parenchyma and changes suggestive of pancreatitis. The bowel findings may be due to direct viral infection, small vessel thrombosis or nonocclusive mesenteric ischemia.

USG findings observed in patients with deranged liver function tests revealed GB sludge with or without distension, GB wall thickening, pericholecystic fluid and fatty liver. Portal venous gas and portal vein thrombosis may be seen in severe/critical patients.

## IMAGING IN CARDIAC MANIFESTATIONS

Acute myocardial infarction, fulminant heart failure, dysrhythmias and arrhythmia have been seen in these patients.[20,21] Patients with pre-existing risk factors like diabetes, cardiac disease or hypertension are more likely to have these problems. Echocardiography remains the main imaging modality being used so far, which may show wall motion defects including global hypokinesia. There may be associated pericardial effusion.

## IMAGING IN NEUROLOGICAL MANIFESTATIONS

Loss of smell and taste are increasingly being recognized as the presenting symptoms. In one of the studies, as high as 36% of the patients had neurological symptoms.[22] Stroke, leukoencephalopathy, acute hemorrhagic necrotizing encephalopathy, Guillain-Barré syndrome have all been reported. Magnetic resonance imaging (MRI) remains the modality of choice, however, if due to logistical reasons MRI cannot be performed, plain CT is recommended. Sachs et al[23] reported leukoencephalopathy in a patient of COVID-19 where plain CT revealed low attenuation lesion in bilateral cerebral hemisphere white matter; MRI of the same patient in addition to showing white matter changes seen on CT also showed microbleeds. The findings are non-specific and may be seen number of other encephalopathies. Kandemirli,[24] in addition to white matter changes, in his study also reported venous transverse sinus thrombosis in a patient and ischemic stroke in middle cerebral artery (MCA) territory in another patient.

## IMAGING, PREGNANCY AND COVID-19

USG remains the imaging modality of choice in pregnancy. A WHO mission analyzed 147 pregnant women with confirmed COVID-19 and 82 presumed cases, amongst which 8% had severe disease, and 1% were critical with multi-organ failure. They found the rate of adverse events to be less compared to the general population (13.8% severe and 6.1% critical), the mission concluded that pregnant women might not be at increased risk.[25] However, more data is required to reach a final conclusion. An increasing incidence of hydatidiform mole with the onset of the pandemic has been observed by Abbas et al. The majority of these cases were primigravidae without other risk factors.[26]

## CONCLUSION

Every day new observations are being made in the COVID-19 disease spectrum and it is clear that the manifestations and involvement is not limited to the respiratory system. This also indicates that the role of imaging will not be limited to just plain X-rays; USG, CT and MRI all are going to play a role and a holistic approach will be necessary.

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