HIGH RESOLUTION COMPUTED TOMOGRAPHY CHEST FINDINGS AMONG PEOPLE AFFECTED BY CORONA VIRUS DISEASE IN A TERTIARY HOSPITAL OF NEPAL

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ABSTRACT

Clinical assessment, chest X-ray (CXR) and chest high-resolution computed tomography (HRCT) are used in the management of Corona virus disease-19 (COVID-19). This retrospective cross sectional study included 251 patients admitted to Nepal Medical College Teaching Hospital (NMCTH) with a diagnosis of COVID-19 infection confirmed by Reverse Transcriptase- Polymerase Chain Reaction (RT-PCR). These patients underwent chest HRCT within the first two weeks of hospital admission. Images were evaluated for various HRCT findings & semi- quantitative CT Severity Score (CT –SS) was calculated based on the extent of lobar involvement. Out of 251 patients with positive RT PCR test, 127 were male (50.6%) and 124 female (49.4%). Typical bilateral peripheral subpleural ground glass opacities were demonstrated in 98.8% of patients; followed by thoracic lymphadenopathy (80.8%), interlobular septal thickening (80.4%),vascular changes (44.2%), focal consolidation (28.6%), consolidation with ground glass opacity (15%), pleural effusion (13.1%) bronchiectasis (3.8%), fibrotic changes (3.1%) and reversed halo pattern (0.7%). Calculated CT- SS showed moderate score in 130 patients (51.7%) followed by severe score in 67 patients (26.6%) and mild score in 51 patients (20.3%). HRCT can be used as a one stop radiological investigation for the diagnosis and prognosis of corona virus disease and CT -SS might be beneficial for diagnostic workflow in symptomatic cases.

KEYWORDS

COVI9-19, corona virus, ground glass opacities, HRCT, CT -SS

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INTRODUCTION

Severe Acute Respiratory syndrome -Corona virus (SARS- COVID -19) was first seen in December 2019 as a series of pneumonia in Wuhan, China.[1] World Health Organization (WHO) declared it as a pandemic on March 11, 2020 after its spread resulting in unprecedented deaths, health care crisis and economic setback in many countries.[2] First positive case of COVID was reported on 23rd January 2020 in Nepal in a student returning from China.[3] Since, there has been a total of 9,95,039 confirmed cases with deaths of 11,992 and recovery of 9,78,422 till August 21, 2022 in Nepal as per Ministry of Health and population.[2] The patients usually present with fever, dry cough, fatigue, nasal congestion, rhinorrhea, sore throat and diarrhea.[3] RT- PCR of viral nucleotides in samples obtained from oropharyngeal swabs, nasopharyngeal swabs, broncho-alveolar lavage or tracheal aspirate is considered as diagnostic criterion for COVID-19.[4] The sensitivity of RT – PCR in COVID -19 detection is reported to be 60 – 71%.[5,6]

Imaging modalities are not considered as diagnostic techniques for COVID-19 but can be used for supporting the diagnosis and grading the severity of disease and its progression. Chest X rays are the first imaging modality which are widely available and are cheap. HRCT is more sensitive than chest X-rays for the diagnosis of COVID -19. CT has been recommended as a key tool for diagnosing and monitoring disease progression and follow up by the National Health Commission of China.[5] The combination of RT- PCR and HRCT may have more accuracy and sensitivity of diagnosis and may render the best diagnostic efficacy.[7]

Typical HRCT imaging features of COVID -19 include peripheral ground glass Opacities (GGO) with or without consolidation, reverse halo sign, multifocal GGO of the rounded morphology with or without consolidation or intra lobular lines (crazy paving) according to multi centric studies at different time points.[6,7] This study aims to evaluate the role of HRCT with COVID-19 in our context and compare these findings with the international studies. Available literature in HRCT chest findings in Nepal is scattered and studies on large sample size are rare.

MATERIALS AND METHODS

Our institute Nepal Medical College Teaching Hospital was designated as a dedicated COVID care Hospital by the Nepal Government. This Cross sectional descriptive study was conducted retrospectively on a total of 251 patients with RT PCR positive test for COVID -19 presented to NMCTH, Attarkhel, Gokarneshwor-8, Kathmandu from January 2021 to March 2022. These patients underwent HRCT test within the first two weeks of admission. The HRCT were assessed for the nature and distribution of the disease pattern, different HRCT findings. The patients were classified according to the lobes involved into mild, moderate and severe.

Inclusion criteria: All patients diagnosed to be infected with COVID-19 virus by RT-PCR testing method tested at Government approved laboratory at the Department of Microbiology.

Exclusion criteria: Suspected COVID -19 cases which were tested negative by RT-PCR test, pregnant, pediatric cases (<18 years) were excluded. Follow up HRCT were not included.

Procedure: Toshiba Aquilon 64 slice CT scanner was used to perform HRCT. Conventional HRCT was performed in the supine position during the end inspirational phase. CT technicians performing CT of patients wore Personal Protective Equipment (PPE), N95 face masks and face shields. All the referred patients wore N95 face masks.

Table 1: CT Parameters for HRCT lung

Kvp and mAs	120 kVp, 350 mAs;
Topogram length	512 cm
Gantry rotation time	0.5 and1second
Pitch	1.0
Section thickness	5mm
Intersection space	5mm

*Kvp- kilovoltage peak; mAs- milliampere per second

Additional reconstruction with a sharp convolution kernel; was obtained. Images were acquired in axial mediastinal window and reconstructed in thin 1.25 mm lung window. All CT images were reconstructed to 1.25-mm thin slices. Multiplanar images were obtained using the multiplanar reformatting (MPR) technique on a workstation. All thin-section CT images were reviewed at a window width and level of 1000 to 2000 HU and −700 to −500 HU, respectively, for lung parenchyma.

Equipment, gantry, table and accessories were sanitized with detergent damp cloth followed by non-dripping 1% sodium hypochlorite. Entire room floor was cleansed in the same manner.

Evaluation

Computed tomography severity score (CT–SS): CT score tried to find objective method to assess significant radiological differences between severe and mild cases of COVID -19 by the score published by Li *et al.*[8]

In this study both lungs are subdivided into five lobes and each lobe was assessed individually. All the aforementioned findings were assessed in individual lobes. Each lobe was given a CT score from 0 to 5, depending upon the percentage of the involved lobe (Table 2).

Table 2: CT Severity scoring system according to the percentage of involved lobe

Score	Percentage of involved lobe
0	0
1	Less than 5%
2	5- 25%
3	26- 49%
4	50-75%
5	Greater than 75 %

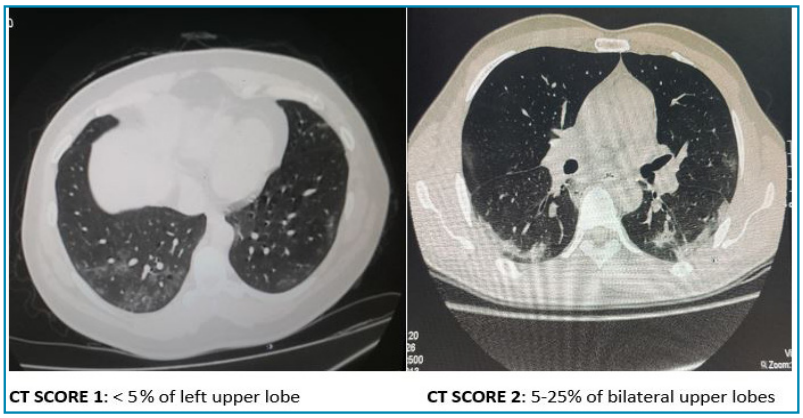

Fig. 1 (a): CT severity score (1, 2)

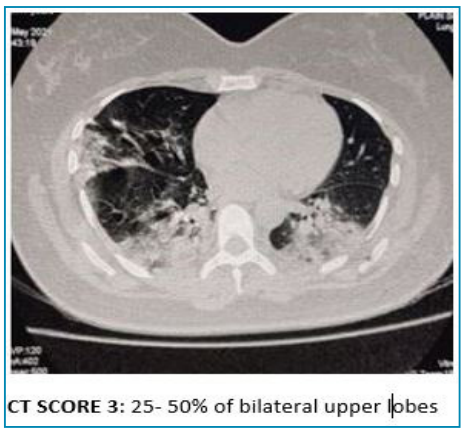

Fig. 1 (b): CT severity score (3)

The overall CT score is the sum of the points from each lobe and ranges from 0 to 25 points.[9,10] The scoring was categorized as follows according to the score (Table 3).

Table 3: HRCT scoring system for COVID changes

Total score	Severity (category)
7 or less	Mild
8-17	Moderate
18 or more	Severe

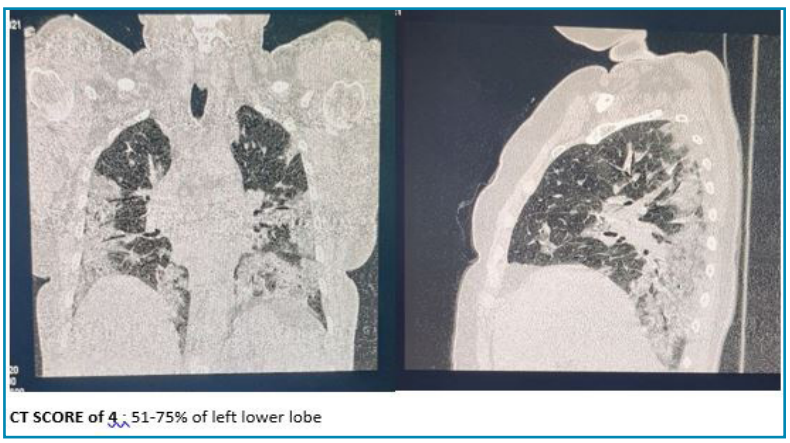

Fig. 1 (c): CT severity score (4)

Fig. 1 (d): CT severity score (5)

HRCT showing CT findings with percentage of involvement of bilateral lungs are shown in Fig. 1 (a, b, c, d).

RESULTS

Total of 251 symptomatic and asymptomatic patients with positive RT PCR test underwent HRCT lungs within the first two weeks of onset of symptoms or diagnosis at hospital. The study included 127 females (50.5%) and 124 males (49.41%) (Fig. 2).

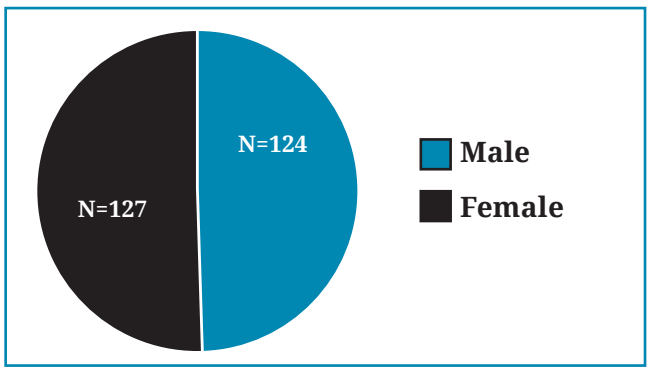

Fig. 2: Pie chart showing chart distribution of cases

Mean age of patients was 50.5 years; age ranging from 18 years to 95 years. High incidence was among the older age group with 4.3% affecting 60 years old and above. Mean COVID score was 12.84 which is moderate CT severity score. Common HRCT findings are as listed below. (Table 4).

Table 4: HRCT findings in COVID positive patients

HRCT Findings	n (%)
Ground glass opacities (GGOs)	98.9
Mediastinal lymphadenopathy	80.8
Interlobular septal thickening/crazy paving Pattern	80.4
Focal consolidation	28.6
Pleural effusion	13.1
Presence of both GGOs and consolidation	8
Bronchiectasis/bronchial dilatation	3.8
Fibrosis	3
Reverse atoll sign	0.79
Normal/ without any HRCT features	1.1

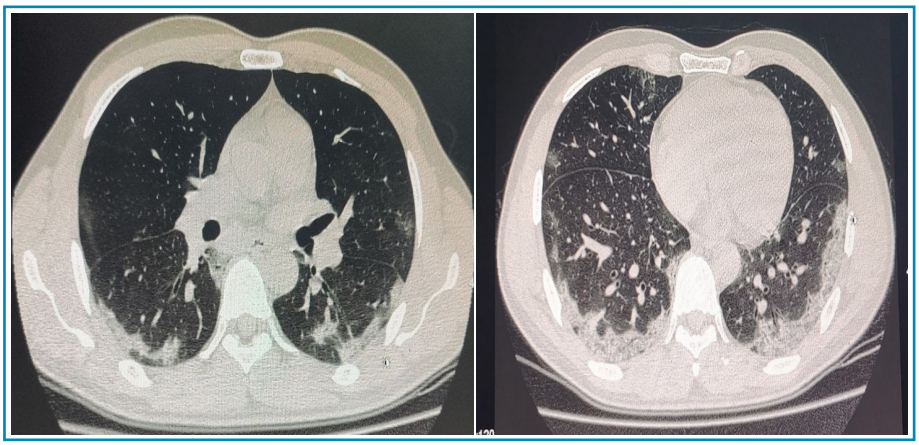

Fig. 3: HRCT axial view showing bilateral peripheral sub pleural ground glass opacities (Severity Score: Mild; involving 5-25% of bilateral lower lobes; < 5% right middle lobe)

Typical findings:

Peripheral ground-glass opacities: On HRCT, Ground glass opacities (GGO) refers to the area of the increased lung opacity in which underlying bronchovascular markings are not obscured.[6] Ground glass opacities were noted in almost all the cases involving peripheral multiple lobes in the subpleural region in 98.9% (248 patients). Out of 251 positive cases 236 of them (95.1%) had bilateral lung involvement while 12 had unilateral right lung involvement (4.8%) (**Figure 3, 4, 5**).

Interlobular septal thickening: Interlobular septa are the 10–20 mm long linear or sheet-like structures that form the lobular borders, which are more or less perpendicular to the peripheral pleura.[11]The lobular septum consists of connective tissue, including lymphatic vessels and pulmonary veins.[11] This was seen in 80.4% of our cases. This along with ground glass opacities gave peculiar crazy paving appearance in HRCT lungs.

Pleural changes: Pleural effusion was seen in 13.1% of our cases; minimal effusion involving the right side (38.6%).

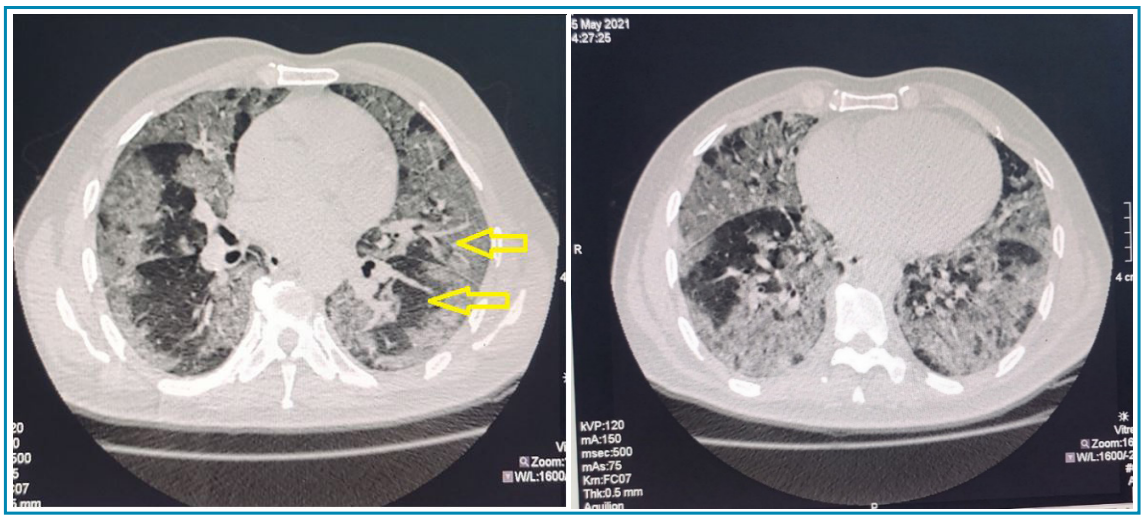

Fig. 4: HRCT axial view showing bilateral multilobar ground glass opacities with interlobular septa thickening and dilated vessels / vascular sign (arrows) (Severity score: Moderate- involving 50 – 75% of bilateral lower lobes)

Focal consolidation: On HRCT, area of the increased lung opacity with obscuration of underlying bronchovascular markings refers to consolidation.[6] Patchy or segmental, multifocal consolidation was present in 28.6% of our cases and consolidation with ground glass opacity was demonstrate in 8% (Fig. 6).

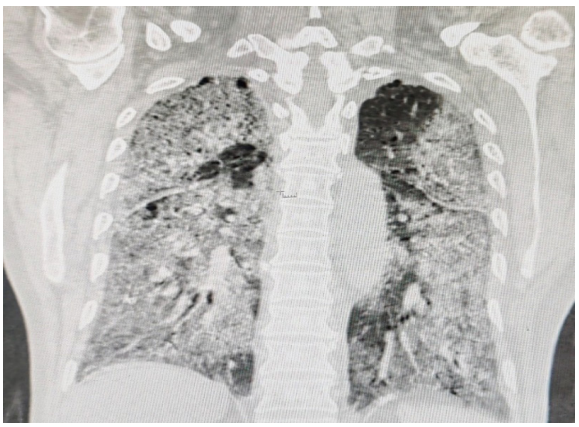

Fig. 5: HRCT Coronal section showing diffuse ground glass opacities with interlobular septal thickening involving more than 75% of bilateral lungs. (Severity score: Severe involving > 75% of all the lobes)

Fig. 6: HRCT axial section showing focal consolidation in the right middle lobe.

Vascular changes: Vascular enlargement refers to the dilatation of blood vessels around or inside the pulmonary lesions, which is always accompanied by GGOs and/or consolidation.[12] This was demonstrated in 44.2 % of our cases (Fig. 7).

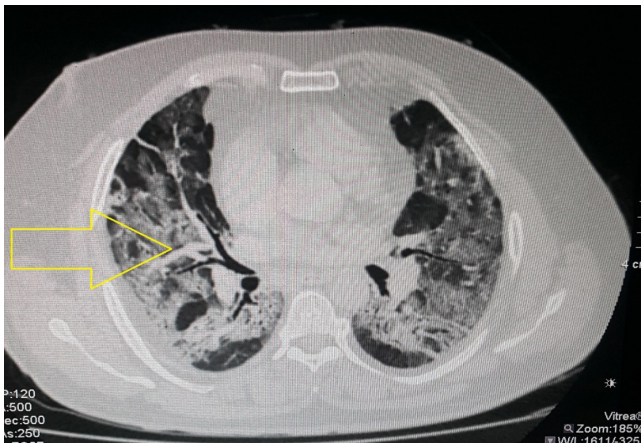

Fig. 7: HRCT axial section showing dilated vessels along the ground glass opacity in right middle lobe

Lymphadenopathy: Lymphadenopathy is not commonly associated with COVID -19. Lymphadenopathy is defined when the mediastinal lymph node short-axis diameter is more than 1 cm.[13] This was seen in 80.8% of cases.

Bronchial dilatation: Brochiectasis was seen in 3.5% of cases around the ground glass opacities.

Fibrosis: Fibrosis was seen in the shape of stripes, reticulations patterns in chest CT images.[14] This was seen in 3.1% of cases.

Reversed Halo Signs: The halo sign is a terminology used in CT which has central ground glass opacity surrounded by denser consolidation.[14] Reverse Halo was seen in 2 patients (0.8%).

Complications: Moderate amount of pericardial effusion noted in 2 patients (0.7%). Pulmonary complications like pneumothorax (0.3%), cavities (0.7%), collapse (8.7%), left sided empyema (0.3%) and pulmonary thrombus (0.7%), confirmed by CT pulmonary angiography, were noted.

Associations: Most common comorbidity present in the study group was Chronic obstructive pulmonary disease (COPD) changes like emphysematous changes which was present in 9.1%, 0.3% had chronic kidney disease, while 0.7% had cirrhosis of liver.

Additional findings: Three of the patients (1.1%) were known cases of malignancy of breast, esophagus and lung, respectively. Two older age patients (0.7%) had compression fractures of thoracic vertebra. Bilateral perinephric fat stranding was noted in 10.7% patients.

CT severity was graded as mild, moderate and severe. 51.7% of sample population had moderate severity followed by severe 26.6% and mild 20.3% was present in 20.3% (Table 4).

Table 4: Percentage of mild, moderate and severe COVID -19 score

COVID-19 score	n (%)
Mild	51(20.3)
Moderate	130 (51.7)
Severe	67 (26.6)

CT-SS score was zero in three patients (1.19%).

DISCUSSION

The WHO advised the use of chest imaging as part of diagnostic workup of COVID-19 disease whenever RT-PCR testing is not available, in case of delayed test results or when there is a clinical suspicion of COVID-19 with initial negative RT-PCR testing.[1,2] In this study, we have attempted to outline the common HRCT features of COVID-19 disease and grade its severity according to the CT-SS.

Our population showed a relatively young age (mean age 50.5 years) with almost equal gender involvement and the eldest participant was 95 years. Among previous studies, Bhandari *et al*[15] reported that the mean age of patient was 50.4 years, very similar to this study. However, unlike many studies[4,5,6] involving almost two third of cases of male patients, our study showed slightly higher female patients compared to male.

A large meta-analysis performed in China with a total of 109 articles involving 2908 adults with COVID-19 described HRCT findings that often occurred were involvement of bilateral lungs (74%) with multifocal (77%) and sub-pleural distribution (81%).[16] Majority lesions showed GGOs (68%), followed by GGO with consolidation (48%).[16] The dilatation of small vessels (70%) and thickening of intra-lobular septum (53%) were also common.[16] Our study also demonstrated similar HRCT findings with 98.8% typical subpleural GGOs ; 93.8 % occurred in bilateral lungs. Interlobular septal thickening was comparatively higher in our study (80.4%). However focal consolidation and consolidation with GGO were comparatively higher than our study that is 28.6% focal consolidation, consolidation with ground glass opacity (8 %). Some studies showed COVID-19 pneumonia manifesting as unilateral GGO even before the onset of symptoms with rapid evolution into diffuse, bilateral disease and in some patients superimposition of reticular patterns were seen giving a crazy paving pattern.[7] Some recent studies have also reported the crazy paving pattern in 5–36% of patients with COVID-19 pneumonia.[16] This appearance can be considered as an indicator of disease progress or it may be recognized as secondary sign

indicating the disease has reached the peak stage.[5] However, we have not assessed the exact timing or course of the disease and the timing of HRCT. All HRCT were performed within the first two weeks of hospital admission. Also follow up chest HRCT were not done to assess the complications.

Another study reported parenchymal consolidation with multifocal, patchy, or segmental distribution in subpleural and peribronchovascular regions in 2–64% of cases infected with this disease.[17] In COVID-19 pneumonia, when there is a longer time interval between the symptom onset and CT scan, or in those patients older than 50 years old, lesions usually show a more consolidative appearance.[18] Accordingly, they were described in 18.7% of cases in a meta-analysis of 34 studies performed on 4121 patients.[19] It is usually seen in the progressive or the peak stage (4 – 14 days after the onset of the initial symptoms) but can also be seen in the early stage (0-5 days).[20] Patchy or segmental, multifocal consolidation was present in 28.6% of our cases, consolidation with ground glass opacity (8%) which was less than these studies mentioned above.

In some studies, the occurrence of interlobular septal thickening was found to be relatively high in patients with COVID-19, ranging from 0.9% to 93.6%, although it was not as common as GGOs and consolidation and it was more likely to occur in elderly patients.[21] These findings correlate with our with involvement of 80.4%.

We noticed pleural effusion (13.1%) mostly unilateral on the right in our study; however there is increased prevalence of pleural thickening (27.1%) on a large meta-analysis with 4121 patients.[22] Reactive mediastinal lymphadenopathy was noted in relatively large number of cases including 80.8%. It is usually associated with superimposed bacterial infections especially in severe pneumonia.[23,24] Vascular enlargement is relatively common involving 44.2% in our cases lower than large metaanalysis study by Li and Xia (involving approximately 82.4%).[23] Bronchial changes like bronchiectasis, bronchiolectasis and bronchiolitis is rare in COVID-19 and usually seen in later stages of the disease.[24] Fibrotic changes were noticed in 3.1% of patients and these changes are considered as predictors of lung fibrosis during the process of COVID -19 infections.[22]

Halo sign is not specific for pneumonia from COVID-19, although has been reported in several studies could be related to fungal infections or organizing pneumonia.[25] On the contrary Reverse Halo sign have been reported in numerous studies, it is less common than the other signs.[26,27] It is seen in only 2 patients in our study.

In a study conducted by Shah *et al*[28] of 216 patients it is noteworthy that 114 of the 216 patients (52.7%) had a normal HRCT scan. However, in our study only 1.1% of patients (3 patients) showed normal HRCT findings considering most of the patients were symptomatic and all the patients were admitted to our hospital requiring oxygen supplement.

Also, we have found pulmonary complications like pneumothorax (0.3%), cavities (0.7%), collapse (8.7%), pulmonary thrombus (0.7%), and left side empyema (0.3%).

Due to unavailability of the software, we used the visual assessment of each of the 5 lung lobes and the severities were further classified on the total cumulative severity score. According to a large scale study CT –SS score of >/= 18 was associated with an increased mortality risk and was found to be predictive of death and CT SS might be beneficial to speed up diagnostic workflow.[29]

There are many limitations of our study. This was a retrospective study done in diagnosed cases of COVID-19 so we cannot use this to calculate the sensitivity and specificity of HRCT in making diagnosis of COVID -19 infection. We just wanted to emphasize on radiologists with common and uncommon HRCT findings in COVID infection. Also initial CT severity score may give an idea of the severity of the infection and help in the management protocols for the clinicians. These findings help the clinicians to understand the disease process, progression of disease and prognosticate the disease accordingly. However the sample size of this study is relatively small. However, we have not done follow up of these patients and we have not assessed the progression pattern of the disease. Most of the HRCT findings show peripheral ground glass opacities signifying that most of the patients were in progressive stage of COVID.

Thus, to summarize HRCT chest can be used in COVID patient to assess the severity at presentation, prognosis and complications of the disease. HRCT can have a pivotal role in assisting physicians in the management plan and work as an indicator for disease severity

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