ORIGINAL ARTICLE

Temporal Evolution of Imaging Findings on High-resolution Computed Tomography Chest in COVID-19 Patients: A Tertiary Care Experience

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Abstract

Introduction: Coronavirus disease 2019 (COVID-19), is an infectious illness caused by the coronavirus strain known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). We set out to monitor the evolution of lung changes in individuals who survived COVID-19 infection, investigate prospectively in the Indian population, and determine their predictive factors. None of the studies was conducted on the Indian people for long-term follow-up prospectively.

Materials and methods: We enrolled patients who had been treated for COVID-19 at All India Institute of Medical Sciences (AIIMS), Rishikesh, Uttarakhand, India. At the time of admission and 3-monthly follow-up visits, high-resolution computed tomography (HRCT) chest was done to look at the evolution of lung changes.

Results: At the 3-month follow-up CT, 28 of the 50 participants (56%) (group I) showed fibrotic changes with or without residual consolidation/ground-glass opacity (GGO). In contrast, the remaining 22 people (44%) (group II) did not show fibrotic changes and had either complete radiologic resolution or only residual GGO consolidation.

Conclusion: Common findings noted on admission were predominant consolidation and predominant GGO. Post-COVID-19 lung fibrosis was observed in about half of the survivors. Consolidation in the initial chest CT scan was linked to a higher risk of developing post-COVID-19 lung fibrosis. These fibrotic changes were linked to an older age, male patient, and acute respiratory distress syndrome at admission.

Keywords: Consolidation, Coronavirus disease 2019, Consolidation, Fibrosis, Ground-glass opacity, High-resolution computed tomography chest.

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Introduction

The SARS-CoV-2, the agent of the recent pandemic caused an illness known as COVID-19.[1] A global lockdown has been imposed to stop the infection from spreading due to worries about its high infectivity, morbidity, and mortality.[2] The most common clinical signs were fever, fatigue, dyspnea, and cough, and they share many characteristics with other viral illnesses, particularly Middle East respiratory syndrome, and SARS-CoV-2.[3,4] It looks like viral pneumonia on HRCT chest imaging; lung parenchyma shows symmetrical involvement with GGO with or without concomitant involvement of consolidation, primarily in the posterior and peripheral location.[5] COVID-19 is a novel entity that causes extensive GGO and occasional fibrosis, and we wish to look into how COVID-19 patients' pulmonary changes have changed over time. When the initial reverse transcription polymerase chain reaction (RT-PCR) test is negative, chest CT imaging might be employed as a backup in symptomatic patients.[6] Treatment for COVID-19 pneumonia is determined by the severity of the infection.[7] In the current study, we sought to analyze the prognostic markers of patients who had survived COVID-19 infection and prospectively examine the progression of pulmonary abnormalities in those individuals.

Materials and Methods

Study Design

After receiving ethical clearance from our Institutional Ethics Committee and adhering to the Declaration of Helsinki principle, the Department of Radiodiagnosis and Imaging collaborated with the Departments of General Medicine and Pulmonary Medicine in All India Institute of Medical Sciences (AIIMS), Rishikesh, Uttarakhand, India to conduct this prospective study. Before enrolling, all patients gave their consent.

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Participants

This study's participants had baseline and 3-month follow-up HRCT chest scans. Patients consented to be enrolled in the study. All patients came for follow-up who had tested to be RT-PCR COVID-19 positive at the admission. Symptomatic patients with a positive finding on HRCT chest suggestive of COVID-19 disease with immunoglobulin M (IgM)/IgG serology positive who came for follow-up. Follow-up with COVID-19 patients undergoing HRCT chest was advised by the clinician. Patients who had underlying chronic lung disease (interstitial lung disease, neoplasm, etc.) and patients who were lost to follow-up were excluded from the study.

Computed Tomography Protocol

In the radiology block of the emergency department, a CT machine was set aside for COVID-19 pneumonia suspects. Infection prevention and control procedures were implemented, including patient isolation, and CT facility cleaning. With the patient's thorax centered in the gantry and both arms elevated, the scan extent from the lung apices to the diaphragm was used to acquire images in the craniocaudal direction. Baseline HRCT thorax was done at single source multidetector computed tomography (MDCT) scanner Ingenuity core 64 slices (Philips, Netherlands). A 3-monthly follow-up of HRCT thorax was done at single-source MDCT-scanner ingenuity core 64 slices (Philips, Netherlands) and dual-source Somatom Definition Flash 128 slices (Siemens, Erlanger, Germany). Images were rebuilt with a 1 mm slice thickness in all three planes, and the mediastinal and lung windows were evaluated. Images were reconstructed with a 1 mm slice thickness in all three planes, and the mediastinal and lung windows were assessed.

Parameters	*MDCT-scanner ingenuity core 64 slices (Philips)*	*Dual-source Somatom Definition Flash 128 slices (Siemens)*
Milliampere second	30	40
Kilovolt peak	120	120
Rotation time	0.5 seconds	0.5 seconds
Slice thickness	5 mm	5 mm
Interslice space	5 mm	5 mm
Pitch	1–2	1–2

Image Analysis

All of the reconstructed images were independently evaluated by two radiologists with >5 years of expertise in chest radiological reporting while they were completely blinded. All findings were entered into a premade pro forma. Various imaging findings including consolidation, GGO, traction bronchiectasis, and cystic changes were evaluated. For better detection, localization as well as quantification we used minimum intensity projection.

According to the Fleischner Society's standard lexicon for thoracic imaging, the typical radiological terms were used to describe lung parenchymal involvement in patients with COVID-19 patients.[8] Consolidation appears as a homogeneous increase in pulmonary parenchymal attenuation that obscures the margins of vessels and airway walls. An air bronchogram may be present. GGO on CT scans, appears as hazy increased opacity of the lung, with preservation of bronchial and vascular margins. The reversed halo sign (atoll sign) is a focal rounded area of GGO surrounded by a more or less complete ring of consolidation. Fibrosis included honeycombing, traction bronchiectasis, architectural distortion, parenchymal bands, and reticulations.

In our study, we scored the CT severity score (CTSS) of the patient based on segments of the lung. Bilateral lungs were divided into 20 segments, with each part being assigned a score between 0 (no involvement), 1 (<50% lung involvement), and 2 (>50% lung involvement).[9] In CTSS, the maximum score is 40, and the minimum score is 0.

At the 3-month follow-up CT, we divided into two groups, group I showed fibrotic changes with or without residual consolidation/GGO in patients. In contrast, group II had nonfibrotic changes which may either complete radiologic resolution, or only residual GGO/consolidation.

Results

Patients' Details at Admission

Finally, 50 patients of COVID-19 were enrolled in the trial for additional analysis, of which 12 (24%) were female and 38 (76%) were male. The range of ages was 18–73, with a mean age of 51 ± 14 years. Diabetes was the comorbidity that was most frequently present in the cases (n = 29, 58%). A comparison of demographic and clinical characteristics between groups were shown in Table 1.

Fever (74%), chills (60%), dyspnea (54%), dry cough (62%), myalgia (40%), headache (18%), and sore throat (32%) are among the patients symptoms.

The initial patient's symptoms correlating with HRCT chest findings at admission was listed in Table 2.

Predominant GGO, predominant consolidation, and crazy paving were all visible on the first chest CT scan in 31 patients (about 62%), 19 patients (38%), and 14 patients (28%), respectively. HRCT chest findings at the time of admission (baseline) are enumerated in Table 3.

Table 1: Comparison of demographic and clinical characteristics between groups

Characteristic	*All of the patients (n = 50)*	*First group (n = 28)*	*Second group (n = 22)*
Age (y)	54 ± 14	54 ± 7.5	49.5 ± 11
Sex			
Male	38	22	16
Female	12	6	6
Smoking history	29	25	4
Comorbidity			
Diabetes	29	20	9
Hypertension	13	8	5

Table 2: Initial patients symptoms were correlating with HRCT chest findings at admission

Initial symptoms	*Predominant consolidation (n = 19)*	*Predominant GGO (n = 31)*	*Crazy paving pattern (n = 14)*
Throat pain	4	12	2
Cough	12	18	5
Fever	14	22	7
Fatigue	10	13	3
Myalgia	5	14	6
Chest pain	5	3	3
Shortness of breath	12	15	5

*Many of the patients had a combination of symptoms at the time of admission

Table 3: HRCT chest findings at the time of admission (baseline)

Characteristic findings on HRCT chest	*All of the patients (n = 50)*
Predominant consolidation	19
Predominant GGO	31
Additional findings	
Crazy paving pattern	14
Pneumothorax	4
Pneumomediastinum	2
Pleural effusion	6
Atoll sign	4

**Few of the patients have a combination of the HRCT chest findings at the time of admission

Table 4: HRCT chest findings at 3-monthly follow-up

Characteristic findings on HRCT chest	*All of the patients*
Residual GGO and consolidation	12
Parenchyma bands	14
Interlobular septal thickening	11
Tractional bronchiectasis	8
Reticulation	7
Architectural distortion	5
Honeycombing	4

***Few of the patients have a combination of the HRCT chest findings at the time of 3-monthly follow-up

The 3-month Follow-up Findings

At the 3-month follow-up CT, 28 of the 50 participants (56%) (group I) showed fibrotic changes with or without residual consolidation/GGO. In contrast, the remaining 22 people (44%) (group II) had either complete radiologic resolution or only residual GGO/consolidation. No dropouts or loss to follow-up occurred at the end of the 3rd-month follow-up of the study.

Pulmonary fibrosis was observed in 28 patients (56%) which were manifested as parenchymal bands (in 14 patients, 28%), interlobular septal thickening (in 11 patients, 22%), bronchiectasis (in eight patients, 16%), reticulations (in seven patients, 14%), architectural distortion (in five patients, 10%) and honeycombing (in four patients, 8%). HRCT chest findings at 3-monthly follow-ups were illustrated in Table 4. At admission, patients with shortness of breath are prone to develop fibrosis at the 3rd-month follow-up CT scan. Fibrosis in the lungs is more common in those over 50. In this study, male patients were more likely than female patients to experience lung fibrosis. In this study, patients with concomitant conditions like diabetes were more likely to develop lung fibrosis. Patients with comorbidities like hypertension do not exhibit any associated differences. Additionally, individuals who had consolidation in their initial CT scan were more vulnerable to developing lung fibrosis after COVID-19. Moreover, the CTSS was more significant in those with pulmonary fibrosis. Comparison findings between baseline and 3 months follow-up HRCT chest findings were shown in Table 5A (group I) and 5B (group II).

Discussion

At the follow-up CT, 28 of the 50 participants (56%) (group I) had signs of fibrotic changes with or without residual consolidation/GGO, whereas the remaining 22 people (44%) had an either complete radiologic resolution, only residual GGO/consolidation. Fibrosis in the lungs is more common in those over 50. In this study, male patients were more prone to fibrotic-like changes than female patients. Patient with comorbidity such as diabetes is more prone to lung fibrosis in this study. Additionally, after COVID-19, lung fibrosis was more likely to occur in people who already had consolidation in their baseline CT scan.

According to Wu et al., in 2021, 40/114 (35%) of the patients (group #I) had follow-up CT results that showed evidence of fibrotic-like changes, while the remaining 74/114 (65%) patients (group #II) had either total radiological remission (43/114, 38%) or continued to have GGO or interstitial thickening (31/114, 27%). In our study, patients developed a percentage of fibrotic-like changes higher than Wu et al. study.[10]

Consolidation and ground opacities are the two most typical chest CT findings, according to Hemraj et al. In our study, GGO was the predominant finding followed by consolidation.[11]

According to Nabahati et al., 3-month follow-up study, 90 patients (52%) had pulmonary fibrosis evidence on follow-up CT scans, including parenchymal bands (58 patients, 33.5%), interlobular septal thickening (75 patients, 43.4%), bronchiectasis (11 patients, 6.4%), and honeycombing (four patients, 2.3%). Age, comorbidity, and gender did not differ between the groups with and without fibrosis. In our study, fibrotic-like changes are similar to the study of Nabahati et al.; male patient comorbidity like diabetes shows a significant association.[12]

To minimize mortality and shorten hospital stays, most COVID-19 research has focused on early detection, figuring out the infection's pathophysiology, and treating acute illness. As the number of survivors continues to rise, clinicians are becoming more conscious that many COVID-19 survivors report chronic respiratory problems. The present emphasis is on monitoring COVID-19 survivors and identifying any long-term effects.

Table 5A: Comparison findings between baseline and 3 months follow-up HRCT chest findings (group I)

Initial chest findings	*Total number of patients (n = 50) (baseline)*	*3 months follow-up Group I (n = 28)*					
		Parenchymal bands	*Interlobular septal thickening*	*Tractional bronchiectasis*	*Reticulation*	*Architectural distortion*	*Honeycombing*
Predominant GGO	31	8	6	5	4	3	3
Predominant Consolidation	19	6	5	3	3	2	1

****Few of the patients have a combination of the HRCT chest findings at the time of the 3-monthly follow-up; group I, patients showing features of fibrosis in the form of parenchymal bands, interlobular septal thickening, traction bronchiectasis, reticulation, architectural distortion, and honeycombing

Table 5B: Comparison findings between baseline and 3 months follow-up HRCT chest findings (group II)

Initial chest findings	*Total number of patients (n = 50) (baseline)*	*3 months follow-up Group II (n = 22)*		
		Complete resolution	*Residual consolidation*	*Residual GGO*
Predominant GGO	31	7	3	7
Predominant consolidation	19	1	2	0

Group II, patients not showing features of fibrosis which includes complete resolution, residual GGO, and residual consolidation

The 3-month follow-up CT revealed that the pulmonary fibrosis CT features (interlobular septal thickening, uneven interface, parenchymal bands, and traction bronchiectasis) were still present.

Limitations

Our study has several limitations. The sample size was relatively small to start. Our subsequent research, however, will consider a larger sample size of patients. Second, although the CT indications of pulmonary fibrosis were typical, pathology had not yet proven the condition. We will monitor these people to see if the radiological fibrosis may be absorbed further.

Although the primary factor causing post-COVID-19 pulmonary fibrosis is unknown, some ideas mention aberrant immunological processes and the resulting cytokine storm. Additionally, more research is required to determine why some people experience lung fibrosis while others do not.

Conclusion

The findings revealed that more than half of the survivors had post-COVID-19 lung fibrosis. Significant COVID-19 pneumonia patients also showed an increased incidence of lung fibrosis. Additionally, the initial chest CT scan revealed a higher CTSS and an elevated risk of consolidation-related post-COVID-19 pulmonary fibrosis. In clinical practice, recognizing and minimizing these risk factors and assessing the therapeutic role of antifibrotic medications can help postpone the onset and slow the advancement of lung fibrosis, a significant negative consequence of COVID-19 pneumonia.

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