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Spectra of radiological findings in COVID-19 RT-PCR positive patients in a subset of Puducherry population

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Abstract
Introduction: HRCT Chest is currently considered as a particularly important tool for diagnosis as well as follow-up for evaluation of lung parenchyma and adjacent structures in COVID-19 patients. The purpose of this study is to assess the radiological findings in COVID-19 patients and evaluate the pattern of involvement as well as complications in various age-groups in a subset of Puducherry population.
Methods: This is a retrospective study done on 40 patients who were RT-PCR positive for COVID-19 and were referred for HRCT Chest to the department of radiodiagnosis of Sri Lakshmi Narayana Institute of Medical Sciences Medical College and Hospital, during the period of June 2020 to August 2020. All the patients who were included in this study were RT-PCR positive for COVID-19.
Results: The most important and frequent findings seen in the study were ground-glass opacities seen in 38 patients (95%) followed by consolidation which was seen in 23 patients (57.5%). The other significant findings were crazy-paving, sub-pleural bands, atelectasis, traction bronchiectasis and adjacent vascular dilatation. A normal non dilated pulmonary artery may be seen in the presence of Pulmonary embolism, especially if unilateral, and further imaging such as CT Pulmonary Angio should be suggested in cases of clinical suspicion.
Conclusion: CT is sensitive for the confirmation of the diagnosis as well as in interpretation of the lung parenchymal involvement to predict the requirement of further follow-up. Atypical findings such as sub pleural bands, atelectasis, cysts, and halo sign may be seen without the presence of typical imaging features in COVID positive patients.

Keywords: COVID-19, RT-PCR, GGO, consolidation, MPA (main pulmonary Artery), PTE (Pulmonary Thrombo-embolism)

Introduction: Background

Lower respiratory tract infections are the utmost deadly infectious diseases, causing mortality of around 3 million annually [1]. Sensitivity of chest CT for diagnosis ranges from 80 to 90% and specificity is 60 to 70% [2, 3].

The novel coronavirus (2019-nCoV) is a recent pandemic which was initially diagnosed in Wuhan, China. Chest CT is a key component of the diagnostic work-up for patients with suspected infection. Most of the COVID-19 positive patients were diagnosed with pneumonia and thus have very distinctive imaging patterns on CT [4].

There are neither specific drugs nor any vaccines for novel corona virus, thus making it very necessary to identify the disease early in its course so that the patient can be isolated as soon as possible from rest of the general population [5]. Despite the enormous effort to characterize the imaging features of COVID-19, there is still limited amount of data to draw definitive conclusions [4].

In the current scenario regarding COVID-19, there are a reported 4.5 crore COVID – 19 positive cases in the world, 80.4 lakh cases in India and approximately 35 thousand cases in Puducherry to date.

RT-PCR has a very low sensitivity in diagnosing COVID-19 and thus giving false negative results to the infected individuals which in absence of proper treatment and isolation, increases the risk of transmission across the healthy population, considering the highly infectious nature of the novel corona virus [6].

There are other syndromes which are caused by same coronavirus family but different strains, for instance MERS [middle east respiratory syndrome] and SARS [severe acute respiratory syndrome] [7].

Imaging provides a guide for preliminary diagnosis as well as monitoring the progression of infection during follow-up in the COVID-19 infection [8]. Chest CT is particularly useful to provide diagnosis and assess the extent of pulmonary involvement in minimal time period compared to RT-PCR [4, 5].

Methods

This is a descriptive study of patients who were RT-PCR positive for COVID-19 and were referred for Chest CT to the department of radiodiagnosis of Sri Lakshmi Narayana Institute of Medical Sciences Medical College and Hospital, during the period of June 2020 to August 2020.

Inclusion criteria: All the patients who were RT-PCR positive for COVID-19.

Exclusion criteria: The study did not include pregnant females and heart failure patients.

The study included 40 patients out of which 34 were male. The age groups included in this study ranged from 15 – 83 years with a mean age of 49.8 years.

The CT equipment used in our study was SOMATOM SCOPE - 32 slice.

All images were viewed on both lung (width, 1500 HU; level, − 700 HU) and mediastinal (width, 350 HU; level, 40 HU) settings. Images were reconstructed in axial, coronal, and sagittal planes to detect the distribution of parenchymal affection (2D multiplanar images reconstruction, MPR).

All the cases were examined for imaging features of COVID-19 infection such as presence and distribution of ground glass opacities, consolidation, crazy paving pattern, subpleural bands, pleural effusion, lymphadenopathy, cysts, nodules, and halo sign.

Results

In our study we analysed the CT findings in 40 RT-PCR positive patients. Out of 40 patients, 34 were male. Their ages ranged between 15 years to 83 years.

The most important and frequent findings seen in the study were peripheral ground-glass opacities seen in 38 patients (95%) followed by consolidation which was seen in 23 patients (57.5%). Ground glass opacities were interspersed with interstitial septal thickening in 25 patients (62.5%), known as crazy paving pattern. This was followed by sub-pleural bands, noted in 19 patients (47.5%) and mediastinal lymphadenopathy in 9 patients (22.5%). GGOs and consolidations were mostly distributed in the peripheral location. There was slight propensity for the involvement of lower lobes compared to middle and upper lobes. The right middle lobe was the least involved (70%)

The other less common findings were focal segmental vascular dilatation which was seen in 10 patients (25%), traction bronchiectasis seen in 4 patients (10%), Pleural effusion (7.5% cases), pulmonary cysts (5% cases) and pulmonary nodules (5% cases).

Discussion

The most common pattern of disease included GGO, which was seen in 38 patients [95%] followed by crazy paving pattern [n=25; 62.5%] and consolidative changes [n=23; 57.5%].

Other CT findings seen were subpleural bands [n=19; 47.5 %], focal segmental vascular dilatation [n=10; 25%], lymphadenopathy [n=9; 22.5%].

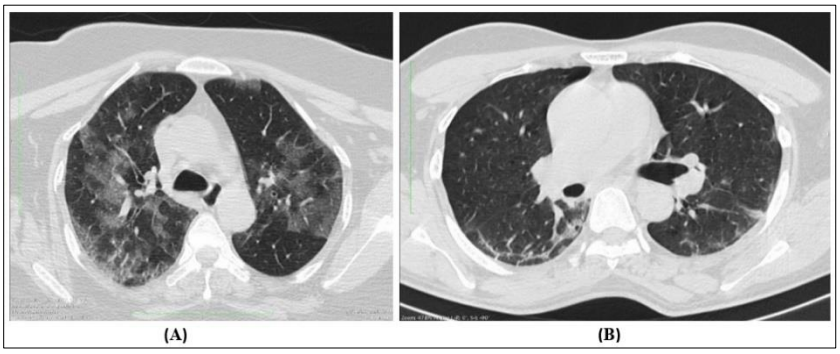

Fig 1: Image (A) Non contrast chest CT of 54-year-old RT-PCR positive female patient. Axial section shows patchy peripheral and central, non-segmental ground glass opacities with areas of interstitial septal thickening giving crazy paving pattern. Image (B) Non contrast chest CT of 61-year-old RT-PCR positive male patient. Axial section at the level of the left main bronchus shows sub pleural bands with no adjacent areas of ground glass opacities.

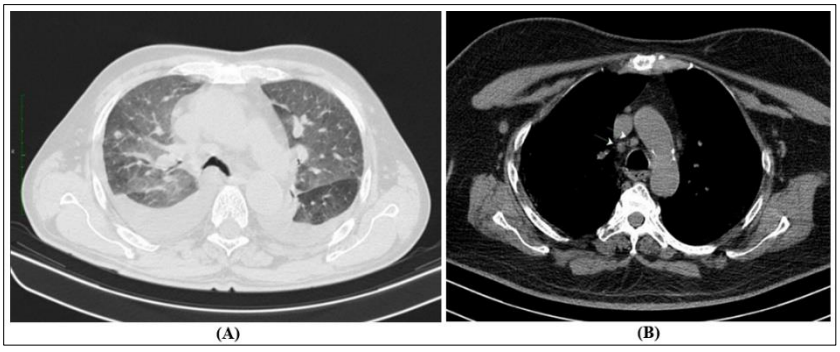

Fig 2: Image (A) Non contrast chest CT of 70-year-old RT-PCR positive male patient. Axial section at aortic root level showing diffuse ground glass opacities bilateral upper lobes. Bilateral moderate pleural effusion is seen along the bilateral posterior costal pleura. With a small nodular opacity measuring 4 mm in the right upper lobe. Image (B) Non contrast chest CT of 66-year-old RT-PCR positive male patient. Axial section at the level of arch of aorta in soft tissue window showing multiple sub centimetric mediastinal lymph nodes.

Uncommon CT findings elicited in the study were traction bronchiectasis [n=4; 10%], atelectatic change [n=3; 7.5 %], architectural distortion (extensive fibrotic change) [n=4; 10%] pleural effusion [n= 3; 7.5%]. Rarely cysts and nodules were also

seen. The above findings can be summarized in the Table 1.

Table 1: Summary of CT Findings In RT-PCR Positive Covid-19 Patients

Findings	Number of patients	Percentage
Ground glass opacity	38	95
Consolidation	23	57.5
Crazy paving pattern	25	62.5
Vascular dilatation	10	25
Traction bronchiectasis	4	10
Sub-pleural band	19	47.5
Atelectasis	3	7.5
Architectural distortion	4	10
Pleural effusion	3	7.5
Cavitation	0	0
Lymphadenopathy	9	22.5
Cysts	2	5
Nodules	2	5
Halo sign	1	2.5

The presence of only GGOs are suggestive of early stages of disease. The early stages of disease may also present with unilateral involvement as was seen in 5 out of 40 cases in our study.

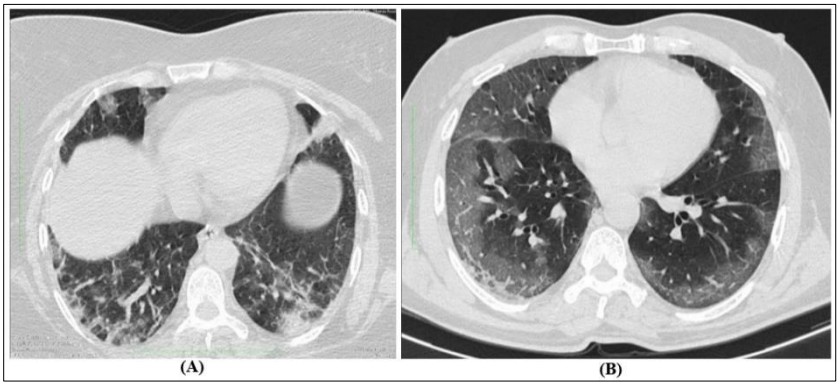

Fig 3: Image (A) Non contrast chest CT of 54-year-old RT-PCR positive female patient. Axial section showing sub-pleural fibrotic bands and dilated vascular markings along with sub segmental atelectasis and areas of GGOs. Image (B) Non contrast chest CT of 64-year-old RT-PCR positive male patient. Axial section shows multifocal non-segmental ground glass opacities and subpleural consolidation noted in the right lower lobe with bronchiectasis.

The pattern of involvement of GGOs showed only peripheral distribution in 11 out of 40 cases. No cases were seen to have only central or perihilar distribution. Majority of cases [n=28; 70 %] showed multicentric pattern of involvement i.e. involving both, the periphery as well as central regions of the lung fields. [Ref. -fig 2]

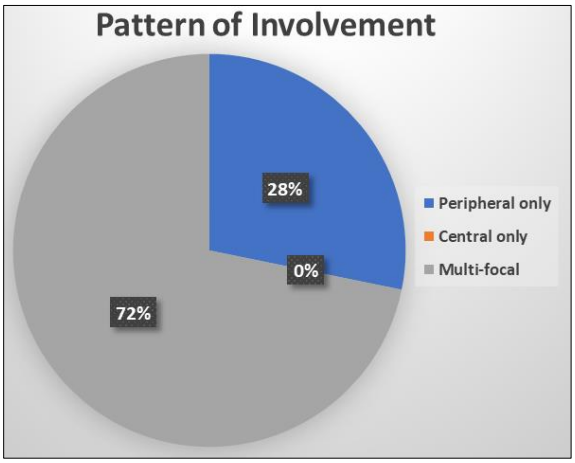

Fig 2: Pattern of Involvement of GGOS In Covid-19 Patients

We also observed the differential lobar involvement in our subset of population. [Ref. table-3]

Table 3: Pattern of Lobar Involvement

Lobar involvement	Number of patients	Percentage (%)
Right upper lobe	34	85
Right middle lobe	28	70
Right lower lobe	35	87.5
Left upper lobe	32	80
Left lower lobe	33	82.5

The parenchymal involvement was more common in the lower lobes, right lower lobe [n=35, 85%] being slightly more often involved compared to the rest of the lobes followed by right upper lobe [n=34, 85%] and left lower lobe [n=33, 82.5%]. The least affected lobe in our study was the right middle lobe [n=28, 70%] which corresponds with the results found in the study done by Francone *et al* [9].

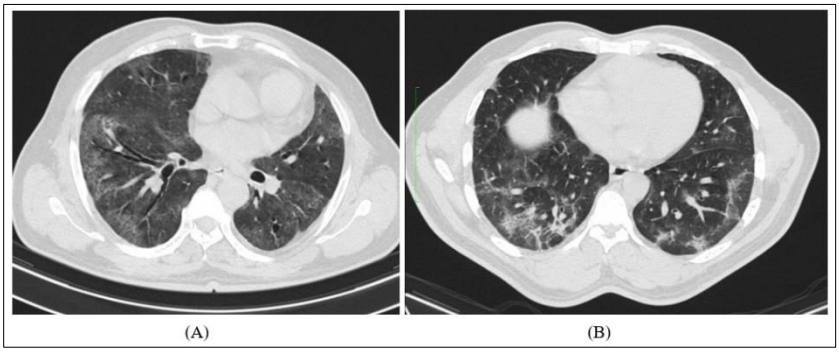

Fig 4: Image (A) Non contrast chest CT of 67-year-old RT-PCR positive male patient. Axial section shows characteristic ground glass opacities distributed peripherally in lower lobes along with bronchiectasis. Image (B) Non contrast chest CT of 47-year-old RT-PCR positive male patient. Axial section shows Sub-pleural fibrotic strands and areas of GGOs in posterior segments of bilateral lower lobes.

These findings like peripheral distribution, preponderance for lower lobes and bilateral lung involvement are consistent with the study done by Ho *et al*. [10] and Kolta *et al*. [11]

These characteristic findings like GGOs and consolidation are commonly seen and help in assessing the progression of disease as well [12, 13, 14, 15, 16]. These imaging findings are however observer dependent and thus the error due to inter-observer variations should always be considered.

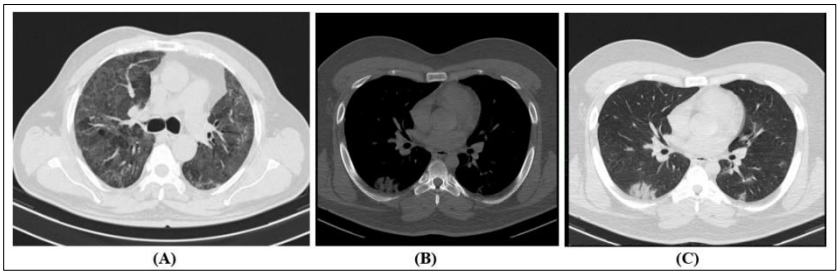

Fig 5: Image (A) Non contrast chest CT of 67-year-old RT-PCR positive male patient with CT score of more than 18. Axial section at the level of carina shows diffuse, non-segmental ground glass opacities with areas of interstitial septal thickening within giving crazy paving appearance with few sub-pleural bands noted bilaterally. Image (B) and (C) Non contrast chest CT of 25-year-old RT-PCR positive male patient. [B. Lung window, C. Soft tissue window] Axial sections show peripherally located focal area of consolidation with air-bronchogram in right lower lobe.

CT Severity Score

A quantitative scoring system was used to assess the pulmonary involvement of above findings based on the area involved.

Each of the 5 lung lobes can be scored from 0 to 5 as:

- 0 - no involvement
- 1 - <5% involvement
- 2 - 25% involvement
- 3 - 26%-49% involvement
- 4 - 50%-75% involvement
- 5 - >75% involvement

The total CT score was the sum of the individual lobar scores and ranged from 0 (no involvement) to 25 (maximum involvement). [16] A CT score of more than or equal to 18 has shown to have poor prognosis and is highly predictive of patient mortality during follow-up [9].

Table 4: Average CT Score within Various Age Groups

	AGE	CT Severity Score [AVG.]
Group A	<20 years	2
Group B	20- 40 years	8.5
Group C	40-60 years	9.0
Group D	>60 years	11.4

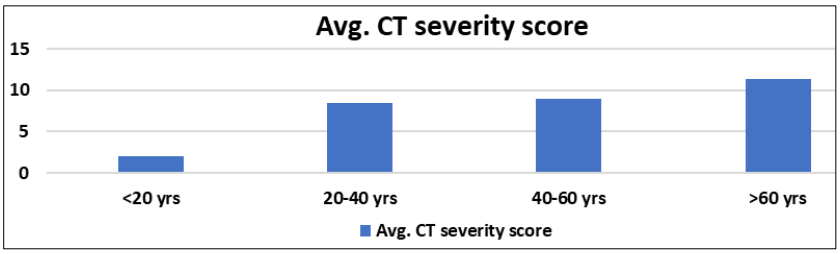

Fig 6

We divided our subset of population in four groups and calculated the average CT severity score for each group. [Table 4] The findings suggested that the age group that was affected the most was Group D, with average CT score of 11.4, followed by group C with a score of 9.0 and group B with a score of 8.5.

An increase in average CT severity score was noted in the higher age groups [D > C > B > A]. It was also noted that along with the severity of disease, complications of COVID – 19 such as pulmonary thromboembolism, extensive consolidatory changes and architectural distortion were higher in Group D compared to other age groups, which had significant implications on the prognosis and recovery of these patients. Massive consolidation that was observed in the later course of disease is an indicator of poor prognosis.

Pulmonary thromboembolism is usually observed in the late stages of disease and can be considered as one of the major life-threatening complications of COVID -19 [17]. In cases that show signs and symptoms suspicious of pulmonary thromboembolism (dyspnoea, pleuritic chest pain, haemoptysis), CT Pulmonary angiogram must be done along with other laboratory investigations.

The main pulmonary artery diameter was measured in all patients in our study and the average diameter was 24 mm. 5 patients out of 40 had CT severity score of more than 18 [i.e. Severe form] and in these 5 patients, mean pulmonary diameter was observed to be 26 mm.

Mean pulmonary artery diameter in severe COVID infectious states was more prominent in 40-60 years and more than 60 years age groups compared to the mean pulmonary diameter in severe COVID infectious state in less than 40 years age group and in those with moderate disease of all age groups.

Dilatation of main pulmonary artery is usually seen in chronic cases of pulmonary thrombo-embolism and pulmonary arterial hypertension whereas in acute presentation it may not show any change in diameter.

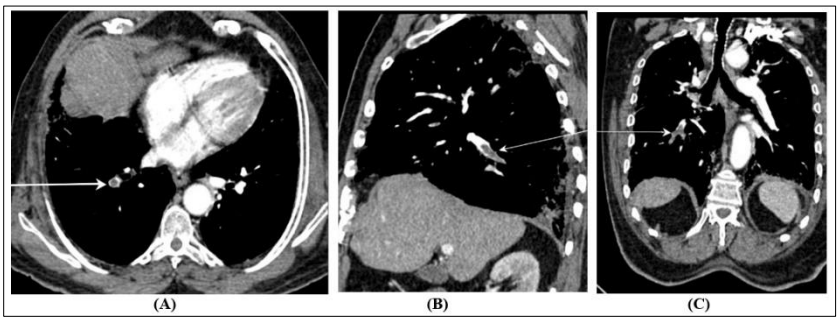

Fig 6: Image (A), (B) and (C), CT Pulmonary angiogram of a 74-year-old male. [A. Axial, B. Sagittal, C. Oblique Coronal images] showing an intraluminal thrombus occupying the common basal trunk branch of the right lower lobe pulmonary artery and the thrombus is also seen extending into the lobar branches. Typical "Polo mint" sign of pulmonary thromboembolism is seen in the axial section.

We also observed that the MPA was not dilated in the cases of pulmonary thrombo-embolism. In one of our cases, the mean diameter of MPA was 26 mm and CT pulmonary angiogram revealed a central thrombus in the branch of right pulmonary artery. Therefore, a normal Mean Pulmonary Artery diameter might not be sufficient to rule out pulmonary thrombo-embolism, especially if it is only unilateral.

Pulmonary thromboembolism should be suspected in cases which have clinical features out of proportion than non-contrast CT findings like persistent fall in oxygen saturation levels. D-dimer levels and regular ECG monitoring needs to be done in such patients. D- dimer has high sensitivity but low specificity in cases of pulmonary thrombo-embolism and negative D-dimer does not rule out pulmonary thromboembolism. Thus, CT pulmonary angiogram must be done in all the cases with a clinical suspicion of pulmonary embolism.

Some uncommon presentations noted in our study were presence of nodules, cysts, isolated focal atelectasis, and halo sign. The presence of cysts can be seen early in the disease as well as in late stages. One case presented with the only imaging finding being unilateral segmental atelectasis without any presence of GGOs or consolidation.

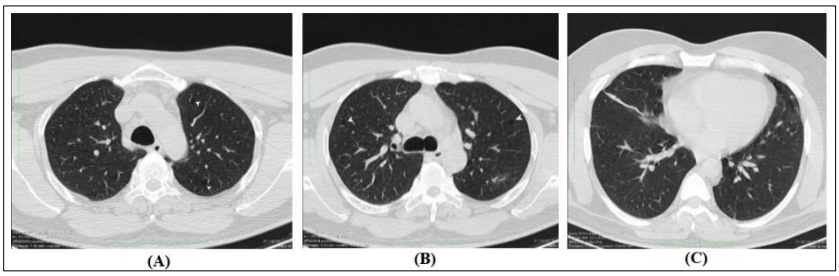

Fig 7: Image A and (B) Non contrast CT chest of a RT-PCR positive 41-year-old male patient. Axial section shows multiple, diffusely scattered small cysts with imperceptible wall noted in bilateral lung fields. Image (C) Non contrast chest CT of 52-year-old RT-PCR positive male patient. Axial section shows area of atelectasis in the region of the right middle lobe with no evidence of GGOs or consolidation.

Halo sign was also observed in one of our cases. The pathophysiology of Halo sign in COVID is still unclear and it is still described as an infrequent finding in most studies. Similar conclusions have been derived in the study by Bernheim *et al*. [4] Therefore, we need to keep in mind to look for atypical findings along with the GGOs and consolidatory changes in lung parenchyma. The absence of GGOs should not be considered enough to rule out the possibility of COVID-19 infection.

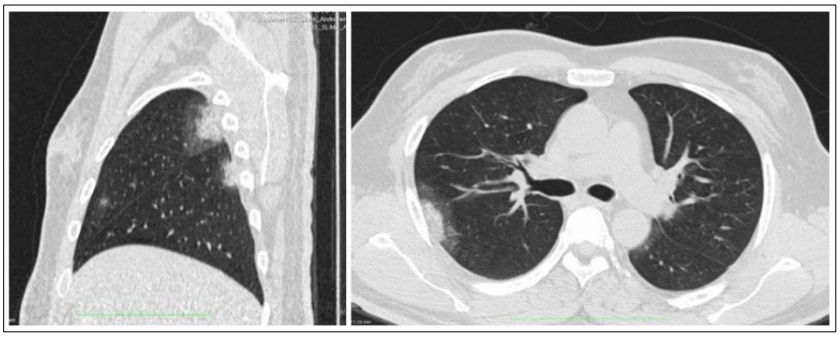

Fig 8: Image (A) Sagittal and (B) Axial Non contrast chest CT of 50-year-old RT-PCR positive male patient, shows a peripherally located consolidation surrounded by an area of ground glass opacity – Halo sign. [*Due to the virtue of its peripheral location, instead of the classical central consolidation with peripheral halo on all sides, the surrounding halo of GGO cannot not seen at the pleural aspect of the consolidation.*]

Conclusion

CT plays an important role in the diagnosis as well as evaluation of progression of COVID-19 in current situation. Its relatively higher sensitivity and quicker results as compared to RT-PCR makes it a better modality altogether.

Compared to RT-PCR, computed tomography scores better in terms of sensitivity and negative predictive value. Technique of obtaining throat swab and nasopharyngeal swab is operator dependent and several variables like presence of shielding booth and thoroughness of the technique used by the technician in collecting the swab, such confounding factors do not affect the results from HRCT thorax.

Typical imaging findings usually include peripheral ground glass opacities which are often bilateral with lower lobe predominance along with consolidation and crazy paving pattern in majority of cases. However, it should be noted that the mere absence of GGOs and consolidation is not sufficient to rule out COVID -19. In our study, confirmed cases of the infection had only uncommon findings like sub pleural bands, atelectasis, cysts, and halo sign as the only imaging feature.

The severe form of disease may present with extensive consolidation and life-threatening complications like pulmonary thrombo-embolism. It is important to note that a normal mean pulmonary arterial diameter on plain CT should not be a criteria to dismiss the presence of pulmonary thromboembolism and CT pulmonary angiogram should be advised in all cases for definite exclusion.

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