



## Atypical Radiological Imaging Findings in RT-PCR Positive COVID-19 Infection.

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### ABSTRACT

#### INTRODUCTION:

HRCT Thorax is currently considered as an imperative tool for diagnosis as well as follow-up for evaluation of lung parenchyma and adjacent structures in COVID-19 patients. Many studies on COVID-19 have elaborated upon its common presentations but the atypical presentations remain relatively less studied in literature even though sometimes it may be the only imaging finding of COVID-19 infection. Therefore, the objective of this article is to review and elaborate the uncommon/unusual HRCT findings of COVID-19 in a pictorial study.

#### 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 in our institute from July 2020 to November 2020.

#### RESULTS:

In our study we analyzed the HRCT findings in 40 RT-PCR positive patients with their ages ranging between 19- 81 years. The most frequent findings in the study were peripheral ground-glass opacities seen in 95% of the patients followed by consolidation (57.5%) and crazy paving pattern (62.5%) which are consistent with the other studies done on COVID. However this study focuses on the lesser known and uncommon findings like traction bronchiectasis (10%), Pleural effusion (7.5%), atelectasis (7.5%), pulmonary cysts (5%), pulmonary nodules (5%) and halo sign (2.5%) which were seen in a small but significant number of patients.

#### CONCLUSION:

The hallmark HRCT findings of COVID -19 infection are peripheral, non-segmental and subpleural Ground glass opacities, that are more frequently involve the lower lobes. They are mostly associated with presence of consolidation and interstitial septal thickening. The above elaborated findings though uncommon are more frequently seen in the later stages of disease and are usually associated with a high CT severity score. Although in rare occasions, these may be the sole imaging finding of COVID-19 infection on HRCT Thorax in RT-PCR positive patients, and presence of these findings should not be overlooked while interpreting the scan.

In all cases of suspected COVID-19 infection, the presence of a secondary infection should always be ruled out as less light has been thrown on the pathophysiology of these findings in the current scenario.

**Keywords:** COVID; Diagnostic imaging; HRCT; COVID-19 or SARS-CoV-2; RT-PCR (Real Time Reverse Transcriptase Polymerase Chain Reaction); GGO (Ground Glass Opacity); Atypical imaging finding

### INTRODUCTION

COVID-19 is a recent pandemic caused due to the virus SARS-CoV-2 and HRCT is the presently regarded as most useful/convenient test for the evaluation of lung involvement by COVID-19 in view of its high specificity and quicker results.

The characteristic CT findings of COVID-19 infection are bilateral ground-glass opacities with

peripheral distribution and basal predominance along with associated consolidation.<sup>(1,2,3,4,5)</sup> Sometimes interspersed interstitial thickening may be present giving crazy-paving appearance with progression of disease. Nonetheless, normal chest CT findings do not exclude this diagnosis.<sup>(6,7,8)</sup>

Most of the studies on COVID-19 have mentioned a little about some of the rare presentations like cysts, nodules, cavitation, halo sign or reverse halo sign etc. These findings were usually present in a lesser group and were seen mostly associated with the hallmark appearance of COVID-19 except in few cases where they were found as an isolated imaging finding of COVID-19.

In this study we are discussing these uncommon presentations of COVID-19 which may or may not be associated with the GGOs and consolidation. Most of these cases were seen associated with extensive GGOs and massive consolidation giving an overall high CT severity score indicating the progression of disease might be a factor to actively look for these presentations.

## METHODS

This is a retrospective study done on patients who were RT-PCR positive for COVID-19.

All the patients were referred to the department of radiology of our hospital for HRCT Thorax. Images were acquired using PHILIPS SOMATOM SCOPE-32 slice equipment. Images were reconstructed to examine for the presence of imaging features of COVID-19 infection in both mediastinal (width-350 HU; level- 40 HU) and lung window (width-1500 HU; level-700 HU).

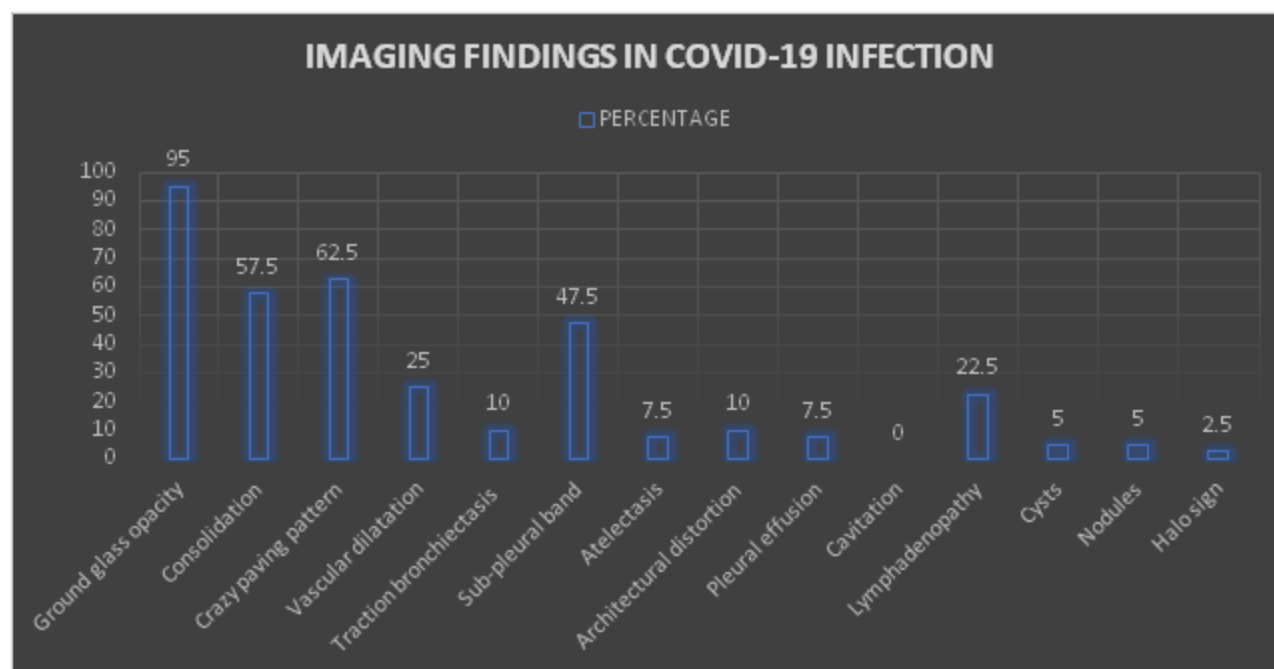
## RESULTS

In our study we analyzed the CT findings in 40 RT-PCR positive patients.

The most important and frequent findings seen in the study [Ref. Table 1] were peripheral ground-glass opacities seen in 38 patients (95%) followed by consolidation which was seen in 23 patients (57.5%). However this study focuses on the less common findings like traction bronchiectasis that was seen in 4 patients (10%), Pleural effusion (7.5% cases), atelectasis (7.5% cases), pulmonary cysts (5% cases), pulmonary nodules (5% cases) and halo sign (2.5%).

**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



## DISCUSSION

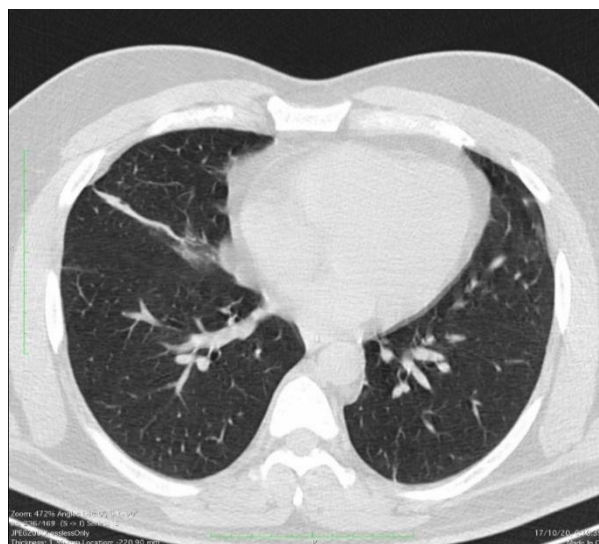
COVID-19 is caused by a novel coronavirus that was announced as a pandemic on 11 March 2020. Early diagnosis is vital to control the spread of the disease and prevent complications. HRCT plays an important role in rapid primary diagnosis, estimation of severity of disease as well as monitoring its evolution compared to Real-time reverse-transcription polymerase chain reaction (RT-PCR). The hallmark HRCT findings in COVID -19 are peripheral, non-segmental and subpleural GGOs that are more frequently seen in lower lobes. They are mostly associated with consolidation and interstitial septal thickening. In this study however, we are focusing on the rare imaging findings which have not been studied thoroughly in literature but are nevertheless important imaging feature of COVID-19 in their respective cases.

The uncommon findings elaborated in our study are traction bronchiectasis [n=4; 10%], atelectatic change [n=3; 7.5 %], pleural effusion [n= 3; 7.5%], pulmonary cysts [n =2; 5% cases], pulmonary nodules [ n=2 ;5% cases] and halo sign [n=1; 2.5%]. All these findings are consistent with other studies done on COVID-19 <sup>(9,10,11,12,13,14,15)</sup>.

## ISOLATED ATELECTASIS

Atelectasis refers to collapse of the whole lung or a segment of the lung. In early infection some subpleural bands may be present and later as the disease progresses the parenchymal bands which were seen earlier may lead to subsegmental and later into segmental atelectasis if the alveoli get collapsed. It can range from Plate atelectasis which is predominantly seen in the base of lungs secondary to hypoventilation or may present as wedge-shaped or linear opacities affecting any of the lobes.

According to study done by Mingzhi et al, subsegmental atelectasis or reduction of lung volume was sometimes noted, along with minimal bilateral pleural effusion <sup>(16)</sup>. The pathophysiology of atelectasis in COVID -19 might be a result of fibrosis leading to reduced expansion of the lung volume or this might be an indicator of associated granulomatous disease like Tuberculosis. Some of the cases had multiple areas of atelectasis. In one case we noted focal atelectasis in right lower lobe in a COVID-19 patient, without typical associated findings like ground glass opacities or consolidation, which is an exceedingly rare presentation, and validates the fact that COVID-19 can present with isolated focal atelectasis as the sole imaging finding. TO our knowledge, a similar presentation of isolated atelectasis has not been noted in any other COVID-19 study at present.

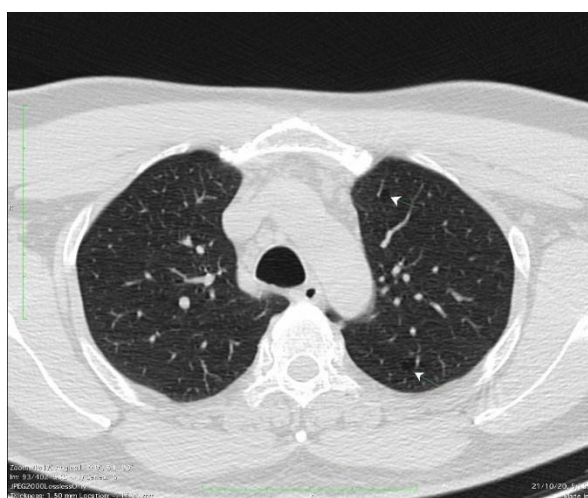


**[Fig-1] Non contrast HRCT Thorax of a 52-year-old RT-PCR positive male patient. Axial section shows area of atelectasis in the region of the right middle lobe with no evidence of ground glass opacities or consolidation.**

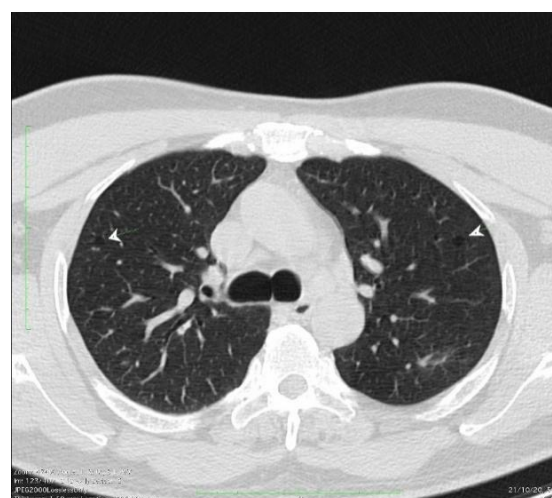
## CYSTS

**Pulmonary cysts** are round, thin-walled, low attenuation lucent areas within the lung parenchyma. It is an unusual finding in cases of COVID-19 infection, usually seen in the advanced stages of the infection. Pathophysiology of cyst formation in this condition is still not understood. The cysts can be present due to a pre-existing disease or it can be a consequence of COVID-19 infection. A few studies have also shown presence of pneumothorax and

pneumomediastinum in cases of COVID-19 infection. A possible explanation for these findings is probably due to rupture of sub-pleural cysts as in all such cases, presence of cysts were identified on HRCT thorax. Diffusely scattered pulmonary cysts were observed in two of the patients (i.e. 5%) in our study subset. The finding of cysts in our subset of population COVID -19 patients was consistent with the studies done by Cheng et al <sup>(17)</sup>, and Heshui Shi et al <sup>(3)</sup>.



(A)



(B)

**[ Fig-2 (A) and (B)] This is Non contrast HRCT Thorax of a 41-year-old RT-PCR positive male patient. Axial section shows multiple, diffusely scattered small cysts (shown by the arrow heads) with imperceptible wall noted in bilateral lung fields.**



## PLEURAL EFFUSION

Pleural effusion is considered a rare manifestation of COVID-19 infection. Its prevalence and pathophysiology in COVID-19 infection can be based on multiple factors like existence of co-existing disease, stage of the disease, setting in which study was done and any secondary infection due to infection of bacterial etiology. Hence, the effusion always needs to be sampled and evaluated for biochemical and microbiological findings to rule out the presence of other co-existing systemic diseases like organ failure or metastasis.

In literature related to COVID-19, pleural effusion was seen to present as an isolated finding as well as along with typical features like ground glass opacities. Pleural biopsy is recommended to identify the etiology of the pleural effusion when results of pleural fluid analysis are inconclusive<sup>(18)</sup>. Although, very limited information is available about properties of pleural fluid in COVID-19 patients as invasive procedures are limited in current situation to control the pandemic, this emphasizes the need to keep in mind COVID-19 as an etiology of effusion specifically if there are no other identifiable causes<sup>(19)</sup>.



**[Fig-3] Non contrast HRCT Thorax of a RT-PCR positive 74-year-old patient. Bilateral lower lobes show diffuse ground glass opacities with interspersed interstitial septal thickening giving crazy paving appearance. Curvi-linear opacity can be noted in sub-pleural region of the right lower lobe – consolidation. Bilateral pleural effusion is also seen.**

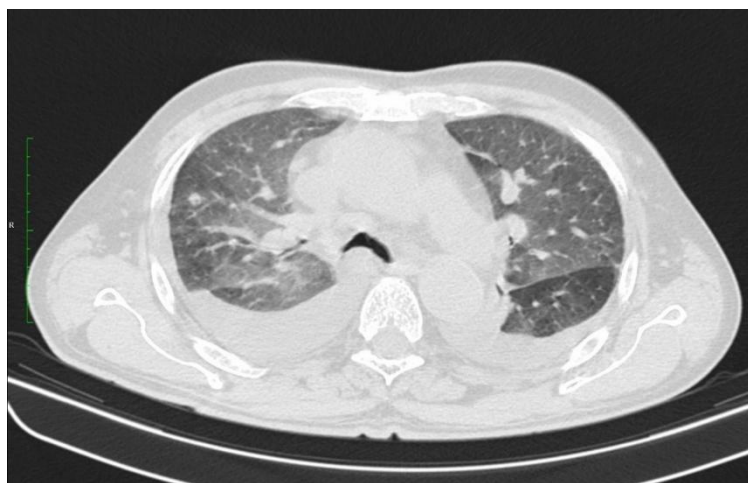
## NODULE

A pulmonary nodule is defined as a round or irregular parenchymal opacity of less than 3 cm in diameter<sup>(20)</sup>. It is frequently associated with viral pneumonia<sup>(21)</sup>. Multifocal/solitary solid irregular nodules can be noted in COVID-19 infection, and when such nodules are surrounded by area of ground glass opacity, it is referred to as “halo sign”<sup>(15)</sup> (Ref Fig 7a and 7b).

In our study, nodules were noted in two patients. One of the cases presented with a solitary nodule whereas in the other patient, multiple nodules were noted however both the cases were associated with the characteristic imaging findings of COVID-19 like

GGOs, consolidation and interstitial septal thickening. Occurrence of pulmonary nodules in cases of COVID-19 infection is a very unusual. Other possible etiologies for the presence of the nodules should also be explored.

In some cases, more than one uncommon imaging finding may be encountered. For example, in Fig-4, the presence of a pulmonary nodule, bilateral pleural effusions and segmental vascular dilatation are seen. Such cases warrant further evaluation. It also validates the fact that even presence of multiple uncommon findings should not prompt us to rule out COVID-19 infection.



**[Fig-4] Non contrast HRCT Thorax a of 70-year-old RT-PCR positive male patient. Axial section at level of aortic root shows diffuse ground glass opacities in bilateral upper lobes. A small nodular opacity measuring 4 mm noted in the right upper lobe. Moderate bilateral pleural effusions are seen adjacent to the posterior costal pleura.**

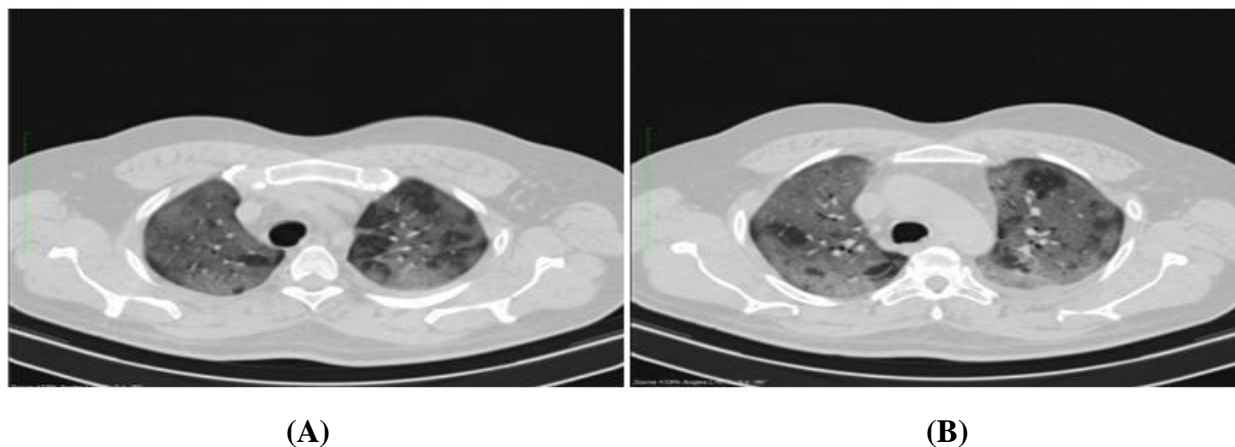
### MOSAIC PATTERN/ATTENUATION

The vascular abnormalities we observed on HRCT correlate well with these pathology findings and support the notion of diffuse vascular abnormalities in COVID-19 infection. The underlying mechanisms of these findings, however, may be related to vascular inflammation, endothelial damage, micro-thrombosis, dysfunctional vaso-regulation, or a combination of all the above<sup>(22, 23, 24, 25, 26, 27, 28)</sup>.

Pulmonary vessels and perfusion are frequently abnormal in COVID-19 infection and may point to a key role of hypoxemia and pulmonary vascular pathology in COVID-19 infection<sup>(29)</sup>.

In our study 2 patients (5%) were seen to have mosaic attenuation involving the lung fields.

According to the study done by Min Lang et al<sup>(29)</sup> mosaic attenuation was a frequent finding in COVID-19 infection, on the contrary, in the study done by Minhua Yu et al<sup>(30)</sup>, mosaic attenuation was seen in just 2% of cases of COVID-19 infection. A possible reason for difference in these studies could be due to the differences in the study population as the former study was done on a group of hospitalized patients. This could also imply that mosaic perfusion is seen in the severe form or advanced stages of the disease like the rest of the uncommon findings.



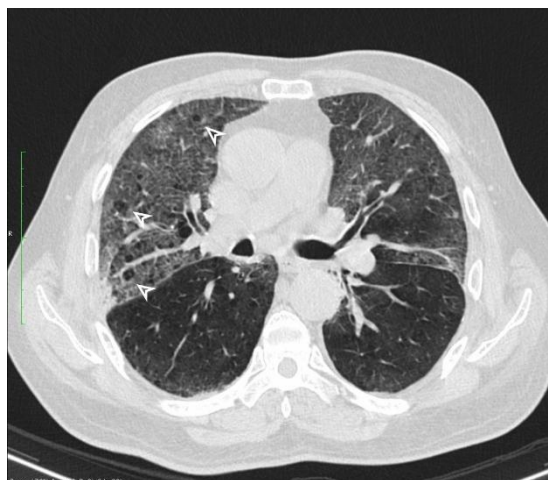
**[Fig-5 (A) and (B)] Non contrast HRCT Thorax of a 54-year-old RT-PCR positive male patient shows Mosaic attenuation involving bilateral upper lobes.**

## BRONCHIECTASIS

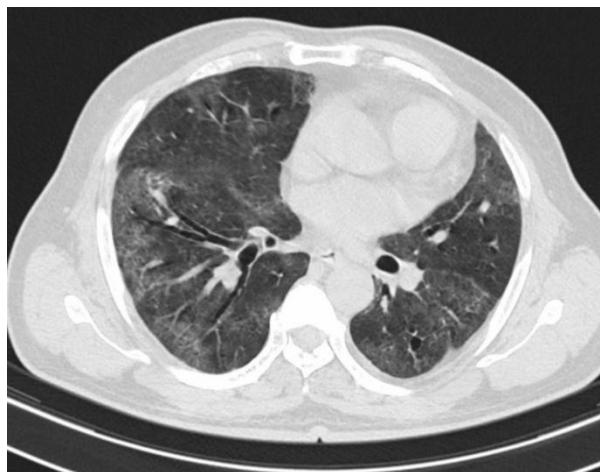
Bronchiectasis is irreversible localized or diffuse bronchial dilatation, usually resulting from chronic infection, proximal airway obstruction, or congenital bronchial abnormalities<sup>(31)</sup>. HRCT criteria include the signet ring sign, lack of normal tapering of the bronchi towards the periphery such that bronchi are seen within 1 centimeter of the pleural surface<sup>(32, 33)</sup>. The signet ring appearance corresponds to a cross

section of dilated bronchus adjacent to its accompanying pulmonary artery when ratio of Bronchial lumen/Artery is more than 0.7<sup>(33)</sup>.

Sometimes tree-in-bud pattern may be seen in HRCT due to trapping of air caused by mucous debris within the airways<sup>(33, 34)</sup>. Follow up study with HRCT is required to find out the association of bronchial dilation with respiratory distress and whether it is progressing into fibrosis.



(A)



(B)

**[Fig-6 (A)]** Non contrast HRCT Thorax of a 74-year-old RT-PCR positive male patient. Axial section shows characteristic ground glass opacities with interstitial septal thickening predominantly in bilateral upper lobes with bronchiectasis.

**(B)** Non contrast HRCT Thorax of a 67-year-old RT-PCR positive male patient. Axial section shows characteristic ground glass opacities distributed peripherally in lower lobes along with bronchiectasis.

## HALO SIGN AND REVERSE HALO

Previous studies have reported the halo and reversed halo signs as less frequent findings in patients with COVID-19<sup>(35, 36,37,38,39)</sup>. Alveolar edema and hemorrhage may create the halo sign, while the reversed-halo sign may be formed by the organization and resolution of alveolar exudates. Although these findings are not specific, they are highly suggestive for early stages of opportunistic invasive fungal infections (e.g. aspergillosis, mucormycosis) in immunocompromised patients. They might be seen in immunocompetent individuals in other conditions such as non-fungal endemic infections, cryptogenic organizing pneumonia, vasculitis, and neoplastic and inflammatory diseases<sup>(40)</sup>.

The Reversed Halo sign in invasive fungal infections appears as one or more large lesions; while in endemic infections (e.g. tuberculosis), lesions have a bilateral and asymmetric appearance with ground glass opacities, centrilobular nodules, or consolidations<sup>(41)</sup>. When reverse halo appearance is seen in COVID-19 patient, history of immunodeficiency should be asked to rule out any co-existing fungal infection. Resolution of the findings without any anti-fungal treatment can also be an evidence to dismiss fungal etiology.

Bernheim et al. reported that the frequency of uncommon chest CT findings, including the reverse halo sign, increases in the later stages of COVID-19 progression<sup>(42)</sup>. There are no adequate data to explain the pathophysiology of the combined lesions in our patient. The coexistence of both halo and reversed



halo signs could be an atypical presentation in COVID-19. To the best of our knowledge, this

imaging feature has never been described before.



(A)



(B)

**[Fig-7 (A) and (B)] Non contrast HRCT Thorax of a 50-year-old RT-PCR positive male patient, Axial (A) and Sagittal (B) sections show a peripherally located soft tissue density 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 be seen on the pleural aspect of the consolidation]**

### Conclusion:

Studies done on COVID-19 infection have been immensely helpful and have been integral in providing common imaging findings like ground glass opacities, consolidation along with other less common appearances such as crazy-paving pattern, air bronchogram and atelectasis. However, such imaging findings have also been seen in other infections such as SARS and MERS infection.

The lesser-known imaging findings of COVID-19 infection like bronchiectasis, cysts, nodules, pleural effusion, mosaic attenuation and the halo sign are focused upon in this study. Emphasis on atypical findings of COVID-19 is paramount as these subtle findings have been found to be the only imaging finding in RT PCR positive COVID-19 patients, as described in our study, and hence these findings should be actively search for if the primary scan appears relatively normal. In cases of such solitary imaging findings with a negative RT PCR test, a high index of suspicion should be maintained, and a follow up imaging or RT PCR test should be considered, especially in symptomatic cases.

In cases where the atypical imaging findings were co-existing with the usual GGOs and consolidation,

most of the times, it was associated with extensive lung involvement leading to high CT severity score for COVID-19 infection.

Since the pathophysiology of some of these manifestations is still not clear as invasive procedures are discouraged in these cases to limit the spread of infection, the possibility of secondary infections cannot be ruled out. So, in advanced stages and co-morbid conditions these may be the indicator of superadded infection.

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