ORIGINAL RESEARCH ARTICLE

HRCT Thorax Manifestations of Covid-19 Infection

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A B S T R A C T

Introduction: Coronavirus Disease 2019 (COVID-19) has become a major health problem causing severe acute respiratory illness. Presently, real-time reverse-transcription–polymerase-chain-reaction (real-time RT-PCR) is the standard method used to make a definitive diagnosis of SARS-CoV-2 infection. However, RT-PCR results can be affected by sampling errors and low virus load. Study objective was to describe the thorax high resolution computed tomography (HRCT) features and imaging characteristics in patients with COVID-19 infection.

Material and methods: A descriptive study was done at department of Radiology in the tertiary care hospital attached to Mysore Medical College and Research Institute, Mysore, India for duration of 6 months from May 2020 to October 2020. The study included 78 patients. Each patient was subjected to high resolution computed tomography of chest. It was performed using Siemens 128 slice SOMATOM dual CT scanner. The results were tabulated and evaluated descriptively by Microsoft excel 2016 and presented in figures, tables, frequency graphs and pie charts.

Results: In our study, the total number of patients were 78. Of these, 57 (73.1%) were male and 21 (26.9%) were female with male preponderance. Most common affected age group was 4rd and 5th decade, youngest patient was aged 23yrs whereas the oldest was of 85 years and the mean age was 50.4 years.

The most common pattern being pure ground glass opacity seen among 32 patients (41%) with predominant distribution being both central and peripheral seen in 40 patients (51.2%).

Conclusion: To conclude interpretation of HRCT images of COVID-19 pneumonia are important in the diagnosis and management of COVID-19 infection. In comparison to other forms of pneumonia, the hallmark pattern and distribution of COVID-19 pneumonia showing. Bilateral multifocal patchy GGOs with predominant subpleural and basal distribution often along with consolidations and interstitial thickening.

Keywords: COVID-19 Infection, High Resolution Computed Tomography, HRCT Thorax, Corona Virus

INTRODUCTION

Coronavirus Disease 2019 (COVID-19) has become a serious health issue leading to severe acute respiratory illness. It has become a pandemic since its first discovery in Wuhan, China, in December 2019. This new epidemic disease was namedCoronavirus Disease (COVID-19) by World Health Organization (WHO) caused by thevirus (SARS-CoV-2) (severe acute respiratory syndrome coronavirus 2).[1]

The most prevalent clinical symptoms of COVID-19 patients are fever, followed by cough, fatigue, and dyspnea. It can lead to acute respiratory distress syndrome, acute renal failure, shock, and death.[2,3] COVID-19 pneumonia are diagnosed by laboratory evaluation of respiratory secretions obtained from commonly nasopharyngeal/ oropharyngeal swab, endotracheal aspiration or bronchoalveolar lavage.[4]

At present, real-time reverse-transcription–polymerase-chain-reaction (real-time RT-PCR) is the standard method used to make a definitive diagnosis of SARS-CoV-2 infection.[5] Unfortunately, RT-PCR results can be affected by sampling errors and low virus load.[6,7]

In addition, although the image finding can be positive in the early stages of the disease, RT-PCR results can be negative at the early stages in some cases. However, RT-PCR can become positive in the following course of the disease.[8,9] Therefore, a combination of repeated swab tests and CT imaging can be used as a tool to diagnose the individual with negative RT-PCR screening and high suspicion of COVID-19 infection.[8]

Radiological imaging techniques have a principal role to play in early diagnosis, management and treatment of patients contracted with SARS-CoV-2. Chest X-rays, usually the preliminary examination, have a chief purpose inunveiling the presence lungparenchymal affection.[10,11,12] However, tinylesions remain undetected and the better resolution of CT is important for early diagnosis of patients with high clinical suspicion of COVID-19 anda negative chest X-ray. It also helps in severity scoring of the disease.

Early diagnosis will enable patients to be isolated and treated in good time, essential for avoiding the spread of disease, improving prognosis, and reducing mortality. Thus, early diagnosis of COVID-19 pneumonia is of great significance.[13]

Study objective was to describe the thorax high resolution computed tomography (HRCT) features and imaging characteristics in patients with COVID-19 infection

MATERIAL AND METHODS

A descriptive study was done at department of Radiology in Krishnarajendra tertiary care hospital attached to Mysore Medical College and Research Institute, Mysore, India for a duration of 6 months from May 2020 to October 2020. Institute Ethics Committee approval was obtained (EC REG: ECR/134/Inst/KA/2013/RR-19). The patients of either sex of more than 18 years age group who are RT-PCR tested SARS-CoV-2-positive and also the patients of either sex of more than 18 years age group with high suspicion for COVID – 19 infection with lung changes were included. Cases were collected with the patient details and clinical history of patients who met the inclusion criteria. Pediatric age group less than 18 years and pregnant women were excluded from the study of concern of radiation hazard. Patients without lung changes were excluded from the study. Based on the inclusion and exclusion criteria, a total of 78 patients were included in the study after obtaining the informed consent by the patients for inclusion in the study. High resolution CT of thorax was performed with 128 slice single source dual energy SOMATOM Definition Edge Siemens MDCT (Multidetector CT) machine.

Scanning protocol: Region from both apices to adrenals were included. Patient position was supine with arms above head and following parameters were used: 20 mA, 100 kV, slice thickness 0.6mm, scan orientation: craniocaudal. The images were reconstructed to obtain 0.6mm section in sagittal and coronal planes.

All examinations were evaluated for number and which of lobes are affected, distribution, patterns and other parenchymal changes.

STATISTICAL ANALYSIS

The results of the study were tabulated and evaluated descriptively by Microsoft excel 2016. Also the results were presented in figures, tables, frequency graphs and pie charts.

RESULTS

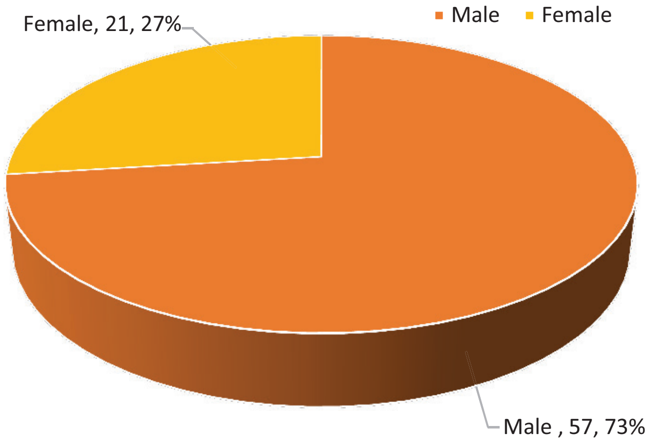
In our study, the total number of patients were 78. Of these, 57 (73.1%) were male and 21 (26.9%) were female with male preponderance [Fig/table 1]. Most common affected age group was 4rd and 5th decade [Fig/table 2,3], youngest patient was aged 23yrs whereas the oldest was of 85 years and the mean age was 50.4 years.

The most common pattern being pure ground glass opacity seen among 32 patients (41%) with predominant distribution being both central and peripheral seen in 40 patients (51.2%) [Fig/table 4A, 4B].

Chest HRCT studies of the 78 patients with COVID-19 showed that disease affected all five lobes in 64 (82%) patients, both lower lobes in 66 (84.6%) patients, the right lower lobe in 76 patients (97.4%), the left upper, lower lobe, right upper and middle lobes in 68 patients(87.1%) and right lower lobe in 76patients(97.4%).

The lesions were predominantly peripheral and subpleural in 40 (51.2%) patients, and there were fewer lesions along the bronchovascular bundles in centroparenchymal location. GGO (Ground glass opacity)and consolidation are two main signs of COVID-19 lesions on CT images. CT showed singular or multiple irregular areas of GGO or consolidation or both in all the patients included in the study.

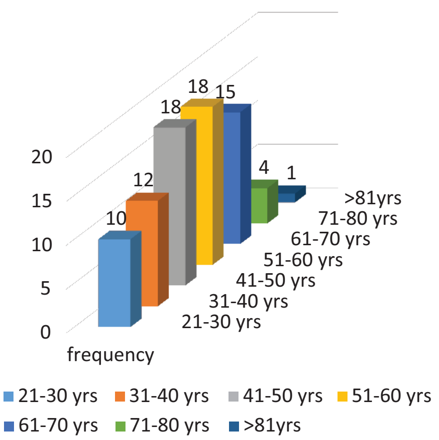
Additional patterns of COVID-19 lesions were noted on



Figure/table-1: Pie chart depicting gender Distribution of COVID-19 infection.

Age	Frequency	Percentage
21-30 yrs	10	12.8%
31-40 yrs	12	15.4%
41-50 yrs	18	23.1%
51-60 yrs	18	23.1%
61-70 yrs	15	19.2%
71-80 yrs	4	5.1%
>81yrs	1	1.3%
Total	78	100.0

Figure/table-2: Age Distribution among COVID-19 infection patients.



Figure/table-3: Bar chart showing Age Distribution among COVID-19 infection patients.

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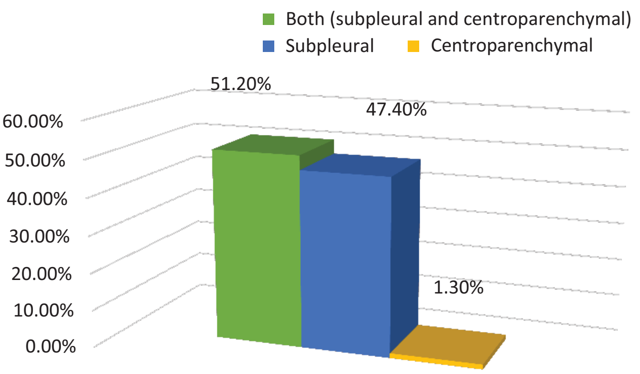
Locationof ground glass opacities	Distribution (n=78)
Subpleural	47.4%
Centroparenchymal	1.3%
Both (subpleural and centroparenchymal)	51.2%

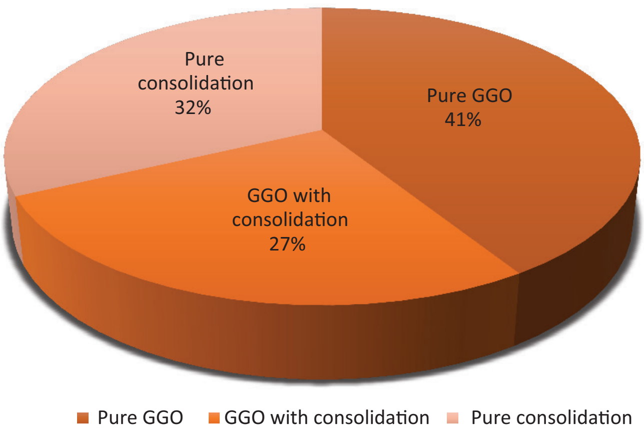
Figure/table-4A1: Location of ground glass opacities



Figure/table-4A2 : Bar chart depicting location of GGO and consolidation

CT characteristics	Distribution (n=78)
Pure GGO	41%
GGO with consolidation	26.9%
Pure consolidation	32%

Figure/table-4B1: Distribution of GGO and consolidation



Figure/table-B2: Pie chart depicting frequency distribution of GGO and consolidation.

HRCT images. Those being interlobular septal thickening with reticular opacities in 28 (35.9%) patients and associated crazy-paving pattern in 8 (10.2%)patients, the air bronchogram sign in 7(8.9%) patients, cavitations were seen in 3 (3.8%) patients, halo sign in 4 (5.1%)patients and "reversed halo" sign in 1 (1.3%) patient. 3 (3.8%) patients showed pleural effusion, 4 (5.1%) of the pericardial effusion and 11(14.1%) of them had mediastinal lymphadenopathy [Fig/Table4c].

DISCUSSION

Characteristic CT features of COVID-19 infection are bilateral presence of multifocal patchy ground glass opacities (GGOs) that may coalesce into consolidatory lesions, which increase progressively. These changes are followed by gradual resorption over weeks and resulting in sequelae in the form of fibrotic stripes. The lesions that are initially predominantly peripheral distribution and subpleural distribution extends to involve central areas with bronchopulmonary distribution as disease progresses.[14,15,16,17]

The supplementaryCT findings or patterns in addition to GGOs and consolidations,are interstitial thickening, crazy-paving pattern, "reversed halo sign", "halo sign", and airway &vascular changes. These collectively help in differentiating COVID-19 pneumonia from other forms of pneumonia.

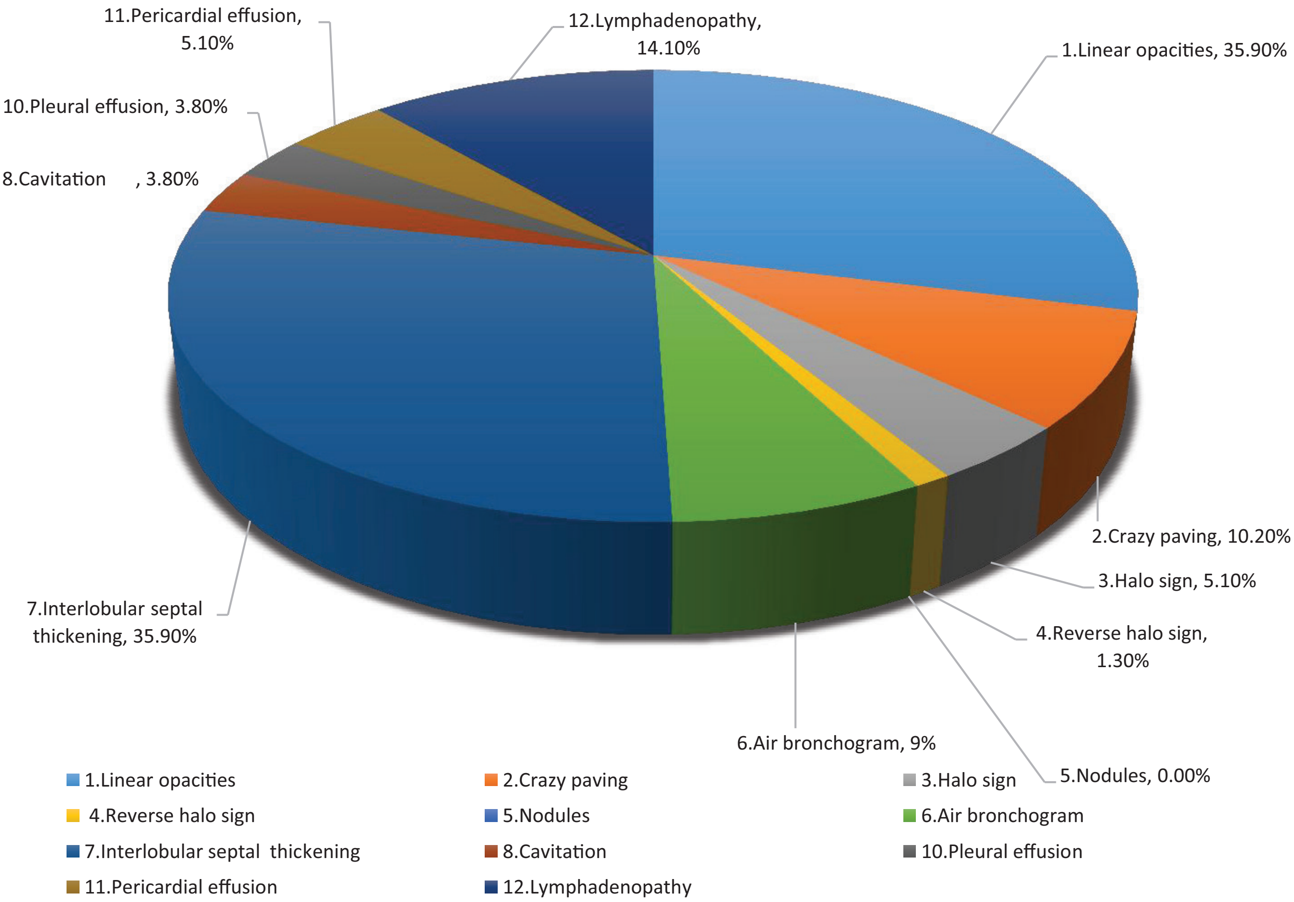
Ground Glass Opacities GGOs one of the most common CT pattern (Fig. 5,6), are due to a partial airspace filling or interstitial thickening.[18] The hallmark CT manifestations of coronavirus disease 2019 (COVID-19) include bilateral and peripheral ground-glass and consolidative pulmonary opacities with predominant peripheral lung distribution. With disease progression the findings some CT patterns compared to initial chest CT increases over time with increasing frequency.[19] GGOs associated with consolidations is most frequently encountered pattern, although it may change patient to patient or with stage of the disease.[14,15] The study by Wang et al. Showed predominantt of GGO pattern at symptom onset, with its declining observation during the course of the disease; also they reported the co-existing presence of consolidation as the next most prevalent observation with the percentage increasing to 24% at 6–11 days after disease onset.[18] Xu et al. reported the first post-mortem biopsy study in which they observed pulmonary edema and a hyaline membrane, which suggested the underlying pathological mechanism of GGOs.[20] In addition presence of interstitial thickening and areas of consolidation reported, suggest lung damage due to organizing pneumonia.[21]

Complete replacement of alveolar airspaces by pathological fluids or cells are termed as consolidations which are seen as increase in parenchymal density that obscure the underlying vessels and bronchial walls[18] (Fig. 7). They too may be multifocal, patchy or segmental, with predominant sub-pleural or peri-bronchovascular distribution and are reported in 2–63% of cases.[21,22] The underlying pathological mechanism is accumulation of cellular fibromyxoid exudates in the alveolar spaces.[18] Study by Kai-Cai Liu et al found coexistent of consolidation with ground glass and fibrotic changes. These changes of pulmonary interstitium occur due to inflammatory cell infiltration, edema, and interstitial thickening, whereas pulmonary parenchymal changes reflects alveolar hemorrhage, edema, cell exudation and hyaline membrane formation.[23] The development of consolidations is related to progression of the disease within two weeks afteronset of the disease[24], this is in agreement with the fact that within 1–3 weeks, GGOs are preceding or co-existing with consolidations.[25]

A reticular pattern are network of linear opacities due to interlobular and intralobular septal thickening[18,26] (Fig. 8) which occur due to lymphocyte infiltration.[20] Reticular opacities are the third most common finding in COVID-19 after GGOs and consolidations[25,27,28], and its frequency

CT characteristics	Distribution (N=78)
Linear opacities	35.90%
Crazy paving	10.20%
Halo sign	5.10%
Reverse halo sign	1.30%
Nodules	0.00%
Air bronchogram	9%
Interlobular septal thickening	35.90%
Cavitation	3.80%
Pleural effusion	3.80%
Pericardial effusion	5.10%
Lymphadenopathy	14.10%

Figure/table-4C1: Distribution of otherhrct characteristics

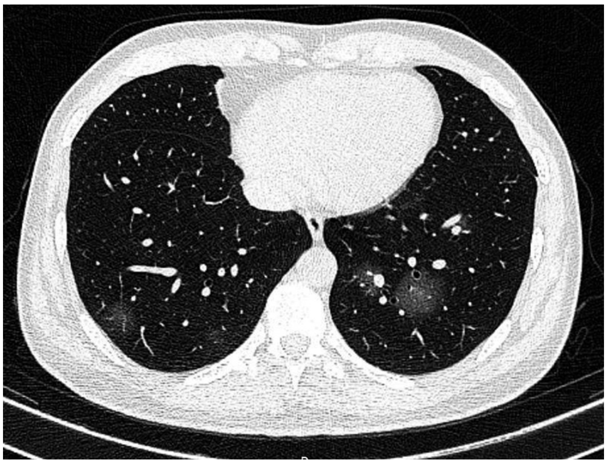


Figure/table-4C2: Pie chart depicting distribution of other hrct characteristics

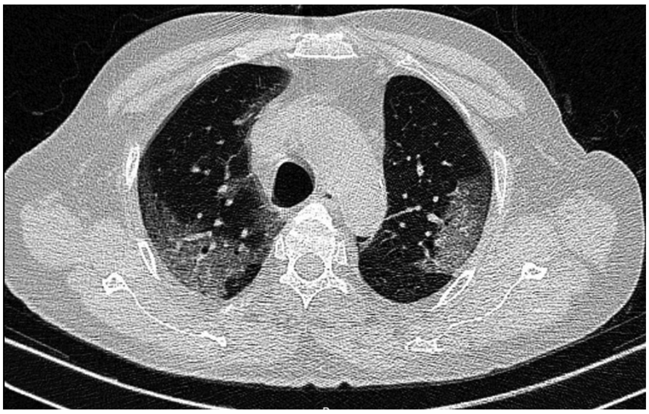
increases along the course of the disease.[25]

In COVID-19, crazy-paving finding is rare than GGOs alone and consolidations.[17] It is defined as GGOs with superimposed interlobular septal thickening that gives the appearance of paving stones[18] (Fig. 9). It has been reported in 5–36% of COVID-19 infected patients[29], and can be considered possibly as a sign of progression when GGOs and consolidations co-exist.[17] Previously found in the case of SARS, wherein alveolar edema coupled with inflammation of interstitial structures were found.[30] The study by showed appearance of crazy-paving pattern many days after symptoms onset, represent the CT correlate for the underlying pathophysiology of the disease process as it organizes.[31]

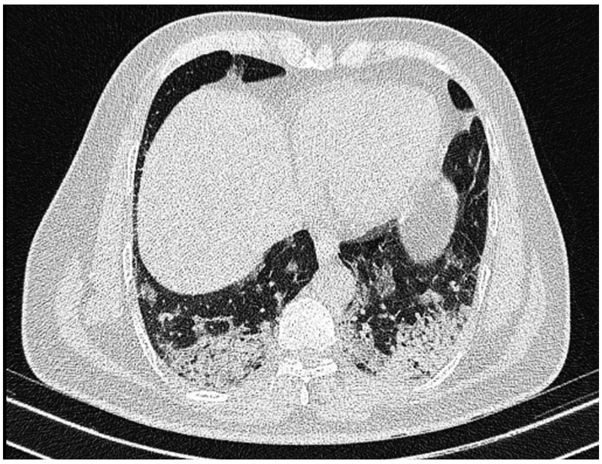
Air bronchograms are air-filled bronchi in a background of attenuated parenchymal[18] (Fig. 10).Ye et al.[15], proposed that "bronchiolectasis" as a more appropriate terminology; wherein they hypothesised that the high viscosity of the mucus leads to bronchiolar damage, thus resulting in bronchiolectasis and characteristic dry cough of COVID-19 patients.Additionally, In an postmortem study by Xi et al on COVID-19 patients, found that bronchi were filled by gelatinous mucus plugs.[32] Hence, the term "air bronchogram" can be considered inaccurate as the bronchi are not air-filledbut mucous and were found in association with a slight bronchial dilatation.



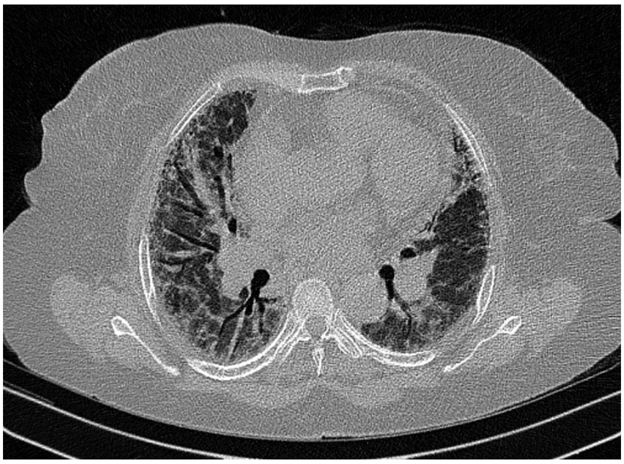
Figure/table-5: Axial HRCT chest image shows ground glass opacities.



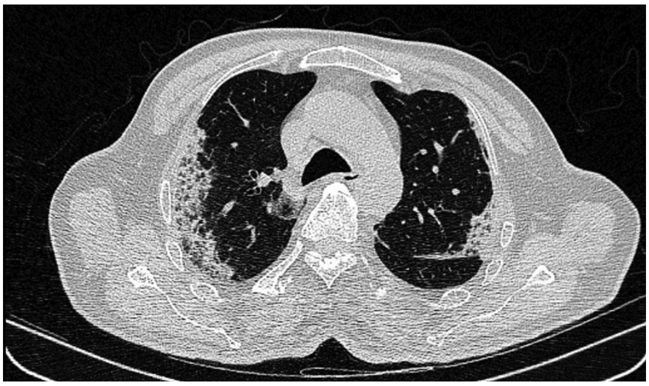
Figure/table-6: Axial HRCT chest image shows subpleural distribution of ground glass opacities.



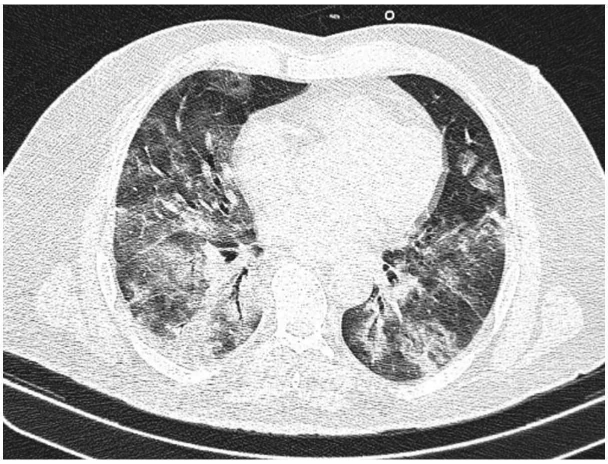
Figure/table-7: Axial HRCT chest image shows subpleural consolidation



Figure/table-8: Axial HRCT chest image shows reticular opacities with bronchiectatic changes



Figure/table-9: Axial HRCT chest image shows crazy paving pattern with subpleural distribution

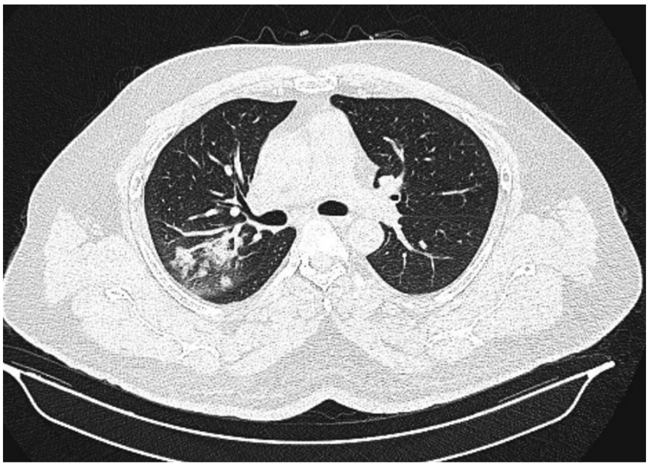


Figure/table-10: Axial HRCT chest image shows consolidatory changes with airbronchogram.

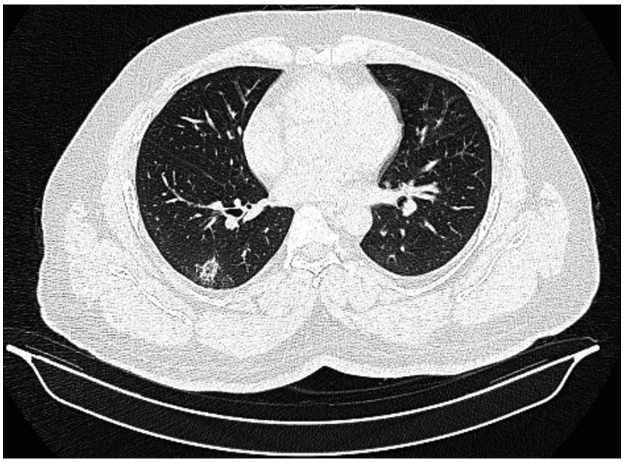
Airway related changes that were reported in COVID-19 infection is bronchiectasis[33] and thickening of bronchial wall in 10–20% of cases[27,29] (Fig. 8). The pathological mechanism assumed is bronchial obstruction and inflammatory damage to wall, leading to their destruction and development of fibrosis with consequent bronchiectasis.[18]

The most common pleural change in COVID-19 patients is pleural thickening (32%) and less commonly pleural effusion (5% of cases).[25] Kai-Cai Liu et al saw that atelectasis and pleural effusion are rare findings on CT. All these were found in critical stages patients, suggesting that these patients have poorer prognosis when these signs occur in CT.[23] This was confirmed in a study where presence of pleural thickening was confirmed by autopsy findingsand is considered as prognostic factor of poorer outcome.[29,32]

Nodules are defined as a rounded or irregular parenchymal



Figure/table-11: Axial HRCT chest image shows "halo sign". Confluent nodules are seen surrounded by GGOs.



Figure/table-12: Axial HRCT chest image shows subpleural nodule with central clearing – "reversed halo sign".

opacity of < 3 cm in diameter[18], is frequently associated withthe presence of viral pneumonia.

A "halo sign" is a nodule or mass surrounded by GGOs[18] (Fig. 11), is thought to be non-specific for COVID-19 as it has only been less frequently reported and observed in studies.[34,35] The underlying pathological mechanism not clear, although it has been seen associated with angio-invasive fungal infections or hypervascular metastases (as a possible sign of peri-lesional hemorrhage[36]) viral infections, and organizing pneumonia.[37] In comparison, the "reversed halo sign" or "atoll sign" is the presence of a ring-like area of consolidation withcentral clearing of GGO[18] [fig 12]. Both these signs have been reported, although rarely, in association to COVID-19 are thought to be related to a healing lesion with a lower attenuation centre or an evolving lesion around a pre-existing GGO.[38,39] However, Li et al.[34] found the halo or reversed halo sign respectively in 17.6% and 3.8% of the COVID-19 patients, and were not reported in SARS or MERS patients. Previouslythese lesions are described in association with cryptogenic organizing pneumonia and other pulmonary infections.[22,40]

Study done by Li, X. et al showed that presence of bronchiectasis, cavitation, and nodules suggested more aggressive or superimposed infection as these findings are rare findings and less commonly seen.[41]

A mediastinal lymph node, when its short-axis diameter is >1cm, is defined as lymphadenopathy.[18] This finding has been reported in 4–8% of patients with COVID- 19 infection[25,27], and it has been thought as a possible significantrisk factor for COVID-19-patients with severe/critical pneumonia.[29] But, a bacterial superinfection should always be suspected when lymphadenopathies are found in along with pleural effusion and lung nodules.[42,43,44]

Pericardial effusion is a rare finding, reported in about 5% of COVID-19 patients and is thoughtto be because of severe inflammation.[27,29] This hypothesis is confirmed by a study that showed a higher incidence of pericardial effusion in association with severe/critical patients.[29]

Limitations of the study

Firstly, there may have been selection bias among the patients underwent CT, as more clinically sick patients were more likely not imaged, this may have an implication on results. Secondly, Follow-up CT examinations were not performed in most cases as to evaluate temporal changes that may have developed lung changes late in the course of disease or cleared on recovery.

CONCLUSION

To concludeinterpretation of HRCT images of COVID-19 pneumoniaare important in the diagnosis and management of COVID-19 infection. In comparison to other forms of pneumonia, the hallmark pattern and distribution of COVID-19 pneumonia showing. Bilateralmultifocal patchy GGOs with predominant subpleural and basal distribution oftenalong with consolidations and interstitial thickening.

Due to low sensitive laboratory investigation, RT-PCR, Chest HRCT ensures early detection of COVID-19 pneumonia in the correct clinical setting. Also, it plays an important role as a follow up investigation to asses the progression disease that may parallel the disease severity. The only possible limitation of CT is the radiation hazard as COVID-19 doesn't spare new-borns, infants and pregnant females.

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