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ORIGINAL ARTICLE

Investigation of HRCT Chest Severity in Patients with COVID-19: A Study of Tertiary Care Hospital in Pakistan

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ABSTRACT

Background: High-resolution computed tomography (HRCT) chest has a key role in diagnosis COVID-19, as it provides specific imaging features, i.e., bilateral, peripheral and sub-pleural, ground-glass opacity (GGO), consolidation and many associated findings.
Aim: To provide the detailed chest HRCT findings along with clinical information in patients with COVID-19.
Methods: A cross-sectional study was conducted in the Department of Radiology SZPGMI, Lahore. Information on clinical data, chest radiography appearance and comorbidities were recorded ona designed proforma. HRCT chest findings were recorded in terms of pattern, distribution, laterality, and other findings. HRCT chest severity was calculated using a 25 point CT severity score. Kendall's Tau test applied to investigate the correlation between the severity of HRCT chest with clinical severity levels of COVID-19.
Results: Fever (74%) was the most reported presenting symptom, followed by dry cough (70%). The majority of patients had abnormal chest X-ray (57%) as well as abnormal HRCT chest (90%). The majority of patients were in mild clinical scoring levels of disease (61%) and mild category (49%) of HRCT chest severity. In majority of the patients (46%), all five pulmonary lobes were involved, whereas the right lower lobe was most frequently affected. The pattern of ground-glass opacity (GGO) was found in 82% of patients. Most common distribution was 'peripheral', reported in 90% patients. Multiple lobe involvement was found in 82% of patients. The unilateral pulmonary involvement was observed in 12% of patients, whereas, bilateral was found in 78% of patients. Reticulations were reported in 22% followed by atelectasis in 18% patients.
Conclusion: COVID-19 patients usually present with abnormal HRCT chest, mostly with a benign course. Multiple pulmonary lobes are commonly involved, especially basal lobes with ground glass opacities. Clinical severity of the disease is reflected in HRCT findings.
Keywords: COVID-19 Pandemic, HRCT Chest Findings, Ground Glass Opacity (GGO), Consolidation

INTRODUCTION

As coronavirus emerged in 2019, there has been an outbreak of respiratory illnesses varying between mild self-limiting disease to life-threatening and fatal pneumonia. The rapidity of its spread from China and then throughout the world brought all authorities on one page and WHO declared it as a pandemic in early March 2020[1-3] Counts suggested one hundred and forty million cases till date in the world with mortality as high as 5%. Common symptoms in reported cohort studies have been fever, dry cough, headaches, muscle aches, fatigue, and difficulty in breathing[4]. Patients who get worse and hospitalized show the typical ground-glass opacities (GGO) on CT chest in 90% of the cases. Other features, often reported in HRCT chest are lower lobe predilection and consolidations with peripheral distribution. It is thereby suggested that a chest radiograph should be sought initially as sufferers do come up with negative RT-PCR tests. Similar chest radiograph findings are known to occur in various other diseases, like adenovirus infections and influenza. Surprisingly the hallmark GGO can occur in up to 26% of normal healthy individuals[5-6]. It is crucial to have an accurate and rapid assessment of COVID-19 clinical severity for early detection, management and monitoring of disease process. Early identification is of paramount significance for severe cases. Apart from GGO of COVID-19 patients its peripheral distribution could be a vital diagnostic choice in COVID-19 patients[7].

The clinical severity of COVID-19 can be from asymptomatic status to death. To make a definite diagnosis of COVID-19 a positive RT-PCR test is needed[4]. However, a considerable percentage of false-negative results associated with this test has been causing a real clinical challenge making radiological imaging necessary. Thoracic imaging in this pandemic using chest radiography and particularly HRCT chest has emerged as irreplaceable diagnostic tests[8]. These imaging modalities helped in the diagnosis, prognosis, and detection of complications[9-11].

Studies on long-term pulmonary function and its relationship to physiological characteristics of COVID-19 survivors have been lacking and many aspects are poorly understood. Patients who suffered from COVID-19 and survived were later recruited and investigated with chest HRCT chest scans, antibody tests, and pulmonary function tests. Clinical manifestation of COVID-19 and the relationship with the pulmonary function was studied with

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HRCT chest scores[12]. In the majority of cases, chest radiograph being the initial imaging modality of choice is enough for evaluation of pulmonary disease in COVID-19. However, there is a significant cohort of patients in which radiographic findings are not typical or are subtle, or are not correlating with the clinical condition. Some patients are RT-PCR negative, but clinically are strongly suspected to have COVID-19. These are the patients in which the HRCT chest may have a useful diagnostic role. Ground-glass opacity (GGO) and consolidation are predominant in peripheral pulmonary distribution. It is essential for all radiologists to be familiar with the imaging appearance and a spectrum of the disease so that they may be able to provide an effective contribution in the management of this pandemic. Fu et al (2020)[13] conducted a study on of 40 patients, the features observed on HRCT scans were GGO, with or without consolidation, consolidation alone, multiple types of intrapulmonary opacities like reticulations in the lung and multiple lobe involvement especially the lower ones. The current research was aimed to provide detailed chest high-resolution computed tomography (HRCT) findings along with other clinical information in patients with COVID-19. The study focused to evaluate the association between the HRCT chest severity levels with the disease severity categories of COVID-19. Understanding the factors predictive of severity of the disease is important as it will impart confidence in stratifying patients by the healthcare staff. A study at Renmin Hospital of Wuhan University, the temporal radiographic changes and clearance of virus were explored by application of statistical calculations. Findings from HRCT chest were ground-glass opacity, air bronchogram, consolidations, nodular opacities and pleural effusion. Peak score of the COVID-19 HRCT with a median value of 24.5 was higher compared to those with pneumonia, median value 10, with air bronchogram and consolidation more frequently seen in the COVID patients [14]. Liu et al (2020) [14] stated that a standardized scoring system of HRCT is highly demanded. Prediction of prognosis and risk assessment in a clinical setting of stretched resources was a key challenge for the clinicians and staff members [14] . The duration of viral clearance can be determined by viral load, the patient's immunity, and treatment given. The radiological imaging of the chest represented the pathophysiology of COVID-19 disease process[14].

MATERIAL AND METHODS

A cross-sectional study was conducted in the Department of Radiology, Shaikh Zayed Postgraduate Medical Institute (SZPGMI), Lahore Pakistan. The duration of the study was 11 months from 3rd April 2020 to 28th February 2021. Total of 100 patients enrolled were referred to the Radiology department for HRCT chest from the inpatient and outpatient sections of pulmonology, medicine and ENT departments of SZPGMI besides few patients referred from other tertiary care hospital. A nonprobability, consecutive sampling was considered. Non-disclosure of patients' information and strict confidentiality of record-keeping was adopted. Approval from the institutional ethical committee and review board were received before the start of the study.

Inclusion and Exclusion Criteria: All patients of both genders with age 14 years and above, who were positive on RT-PCR were included. Those patients were also included who were negative on RT-PCR, but found with strong clinical suspicion of COVID-19. Patients with ages below 14 years were excluded.

Data collection: Information on following clinical data was collected: age, gender, medical record number, presenting symptoms (fever, dry cough, breathlessness, myalgia, fatigue & headache) of COVID-19, comorbidities like diabetes mellitus, hypertension, coronary artery disease (CAD), chronic kidney disease (CKD), congestive heart failure (CHF), obesity, asthma & chronic obstructive airway disease (COPD) were recorded on a designed proforma. Results of RT-PCR test in each patient was recorded as positive or negative. Chest radiographic appearances (normal or abnormal) were also recorded. Presence of airspace shadowing or consolidation was considered abnormal and its location was recorded.

HRCT Chest: The HRCT chest was done using Toshiba Asteion 4 slice CT scanner using 1 mm thin sections 10 mm apart. Imaging findings were interpreted by two experienced radiologists and reporting was done with mutual consensus. HRCT chest findings were recorded in terms of the pattern (ground-glass opacity, consolidation, or mixed), distribution (single, multiple, upper, lower, middle lobe, central or peripheral), laterality (unilateral or bilateral) and other findings (like atelectasis, reticulation, architectural distortion, vascular enlargement, cavitation, pleural effusion and lymphadenopathy).

Calculation of Clinical Severity and HRCT Chest Severity Scoring: The HRCT chest severity was calculated using 25 point CT severity score as described by Saeed et al. (2021) and Chang et al. (2005) [15-16] . The individual lobar scores were based on percentage of involvement: score 1: 5% or less; score 2: 5-25 %; score 3: 26-49%; score 4: 50-75% and score 5: >75% [15]. The 0-5 score was calculated for each lobe depending upon the percentage of area involved by disease and finally, all scores from 25 lobes were added to make the final score of HRCT chest severity. Then, these were categorized as mild (less than 7) moderate (8-17) or severe (18 or more). The clinical severity was calculated in following categories: mild, moderate, severe and critical, according to the guidelines described by the Ministry of National Health Services Regulations and Coordination, Government of Pakistan. Government of Pakistan follows the guidelines of the CDC (Centers for Disease Control and Prevention) [17] .

Data Analysis: All the descriptive and quantitative data was analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. In order to investigate the correlation between the severity levels of HRCT chest with the COVID-19 clinical severity levels, a non-parametric correlation test the Kendall's Tau_b applied. A P-value of less than 0.05 was considered significant.

RESULTS

Demographics & Clinical Information: The mean age of the patients was around 51 years. Most of the patients (30%) were over 60 years of age. More male patients (70%) suffered from COVID-19 infection as compared to

female patients. Fever (74%) was the most reported presenting symptom followed by dry cough (70%), breathlessness (64%) and myalgia (30%). The majority of patients (59%) were positive on RT-PCR. The majority of patients had abnormal chest radiograph (57%) as well as abnormal HRCT chest (90%). Asthma was reported in 4% and chronic obstructive airway disease (COPD) in 1% of patients. The most-reported comorbidity was hypertension (18%), followed by diabetes mellitus (16%) and chronic kidney disease (CKD) (6%). Other comorbidities were reported in 1-5% patients (Table 1).

Disease Severity and HRCT Chest Severity Levels: The majority of patients were in mild clinical severity levels (61%). Similarly, the majority of patients were found in mild category (49%) of chest HRCT severity levels. 32% of patients had moderate levels of severity in HRCT chest. **Table 1** describes the detailed information (Table 1).

HRCT Chest Scan Findings: Table 2 shows the information about the investigation in detail. In the majority of patients (46%), all five pulmonary lobes were involved, two lobes were involved in 18%, and four lobes were involved in 14% patients. In 84% of patients, the right lower lobe was involved. The left lower lobe was involved in 78% and the upper right lobe was involved in 60% of patients.

The pattern ground-glass opacity (GGO) was found in 82% patients, consolidation in 58% patients, and mixed in 50% patients. Peripheral distribution was reported in a maximum number of the patients (90%). Multiple lobes involvement was found in 82% of patients. The unilateral pulmonary involvement was observed in 12% of patients, whereas, bilateral was found in 78% patients. Regarding associated findings, mostly reticulation was reported (22%), followed by atelectasis (18%), septal thickening (4%), architectural distortion (2%), vascular enlargement (6%), cavitation (2%), pleural effusion (8%), lymphadenopathy (4%) and pericardial effusion (2%) (Fig. 1-4)

Figure 1. Thickened interlobular and intralobular septae (arrow) in combination with ground glass haze giving crazy paving appearance. Enlargement of vessel is also seen.

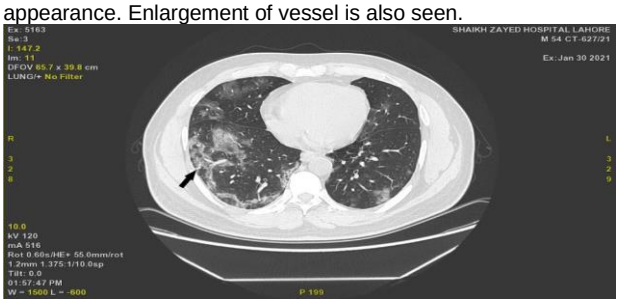

Figure 2: Bilateral multifocal ground glass opacities (arrow) in peripheral sub-pleural locations. Few sub-pleural reticulations (*) are also seen.

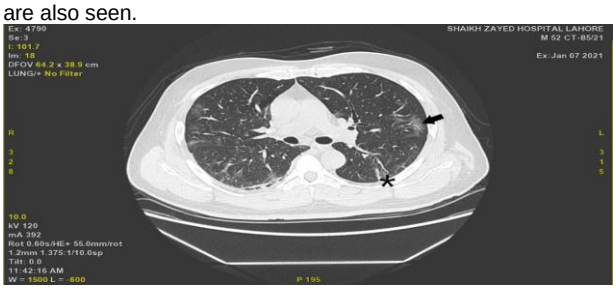

Table 1: Clinical Information and prevalence of enrolled patients (n=100)

Characteristic	**n**
Age Groups (years)*Mean Age: 50.84±16.690 years Minimum: 15 years; Maximum: 90 years*	
<18	2(2%)
18-20	0(0%)
21-30	10(10%)
31-40	22(22%)
41-50	18(18%)
51-60	18(18%)
>60	30(30%)
Gender	
Male	70(70%)
Female	30(30%)
Presenting Complaints	
Fever	74(74%)
Dry cough	70(70%)
Breathlessness	64(64%)
Myalgia	30(30%)
Fatigue	8(8%)
Headache	2(2%)
Coexisting Lung Diseases	
Asthma	4(4%)
Chronic Obstructive Airway Diseases (COPD)	1(1%)
Comorbidities	
Diabetes Mellitus (DM)	16(16%)
Obesity	2(2%)
Hypertension (HTN)	18(18%)
Congestive Heart Failure (CCF)	1(1%)
Coronary Artery Disease (CAD)	5(5%)
Chronic Kidney Disease (CKD)	6(6%)
Parkinson	1(1%)
Clinical Severity	
Mild	61(61%)
Moderate	35(35%)
Severe	4(4%)
RT-PCR Result	
Positive	59(59%)
Negative	41(41%)
Chest Radiograph	
Normal	43(43%)
Abnormal	57(57%)
HRCT (High Resolution Computed Tomography) Chest	
Normal	10(10%)
Abnormal	90(90%)
HRCT Chest Severity	
Normal	13(13%)
Mild	49(49%)
Moderate	32(32%)
Severe	6(6%)

Figure 3: Enlargement of vessels (arrow)in the areas of ground glass haze.

Figure 4: Bilateral small sub-pleural airspace consolidations (arrows)

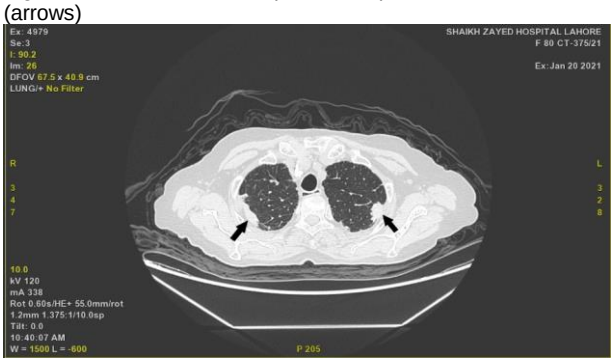

Table 2: HRCT Chest Results in RT-PCR Confirmed or Clinically Diagnosed COVID-19 Patients

HRCT Chest Findings	n	Percentages
Number of Lobes Involved		
0	10	10%
1	8	8%
2	18	18%
3	4	4%
4	14	14%
5	46	46%
Occurrence of Lobe Involvement		
Right Upper Lobe	60	60%
Right Middle Lobe	52	52%
Right Lower Lobe	84	84%
Left Upper Lobe	62	62%
Left Lower Lobe	78	78%
HRCT Chest Findings		
Occurrences in Different Imaging Appearances		
Pattern		
Ground Glass Opacity (GGO)	82	82%
Consolidation	58	58%
Mixed	50	50%
Distribution:		
Single Lobe	8	8%
Multiple Lobes	82	82%
Central	38	38%
Peripheral	90	90%
Laterality:		
Unilateral	12	12%
Bilateral	78	78%
Associated Findings		
Reticulation	22	22%
Atelectasis	18	18%
Septal Thickening	4	4%
Architectural Distortion	2	2%
Vascular Enlargement	6	6%
Cavitation	2	2%
Pleural Effusion	8	8%
Lymphadenopathy	4	4%
Pericardial Effusion	2	2%

Table 3: Kendall's Tau_b Test for Correlation Analysis

Correlation Between:	Correlation Co efficient	p- value
HRCT Chest Severity Levels (normal/mild/moderate/severe) and ***Clinical Severity Levels*** (mild/moderate/severe)	0.755	0.000<0.050* *significant

Kendall's Tau_b Test for Correlation Analysis: A significant, strong correlation (p value 0.000) existed between the HRCT chest severity score (normal/mild/moderate/severe) with the clinical disease severity levels (mild/moderate/severe) (Table 3).

DISCUSSION

There is constant evolution of the radiological information regarding COVID-19. The imaging spectrum of COVID-19 pneumonia should be well understood and learned by radiologist physicians and pulmonologists. Early diagnosis of disease by HRCT chest plays an important role in control of the pandemic by prompt management of patients Comparison between the severity levels of HRCT chest and Disease Clinical Categories particularly those with false negative RT-PCR reports[18]. The current research provided detailed HRCT chest findings along with other clinical information in patients with COVID-19. The study evaluated the association between the HRCT chest severity levels with the disease severity categories of COVID-19. We discovered a significant, strong correlation between the HRCT chest severity levels (normal/mild/moderate/severe) with the clinical severity levels of the disease (mild/moderate/severe). In our patients, fever, dry cough, and breathlessness were the most reported presenting symptoms. More male patients suffered from COVID-19 infection as compared to female patients. Asthma, as well as COPD, existed in very few patients. The most-reported comorbidity was hypertension and diabetes mellitus. The majority of patients had abnormal chest radiograph (57%) as well as abnormal HRCT chest (90%). The majority of patients were in the mild category of clinical severity of COVID-19 and mild category of HRCT chest severity levels. In majority of our patients, all five pulmonary lobes were involved. Right lower lobe was the most commonly affected in maximum number of patients. The pattern ground-glass opacity (GGO) was found in the majority of patients. Peripheral distribution was reported in a maximum number of patients. Multiple lobe distribution with bilateral involvement was most common in patients. Among other findings reticulations were commonly reported followed by atelectasis [. Altmayer et al (2020)[6] also reported that a predominantly GGO pattern is more common to occur in COVID-19 as compared to a mixed pattern of GGO and consolidation in the non-COVID viral pneumonia. The least common pattern to occur between the two groups is usually the predominant consolidation pattern. Both types of pneumonia involved the lungs bilaterally and heterogeneously. In COVID-19 pneumonia, upper and middle lobes were peripherally involved, whereas in non-COVID pneumonia, the distribution was random or diffuse. Altmayer et al (2020)[6] reported that pleural effusion did not occur significantly in COVID-19, but was seen to occur more commonly in non-COVID viral pneumonia. H1N1 diagnosed patient also exhibited typical features of COVID-19 [6]. It was noted that 98% of COVID-19 patients HRCT chest showed abnormalities and 2% of patients had normal HRCT chest. Among COVID-19 patients a negative RT-PCR result but presence of bilateral pulmonary involvement was found in 80% of patients, 65% had ground-glass opacity (GGO), while mixed GGO with consolidation were observed in 18% of patients. Intralobular septal thickening was found in 27% of patients.

Frequent findings of ground-glass opacity, consolidation, air bronchogram, crazy paving pattern and intralobular septal thickening were found in COVID -19 patients[5].

Awulachew et al (2020)[5] reported that among COVID-19 patients with abnormalities in HRCT chest, 80% had bilateral lung involvement. 20% of patients had single lung involvement, out of which 62% patients were having the right lung affected. Middle lobes were less frequently involved as the lower lobe was more commonly involved. The upper lobe of the left lung was commonly involved. Patterns of pulmonary lesions in COVID-19 showed mixed GGO/consolidations in 18% and GGO in 65% of patients. Consolidation was found in 22% of all cases. Interlobular septal thickening was found in 27% of patients. 12% had crazy paving patterns. 8% of patients showed the air bronchogram sign. Only, 1.6% had pleural effusion and lymphadenopathy was reported in 0.7% of COVID-19 patients. Whereas, 9% had pulmonary nodules[5].

Cao et al (2020)[19] from Wuhan Union hospital China, worked on the prognostic value of HRCT in COVID-19 affected patients and mentioned the predictors of outcome in those patients. Diabetes and chronic pulmonary diseases, hypertension, and cardiovascular diseases were the common coexisting conditions. A study in Razi Hospital in Rasht on COVID-19 pandemic patients included 92 confirmed RT-PCR patients. Among them, there were 47 males and 45 females. The commonest symptoms were cough, fever, and muscle pain. Only six patients had to be intubated and ventilated at some stage. Commonest findings included, bilateral involvement in 95.7%, left lower lobe in 94.56%, peripheral lesion in 87%, mixed in 76.08%, and GGOs in 75% cases. Cardiomegaly was found in two patients, unilateral pleural effusion in three patients and only one patient had bilateral pleural effusion[20]. He X et al (2020) investigated the HRCT chest imaging manifestations of patients with COVID-19 disease. The commonest findings were ground-glass opacities and consolidation. Only 25% had crazy paving pattern, air bronchogram was found in 25%, 16.67% patients had bronchial wall thickening and vascular enlargement was seen in 41.67% of patients. Pleural effusions, lung cavitation, and intrathoracic lymph node enlargement were found invariably. The severity of the lesions was more in the right lung. The lower lobe was damaged more than the upper or middle lobes. There were 75% of patients with negative RT-PCR test but positive HRCT chest findings of COVID-19 pneumonia. They concluded that the HRCT chest is more consistent with the presence of the disease than RT-PCR tests[21].

Liu et al (2020)[14] found a positive correlation between temporal changes in HRCT chest scores and disease severity as well as viral clearance. Accurate severity assessment with HRCT chest of COVID-19 patients could help with management decisions in serious patients [22]. Park et al (2020)[23] observed the clinical features and reported CT scan findings of Wuhan patients and compared these with the previous findings in other areas of China. Chest infection along with fever was the most common clinical findings in all Wuhan patients with COVID 19. Fever and dyspnoea were less common outside of Wuhan [23]. Wei et al (2020)[24] presented the serial CT scans of the chest during the course of the disease. By the end of the treatment, the GGO and peripheral involvement were absorbed, leaving only the fibrotic lesion. Zou et al (2021)[25] studied the outcome and found improvement and sometimes the resolution of fibrosis occurs after 3 months in COVID-19 patients. In another study, however, in most patients, the pulmonary fibrosis was settled in three months[26]. A study of 80 patients was carried out and noted for clinical manifestations. Cough was found in 73% of patients while 76% had fever. Most reported CT abnormalities observed were GGO in 91%, consolidation in 63% and interlobular septal thickening reported in 59% cases. Most patients had more than 12 lobes of the lungs involved. The SARS-CoV-2 caused dyspnea and hypoxemia in or after a week of onset. The sequel of metabolic acidosis, septic shock, ARDS, and coagulopathies followed are difficult to correct[27].

Xiong et al (2020)[28] assessed the HRCT features which were analyzed along with clinical and laboratory findings of 42 patients. The severity and progression of pneumonia in those patients were assessed by initial and subsequent CT scans. 83% of patients showed progression in CT features of the disease between onset and early stages. There was a progression of consolidation, thickening of interstitium, ground glass opacities, fibrotic stranding and air bronchograms. Zhao et al (2020)[12] included 55 patients and SARS-CoV-2 was found in 35 of them while radiographic changes were present in 39. Even three months after discharge, the patients of COVID-19 showed radiological abnormalities, in addition to physiological abnormalities[12]. The pulmonary fibrosis was incidentally higher in patients with severe COVID-19 than moderately affected patients. The two diseases, influenza and COVID-19, shared very similar chest CT findings. COVID-19 shows a common involvement of peripheral lungs in the lower lobes. Influenza, however, showed a central, peripheral or random involvement in all five lobes. Vascular engorgement, sub-pleural lines, and pleural thickening were commonly seen in COVID-19 patients. In contrast, influenza patients showed pneumomediastinum and pneumothorax that were uncommon in COVID-19 cases. Additional studies are recommended to draw differences between influenza and COVID-19 disease[29].

There are a number of considerable issues associated with the use of HRCT chest as a screening investigation. After every scan, the room will have to be cleaned and sanitized. Also, the exposure of CT radiation to normal asymptomatic healthy individuals is unacceptable. The CT scanner can be a source of infection transmission too, hence, authorities like the American College of Radiology (ACR), have urged the need for seeking out proper diagnostic means like viral testing and appropriate treatment for COVID-19, including the quarantine and safety measures. Conditions like viral pneumonia can also show abnormal HRCT chest findings and therefore an abnormal HRCT chest alone cannot be held as diagnostic. Viral pneumonia and COVID-19 have similar findings except for a higher prevalence of peripheral lung involvement in the COVID-19. Caution is advised when radiological testing is carried out for suspected COVID-19 cases[6].

CONCLUSION

The COVID-19 pandemic showed the following common features: fever, dry cough and abnormal HRCT chest, mostly running a benign course but fatal also in a small percentage. Multiple pulmonary lobes usually get involved, especially basal lobes with ground glass opacities. Clinical severity of the disease is reflected in HRCT chest findings
Authors report no conflict of interests. The study was conformed to the institutional ethical standards.

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