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Original Article

High Resolution Ct Features of Coronavirus Disease Pneumonia: Initial and Follow-up Changes

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Abstract

Introduction: In the latter part of December 2019, new pneumonia cases have emerged in China and were reported to the World Health Organization that coined the term coronavirus disease (COVID-19). On March 11, 2020 WHO has declared the novel CORONA virus (COVID-19) outbreak a global pandemic. The first of the few cases was confirmed in our country on January 27, 2020 in Kerala. The diagnosis of COVID-19 requires specific viral genetic material in the specimen collected from nose, pharynx, and respiratory secretions which were detected by reverse transcription-polymerase chain reaction (RT-PCR) method. However, its variable sensitivity threatens its validity. High-resolution computed tomography (HRCT) chest plays an essential role in the evaluation of COVID-19 even sometimes before the clinical symptoms become apparent and also when other diagnostic methods are inconclusive.

Purpose: The aim of our study was to characterize the various HRCT features in the patient with COVID-19 infection retrospectively and to facilitate its early identification and isolation. We also aimed to evaluate the changes in the HRCT pattern on short-term follow-up including changes in the CT severity score, mean attenuation value, and cross section area of involvement of the largest patch.

Materials and Methods: It was a hospital-based retrospective observational study in 31 COVID positive patients (by genomic analysis through RT-PCR) at tertiary care center in Gandhi Medical College, Bhopal and Hamidia Hospital from July to December 2020. Only those patients who had undergone at least one follow-up scan 1 week apart were included in the study. HRCT findings were correlated with the initial and follow-up studies.

Results: Among the confirmed COVID positive 31 cases, most of patients were young adults in the fifth and sixth decade of age group with mean age of 47.5 years. There was a male preponderance (77% male and 33% female). In terms of distribution, our study suggested involvement of the right lung predominantly. In the early stage as per initial HRCT scan single or multiple ground-glass infiltration, consolidation, interstitial thickening could be seen, with ground-glass opacity as the predominant finding. As the disease progressed as per follow-up scan the patches of discrete ground-glass opacities were seen coalescing to form a larger patch, severe cases had more consolidation with air bronchogram and fibrosis. Our study also showed the difference in initial and follow-up CT which was of Δ sum area cm^2 −3.2±12.1 in the cross-sectional area of the largest patch and Δ HU – 69.4±311 in density.

Conclusion: The results of the study confirmed that HRCT chest is an important tool in COVID-19 infection for the diagnosis and its management with follow-up. The pattern of changes in the progression of disease has been documented in various studies and our study describes the same. The role of cross section area of largest patch and density had showed some role along with CT severity scores in the evaluation, progression, and management of the disease, thereby it should be considered while making the radiological assessment of the disease.

Key words: Area, Coronavirus disease, Density, Follow-up, High-resolution computed tomography, Pneumonia

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INTRODUCTION

In the latter part of December 2019, new pneumonia cases have emerged in Wuhan city of China and were reported to the World Health Organization who coined the term coronavirus disease (COVID-19).[1] This novel strain had respiratory symptoms similar to that of MERS and

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SARS-CoV-2.[2] The World Health Organization (WHO) on March 11, 2020 has declared the novel CORONA virus (COVID-19) outbreak a global pandemic.

The first of the few cases was confirmed in our country on January 27, 2020 in Kerala.[3] The diagnosis of COVID-19 requires specific viral genetic material in the specimen collected from nose, pharynx, and respiratory secretions which was detected by reverse transcription-polymerase chain reaction (RT-PCR) method. However, its variable sensitivity threatens its validity.[4]

High-resolution computed tomography (HRCT) chest plays an essential role in the evaluation of COVID-19 even sometimes before the clinical symptoms become apparent also when the other diagnostic methods are inconclusive.[5,6] For every suspect patients, HRCT chest is indispensable for definitive diagnosis and follow-up. There is evidence of prognostic value of HRCT chest which has been documented in the recent studies where a specific score of CT scan could predict the morbidity and mortality of the patients with COVID-19. Various patterns of changes have been mentioned in the previous studies in the HRCT follow-up, ranging from a patch of ground-glass opacity (GGO) to consolidation, crazy paving pattern and fibrosis, its area of involvement, and its mean attenuation value (HU).[7,8]

The purpose of our study was to characterize the various HRCT features in the patient with COVID-19 infection retrospectively and to facilitate its early identification and isolation. We also aimed to evaluate the changes in the HRCT pattern on short-term follow-up including changes in the CT severity score, mean attenuation value, and cross section area of involvement of the largest patch.

MATERIALS AND METHODS

It is a hospital-based retrospective observational study in 31 patients which was done after the approval of the ethical committee; informed consent was waived off as the study involves no potential risk to the patients. Here, we included patients with COVID-19 who had been admitted to the Gandhi Medical College and Hamidia Hospital, Bhopal (Madhya Pradesh) from July to December 2020 and had undergone at least one follow-up scan 1 week apart. The COVID-19 infection was confirmed using RT-PCR test.

The patients with pre-existing lung diseases were excluded from the study such as lung mass or any other infective pathologies or interstitial lung diseases.

The HRCT images were obtained using Hitachi 128 slice CT machine. Patients were scanned in the supine position from the level of the upper thoracic inlet to the inferior level of costophrenic angle with the following parameters: A tube voltage of 120 kVp and automated tube current modulation of 196 mAs, and slice thickness reconstruction of 0.625–1.25 mm. All patients underwent initial CT on an average of 4 days, range 1–11 days after the onset of symptoms the mean interval from the initial to follow-up examination was about 7 days ranging from 5 to 13 days.

All the CT images were reviewed by the radiologists through OSIRIX viewer. HRCT was reviewed at the window width/level of 1000–1500 HU and −500–−650 HU, respectively, for the lung parenchyma.

For each 31 patients, the initial and follow-up CT images were evaluated for the following.

1. GGO, consolidation, inter lobular septal thickening, crazy paving, and fibrous stripes.[9-11]
2. Severity of opacification (CT severity score)
3. Any other manifestations such as pleural effusion.

Segments of bilateral lung were assessed for the involvement and the lesions were graded as 0, 1, and 2 (0-none, 1–<50%, 2–>50%) with a total sum score of 40 for the severity of opacification.[12]

Changes in the score between initial and follow-up scan were calculated to qualify the changes of opacification over time. The largest cross section area and its attenuation (HU value) of the most obvious largest patch of the lungs on the initial CT were delineated and followed up.

RESULTS

In our study of 31 COVID-19 positive patients, the mean age group of the patients was 47.5±13.8 years, with maximum number of patients from the 5th decade with male predominance (24/31, 77.4%) [Table 1].

Initial HRCT Findings

The data of the initial and follow-up HRCT chest imaging findings are listed in the table.

In our study of 31 cases of covid-19, in initial HRCT, right lung was predominantly involved than the left lung (21 and 10 cases, respectively) and the superior segment of right lower lobe (11/31, 35.5%) was the most vulnerable bronchopulmonary segment involved followed by posterior basal segment of right lower lobe (4/31, 12.9%).

The initial HRCT showed single or multiple patches of GGO as a predominant finding (21/31, 67.7%) and in 29% of cases consolidation was the predominant finding, pleural effusion (2/31, 6.5%) was also seen in Table 2.

In the initial HRCT, the CT severity score ranged from 2.5% to 55% of lung involvement with mean 21.61±17.39, the average area of largest lesion in cross section was 8.65±11.7 cm², and the mean density of that lesion was −481±223.6 HU, respectively.

Changes in Follow-up CT

Most of the cases exhibited a progressive process according to HRCT during the study time window. In the follow-up HRCT, most of the single GGO patch progressed to multiple GGO patches, also had more cases of consolidation, crazy paving pattern, inter lobular septal thickening, pleural effusion, and fibrosis.

The CT severity score in follow-up cases ranged from 0% to 72.5% of the lung involvement with the mean score of 25.33±18.93. The difference between initial and followup CT severity score was (Δ *score* 7±24). In follow up scans the average area of largest lesion in the cross section was 6.94±9.84 cm² and the mean density of that lesion was −445.03±256 HU. The CT severity score and density of the largest lesion in the initial CT were less than follow-up ΔHU −69.4±311

However, cross-sectional areas of the largest patch in follow-up CT cases were smaller compared to the initial CT findings (Δ sum area cm² −3.2±12.1) [Table 3].

Table 1: Demographic characteristics

Age (years)	
<40	10 (32.2%)
40–50	4 (12.9%)
51–60	11 (35.4%)
>60	6 (19.3%)
Sex	
Male	24 (77.4%)
Female	7 (22.6%)

Table 2: Comparison of initial and follow-up HRCT findings

Characteristics	Initial HRCT	Follow-up HRCT
Both absent	2	1
Only GGO present	15	12
GGO and consolidation both present	12	15
Only consolidation	2	3
Frequency of lobe involvement		
Right upper lobe	1	1
Right middle lobe	4	4
Right lower lobe	16	16
Left upper lobe	2	2
Left lower lobe	8	8
CT severity score	21.61±17.39	25.33±18.93
Cm² of max lesion in cross section	8.65±11.7	6.94±9.84
Density (HU) of max lesion in cross section	-481±223.6	-445.03±256
GGO	22 (70.9%)	20 (64.5%)
Consolidation	9 (29%)	11 (35.4%)
Fibrosis	1 (3.2%)	5 (16.1%)
Crazy paving	3 (9.6%)	10 (32.2%)
Pleural effusion	1 (3.2%)	4 (12.9%)
CT severity index		
Mild	21	18
Moderate	8	9
Severe	2	3

GGO: Ground-glass opacity, HRCT: High-resolution computed tomography

DISCUSSION

COVID-19 infection is a newly described viral infection leading to the current pandemic, along with the symptoms lab investigations such as RT PCR, rapid diagnostic kit, and imaging investigations emerged to be a valuable tool to diagnose, evaluate, and follow-up the disease. Various patterns on HRCT have been described by multiple studies worldwide.

Our study was aimed to establish the facts and to observe the changes in COVID-19 positive patients over a week span gap by a follow-up scan.

In our study, the cases were seen predominantly in the fifth decade of life with male preponderance which was seen in 77% of the total cases which were similar to other studies.[13-15]

In terms of distribution, our study showed involvement of the right lung predominantly and among the bronchopulmonary segments the superior segment of right lower lobe was the most commonly involved, these findings were similar with the study by Li *et al.*,[13] Long *et al.*,[16] and Vancheri *et al.*[14]

In our study, the pulmonary lesions were most commonly in the subpleural, peribronchovascular area, or diffusely distributed. In the early stage, as per initial CT scan single or multiple ground-glass infiltration, consolidation, interstitial thickening could be seen, with GGO as the predominant lesion.[13-15,17,18]

As the disease progressed as per follow-up scan, the patches of discrete ground-glass opacities were seen coalescing to form a larger patch, severe cases had more consolidation and fibrosis. The diffuse lesion described as white lung was seen in the most severely affected patients; these findings were similar to the studies by Zheng *et al.*,[18] Li *et al.*,[13] and

Table 3: Changes in the follow-up high-resolution computed tomography over a mean of 7 days

Δscore%	7.08±24
Δcm² of max lesion in cross section	−3.25+12.1
ΔHU of max lesion in cross section	69.4+311

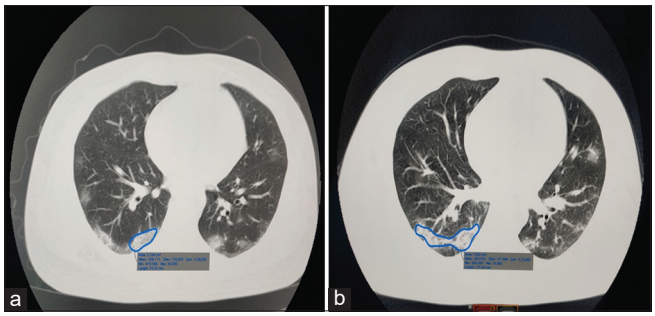

Figure 1: Initial (a) and follow-up (b) high-resolution computed tomography axial images of same patient; showing increase in the cross-sectional area of largest patch of ground-glass opacity and consolidation along with its density (HU)

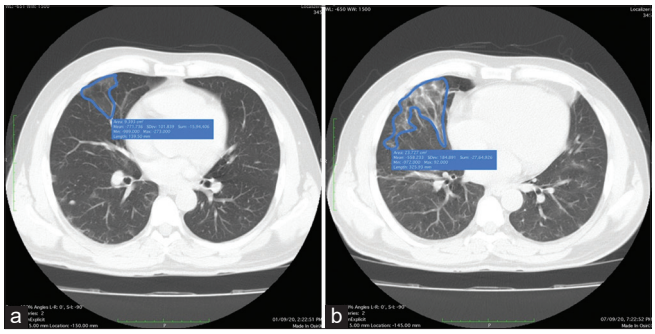

Figure 2: Initial (a) and follow-up (b) high-resolution computed tomography axial images of middle aged male patient; showing progressive change from a patch of ground-glass opacity to consolidation with increase in the cross-sectional area along with its density (HU)

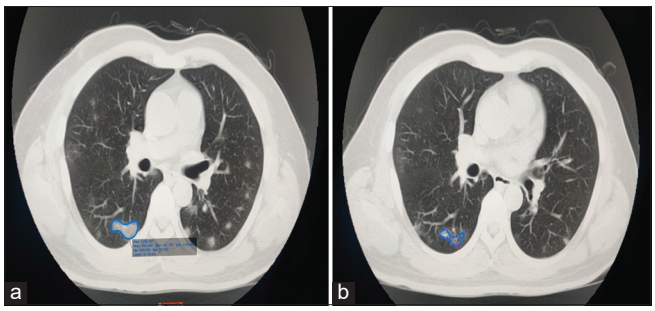

Figure 3: Initial (a) and follow-up (b) high-resolution computed tomography axial images of a male patient; showing resolving changes in the form of decrease in the cross-sectional area and its attenuation (HU), however, the computed tomography severity score in this patient was same

Barbosa *et al.*[15] Fibrous stripes, crazy paving could also be seen in our study in the follow-up scans.

Various previous studies suggested the role of CT severity scores in the treatment protocol, its progression, recovery, and prognosis; our study suggested the same.[19-21]

The sum of opacification (severity score) was positively correlated with days of illness onset to initial CT; in our study, the mean score in the initial scan was 21.61±17.39, while follow-up scan suggested increase in the score of severity by the difference of about Δ *score* 7±24%, which was again consistent with the studies done by Xiong *et al.*[19] and Jiang *et al.*[20]

Along with the CT severity scores, the role of the cross-sectional area of the largest patch and its mean density in the Hounsfield unit has also been described which has been found useful in assessment of the treatment, improvement, progression, and prognosis of the disease.[7,18,22] Our study showed the difference in initial follow-up CT which was of Δ sum area cm^2 −3.2±12.1 in the cross-sectional area of the largest patch and Δ HU −69.4±311 in density. Similar findings were reported by Xiong *et al.*[19] and Jiang *et al.* [Figures 1-3].[20]

CONCLUSION

The results of the study confirmed that HRCT chest is an important tool in COVID-19 infection for the diagnosis, its management, and follow-up. The pattern of changes in the progression of disease has been documented and our study describes the same. The role of the cross section area of largest patch and density had shown some role along with CT severity scores in the evaluation, progression, and management of the disease; it should be considered while making the radiological assessment of the disease.

Our study has some limitations, major being the sample size, in which we included only the hospitalized patients with follow-up sheet examination the possible selection bias, should be noted and further study of a larger cohort is required. Second, the quantitative and semi quantitative methods for measuring the pulmonary lesions may have certain subjectivity. Third, the susceptibility of COVID-19 was considered (initially and incorrectly) to be very low among infants, children, and adolescents, so we did not retrospectively study these groups. Fourth, CT imaging was not possible in severely or critically ill patients. More effort should be made to identify the clinical and imaging features in these groups in future studies.

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