ORIGINAL RESEARCH PAPER
Volume - 12 | Issue - 05 | May - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

CHEST CT CHARACTERISTICS OF COVID-19 SURVIVORS 6 MONTHS AFTER INFECTION-A PROSPECTIVE OBSERVATIONAL STUDY

Radio-Diagnosis

Dr. Prajwaleet P Gour MBBS, MD Radiodiagnosis, Professor, Department Of Radiodiagnosis, Government Medical College, Nagpur, India.

Dr. Deoyani Sarjare MBBS, MD Radiodiagnosis, Associate Professor, Department Of Radiodiagnosis, Government Medical College, Nagpur, India

Dr. Ashwini H. Lahoti* MBBS, MD Radiodiagnosis (ongoing), Department Of Radiodiagnosis, Government Medical College, Nagpur, India *Corresponding Author

ABSTRACT

Background: Little is known about the long-term lung radiographic changes in patients who have recovered from corona virus disease 2019 (COVID-19). Aim of the present study was to provide the chest CT manifestations in post COVID patients on follow-up at 6-months after initial infection. **Method:** Follow-up chest CT of 160 patients of confirmed COVID-19 infection was done at 6 months after recovery. Patients were divided into fibrotic and non- fibrotic groups depending on fibrosis on follow-up CT. The clinical data and CT findings were recorded and analysed. **Results:** Out of 160 cases, 70 patients had fibrotic changes while 90 did not have fibrotic changes. The predominant CT patterns of abnormalities observed at 6 months after discharge were pleuro-parenchymal bands (40%), reticulation/ interstitial septal thickening (38.12%), and persistent GGO (26.87%). Out of 160, 89 (55.62%) patients achieved complete radiological resolution. CTSS score was severe in 59(36.9%), moderate in 49(30.6%) and mild in 52(32.5%) cases. Compared with the mild and moderate cases, severe cases had longer hospital stay, a higher rate of steroid and mechanical ventilation therapy. The severity scores were found to be significantly higher in RLL followed by LLL, RML, LUL and lowest in RUL, ($p<0.001$). **Conclusion:** The chest CT lesions could be absorbed without any sequelae for most COVID-19 patients predominantly having mild to moderate CTSS score at discharge. The combined clinic-radiological model may be better than the clinical-only model in the prediction of developing pulmonary fibrosis on follow-up.

KEYWORDS

COVID-19; Fibrotic; CT; Pleuro-parenchymal; Radiological; CTSS score; Steroid; Mechanical ventilation

INTRODUCTION

An outbreak of COVID-19 caused by 2019 novel corona virus (SARS-CoV-2) began in Wuhan, Hubei Province, China in December 2019. Being declared by the World Health Organization (WHO) as a pandemic on March 2020, the novel corona virus disease (COVID-19) [1] became a major challenge for health care systems worldwide.

In this scenario, thoracic imaging can be assessed for diagnosis and clinical course monitoring. Although radiographs and ultrasonography have proved their utility, especially in intensive care units (ICU) and campaign hospitals settings, high-resolution computed tomography (HRCT) is the first choice for imaging due to its high sensitivity [2, 3]. However, the low specificity of the computed tomography (CT) [4] explained why radiology societies' recommendations are against the method as an initial approach to diagnosis [5]. Even though reverse transcription polymerase chain reaction (RT-PCR) tests were adopted as the reference standard, dissociation between laboratory and tomographic findings must be expected and CT manifestations remain critical for patient management when first RT-PCR results are negative or unknown [6]. Thin-section chest CT scans have been making significant contribution to the disease assessment. Currently, the radiological characteristics of COVID-19 have been extensively studied. The typical chest CT features of COVID-19 include ground glass opacities (GGO), consolidation, and interlobular septal thickening with peripheral distribution [7, 8].

To date, many patients have recovered and discharged after treatment. It has remained a concern to the public whether any pulmonary sequelae exist for COVID-19 survivors. Recent studies have shown that pulmonary fibrosis may develop in patients with COVID-19 for short term after discharge [9, 10]. However, number of discharged COVID-19 patients keeps increasing worldwide but definite long-term radiological outcomes of the patients after discharge are scarcely described in the literature. The present study aims to provide the chest CT manifestations in post COVID patients on 6-months follow-up.

MATERIALS AND METHODS

After obtaining Institutional Ethical Committee approval and written informed consent from all the patients, this prospective observational study was conducted in the Department of Radio-Diagnosis at a tertiary care centre in Central India during a period of 2 years. A total of 160 survivors of age 18 years or more with RT- PCR positive COVID 19 pneumonia who had undergone HRCT chest during initial or active phase of illness and visited post COVID OPD for follow up at 6 months were included in the study. If the patient had undergone more than one CT scan during the initial illness, then the CT with highest percentage of total lung involvement (highest CT severity score) was considered. Patients with incomplete information about RT-PCR result or co morbidities, patients with history of smoking and interstitial lung disease and pregnant women were excluded from the study.

The main indications for follow-up CT were persistent dyspnea, cough, functional impairment, or persistent significant lung findings on follow-up chest radiograph (CXR) such as reticulation/ interstitial septal thickening, volume loss or radio-opacities. Their clinical data and HRCT findings of initial infection for analysis was derived from HMIS, an electronic medical record system available in our institute. HRCT Thorax using BRILLIANCE ICT 256 SLICE MDCT SCANNER; Philips Healthcare or SOMATOM Definition AS+(Siemens Healthineers) was done.

Images of Chest HRCT of initial illness and at 6 months follow up were collected using the Picture Archiving and Communication Systems (PACS) and compared.

Hrct Thorax Imaging Protocol:

- Non contrast HRCT scans in caudo-cranial direction in supine position at the end of inspiration during a single breath hold was acquired from thoracic inlet to diaphragm. In few patients who unable to hold breath, the scan was completed in two or three stacks.
- Multiplanar reconstruction of HRCT images was done with slice thickness of 1 mm and slice interval of 1 mm in mediastinal window (center, 50 HU; width, 350 HU) and lung window (center, −600 HU; width, 1200 HU).
- We quantified the overall extent of opacified lung and for abnormally opacified lung, the proportional extent of the following radiologic patterns:

a. ground glass opacification or resolving ground glass opacities.
b. consolidation
c. linear or curvilinear band opacities
d. reticulation/ interstitial septal thickening.
e. traction bronchiectasis

The presence of other abnormalities such as pulmonary nodule/ mass, pleural effusion was also noted.

- The following parameters were used: Detection collimation width of 128 x 0.6mm or 256 x 0.6mm and tube voltage 120 kV. The tube current was regulated by an automatic exposures system. From the raw data, CT images were reconstructed with a matrix size of 512 × 512 as axial images (thickness of 1mm and increment of 1mm) with hybrid iterative reconstruction (iDose level 5, Philips Medical Systems, the Netherlands) or a pulmonary B70F kernel and a mediastinal B30f kernel (Siemens Healthineers, Germany).
- All image analysis was performed using institutional digital database system (PACS)
- Patients were divided into fibrotic like and non-fibrotic like changes.
- For each patient with severe pneumonia (CTSS >15), predominant CT patterns according to the Fleischner Society glossary (19) was enumerated as follows: ground- glass opacities (GGO), consolidation, reticulation/ interstitial septal thickening/ interstitial septal thickening, emphysema, thickening of the adjacent pleura, pleural effusion, presence of nodules or masses, honeycombing, traction bronchiectasis, and interlobar pleural traction (retraction of the interlobar pleura toward the lesions).
- The CT evidence of fibrotic-like changes was defined as presence of, reticulations/ interstitial thickening, traction bronchiectasis and parenchymal bands.

To quantify the extent of pulmonary abnormalities (total lesions, GGO, consolidation, reticulation/ interstitial septal thickening/ interstitial septal thickening and fibrotic-like changes), a semi quantitative CT score (15) was assigned on the basis of the area involved in each of the five lung lobes, as follows:

0- no involvement.
1- Less than 5% involvement.
2- 5%–25% involvement.
3- 26%–49% involvement.
4- 50%–75% involvement; and
5- Greater than 75% involvement.

The total CT severity score was calculated by summing the individual lobar scores, with possible scores ranging from 0 to 25. The CT scans obtained during the participants' inpatient stay were not used for analysis in this study.

Statistical Analysis

The data were analysed using SPSS V.24 software. The continuous variables were presented with mean and standard deviation. The categorical variables were presented with frequency and percentage. Independent t test, one way ANOVA and Chi square test were used for comparison. The p value ≤0.05 was considered as statistically significant.

OBSERVATIONS AND RESULTS

Out of 160 patients, 70 had fibrotic changes while 90 did not have fibrotic changes. Compared with patients in the non-fibrotic group, patients in fibrotic group were older in age which was statistically significant, (p<0.001). Male predominance was observed in this study. Overall, 114 (71.3%) patients had dyspnea. The mean grade of dyspnea in patients with fibrosis was significantly greater than mean grade of dyspnea in patients without fibrosis. Out of 160 patients, 66 (41.3%) had pre–existing diabetes mellitus and 56 (35.0%) cases had pre-existing hypertension. Hypertension was significantly more common in fibrotic group as compared to non- fibrotic group with p value = 0.001 (Table 1).

Table 1: Demographic profile of the patients, dyspnea and pre–existing comorbidities

Variables		Fibrotic	Non-fibrotic	P value
Age in years	Mean ±SD	57.47±12.66	47.29±13.53	<0.001
Gender	Male	58 (82.9%)	65 (72.2%)	0.113
	Female	12 (17.1%)	25 (27.8%)	
Dyspnea	Absent	22 (31.4%)	24 (26.7%)	0.509
	Present	48 (68.6%)	66 (73.3%)	
Grade of dyspnea	Mean	2.10±0.89	1.34±0.81	<0.001
Diabetes mellitus	Absent	34 (48.6%)	60 (66.7%)	0.021
	Present	36 (51.4%)	30 (33.3%)	
Hypertension	Absent	34 (48.6%)	70 (77.8%)	<0.001
	Present	36 (51.4%)	20 (22.2%)	

Distribution of CTSS score was severe in 59 (36.9%), moderate in 49 (30.6%) and mild in 52 (32.5%) of cases (Figure 1).

Compared with mild and moderate cases, severe cases had longer hospital stay, a higher rate of steroid and mechanical ventilation therapy (Table 2).

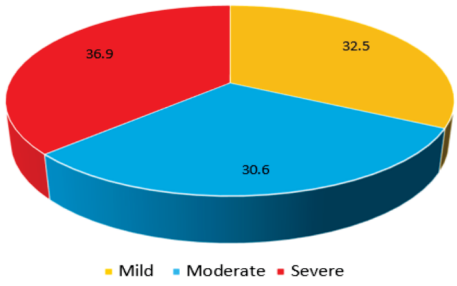

Figure 1: Distribution of severity based on CTSS score

Table 2: Distribution of mechanical ventilation and steroids received by patients and hospital stay >15 days in different severity.

Parameters	Severity			Total
	Mild	Moderate	Severe	
Mechanical ventilation	00 (0.0%)	15 (30.6%)	59 (100.0%)	74 (46.25%)
Steroids	00 (0.0%)	25 (51.0%)	59 (100.0%)	84 (52.5%)
Hospital stay >15 days	00 (0.0%)	37 (75.5%)	55 (93.2%)	92 (57.5%)

Out of 160 cases, 89 (55.62%) patients achieved complete radiological resolution. Maximum patients with mild and moderate CTSS score had complete resolution as compared to patients with severe CTSS score (Figure 2).

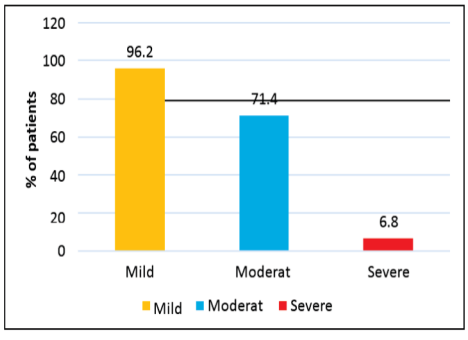

Figure 2: Distribution of complete resolution in different severity

The predominant CT patterns of abnormalities observed at 6 months after discharge were pleuro-parenchymal bands (40%), reticulation/ interstitial septal thickening (38.12%) and persistent GGO (26.87%). In severe cases chest CT findings at 6 months after discharge were predominant followed by in moderate cases and then in mild cases (Table 3).

Table 3: Chest CT findings in covid-19 survivors 6 months after recovery

Parameters	Severity			Total
	Mild	Moderate	Severe	
Persistent GGO	01 (1.9%)	11 (22.4%)	31 (52.5%)	43 (26.87%)
Consolidation	00 (0.0%)	01 (2.0%)	03 (5.1%)	04 (2.5%)
Reticulation/ interstitial septal thickening	01 (1.9%)	10 (20.4%)	50 (84.7%)	61 (38.12%)
Ground glass nodule/mass	00 (0.0%)	01 (2.0%)	03 (5.1%)	04 (2.5%)
Pleural effusion	00 (0.0%)	01 (2.0%)	02 (3.4%)	03 (1.87%)
Emphysema	00 (0.0%)	01 (2.0%)	04 (6.8%)	05 (3.12%)
Pleuro-parenchymal bands	00 (0.0%)	11 (22.4%)	53 (89.8%)	64 (40%)
Traction bronchiectasis	00 (0.0%)	01 (2.0%)	13 (22.0%)	14 (8.75%)

The severity scores were found to be significantly higher in RLL followed by LLL, RML, LUL and lowest in RUL, ($p<0.001$) (Figure 3).

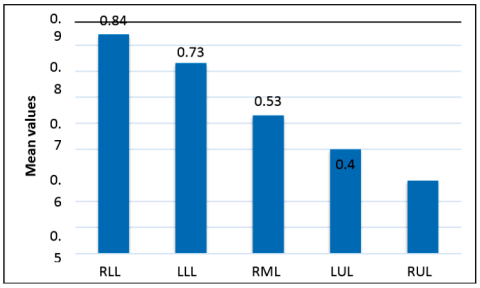

Figure 3: Comparison of severity of scores in different lobes

DISCUSSION

This prospective study of COVID-19 survivors discharged from hospital was performed to better understand the clinical, physiologic and radiologic recovery with time. The study showed that, in addition to symptoms, persistent physiologic and radiologic abnormalities are common at 6-month follow-up. The survivors of COVID-19 show varied clinical course after the initial recovery. Some patients recover fully with no residual symptoms or functional impairment, however, some experience persistent symptoms or functional impairment after initial recovery. The typical chest CT features of COVID-19 include ground glass opacities (GGO), consolidation and interlobular septal thickening with peripheral distribution.

In the present study, out of 160 cases, 70 (43.75%) patients had fibrotic changes while 90 (56.25%) did not have fibrotic changes. Recent data suggest that the prevalence of fibrosis after COVID-19 ranges from 39% to 67% [11-13]. The mean age of patients with fibrosis was 57.47±12.66 years which was significantly higher than the mean age of the patients without fibrosis which was 47.29±13.53 years. Among the 70 fibrotic cases, 58 (82.9%) were males and 12 (17.1%) were females. Among the non-fibrotic cases, 65 (72.2%) were males and 25 (27.8%) were females. Out of 70 fibrotic cases, 48 (68.6%) had dyspnea and among the non- fibrotic cases, 66 (73.3%) had dyspnea. The mean grade of dyspnea in patients with fibrosis was 2.10±0.89 which was significantly higher than the mean grade of dyspnea in patients without fibrosis which was 1.34±0.81. Out of 70 fibrotic cases, 36 (51.4%) had preexisting diabetes mellitus and among the non-fibrotic cases, 30 (33.3%) had preexisting diabetes mellitus. Among the fibrotic cases, 36 (51.4%) had preexisting hypertension and among the non-fibrotic cases, 20 (22.2%) had preexisting hypertension. These findings are in accordance with the study conducted by Liu et al [14]. Also, in the study by Liu et al [14] compared with the patients in the non-fibrosis group, the patients in the fibrosis group were older, with a longer hospital stay, a higher rate of steroid intake and mechanical ventilation therapy and higher quantitative CT parameters (opacity score, volume of opacity) which correlates with the present study.

In the present study, distribution of CTSS score was severe in 59 (36.9%), moderate in 49 (30.6%) and mild in 52 (32.5%) of the cases. 96.2% of the patients with mild CTSS score had complete resolution, 71.4% of the patients with moderate CTSS score had complete resolution and 6.8% of the patients with severe CTSS score had complete resolution. Overall, 55.62% patients achieved complete resolution which correlate with the follow up study by Liu et al [14] and Vijaykumar et al [15].

In the current study, 1.9% of the patients with mild CTSS score had GGO, 22.4% of the patients with moderate CTSS score had GGO and 52.5% of the patients with severe CTSS score had GGO. Among 160 patients, GGO was seen in 26.8% of patients. 2.0% of the patients with moderate CTSS score had consolidation and 5.1% of the patients with severe CTSS score had consolidation. 1.9% of the patients with mild CTSS score (1 out of 52) had reticulation/ interstitial septal thickening, 20.4% of the patients with moderate CTSS score (10 out of 49) had reticulation/ interstitial septal thickening and 84.7% of the patients with severe CTSS score (50 out of 59) had reticulation/ interstitial septal thickening. None of the patients with mild CTSS score had pleuro-parenchymal bands, 22.4% of the patients with moderate CTSS score (11 out of 49) and 89.8% of the patients with severe CTSS score (53 out of 59) had pleuro- parenchymal bands. None of the patients with mild CTSS score had traction bronchiectasis, 2.0% of the patients with moderate CTSS score (1 out of 49) and 22.0% of the patients with severe CTSS score (13 out of 59) had traction bronchiectasis. Out of 160 patients' reticulations/ interstitial septal thickening was seen in 38.1% (61/160), pleuroparenchymal bands in 40% and traction bronchiectasis in 8.75% (14/160) predominantly in patients with moderate to severe COVID-19 pneumonia. These findings are consistent with the study done by Liu et al [14], Vijaykumar et al [15] and Han X et al [16].

The present study had few limitations. The lack of histo-pathologic confirmation of fibrosis is a limitation of our study, making inference based on surrogate CT signs mandatory. We propose to follow up these patients to confirm whether the radiological fibrosis could be further resorbed. This study includes includes a small proportion of patients with critically severe type, which may underestimate the incidence rate of pulmonary fibrosis. In the cohort, difficulty in differentiating between breathlessness and fatigue calls into question the validity and cause of patient-reported breathlessness. This may explain the lack of association between patient-reported breathlessness and observed radiologic findings. The improvement in radiologic features with time accords with data from SARSCoV-1, in which the prevalence of parenchymal abnormalities also decreased with time [17-19]. The view that all bands denote fibrosis is also presumptuous: other pathologic processes, for instance subsegmental atelectasis and organizing pneumonia (incidentally, a frequent pathologic finding in COVID-related acute respiratory distress syndrome) may manifest in this way on CT scans. The reversibility of fibrosis probably indicated that the pulmonary fibrosis on chest CT did not signify actual pathologic fibrosis [17-19] and thus whether these lesions would completely disappear requires further observation.

One of the strengths of our study is that in contrast with earlier studies, we have restricted our CT evaluation to accepted radiologic terms (40). We have also captured the spectrum of disease severities requiring hospital admission, rather than restricting our cohort to participants requiring level 2 or 3 ventilatory support—a subgroup more likely to have significant sequelae and over-represented in the current literature [11-13].

CONCLUSION

In the present study, the most common imaging patterns of COVID-19 pneumonia at 6 months after discharge are reticulations/ interstitial septal thickening and parenchymal bands.

The chest CT lesions could be absorbed without any sequelae for most patients with COVID- 19 predominantly with mild to moderate CTSS score at discharge. The combined clinical- radiological model may be better than the clinical-only model in the prediction of developing pulmonary fibrosis on follow-up.

REFERENCES

1. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19 – 11 March 2020. Geneva: World Health Organization; 2020.
2. Wu G, Li X. Mobile X-rays are highly valuable for critically ill COVID patients. Eur Radiol. 2020;30(9):5217-9.
3. Gargani L, Soliman-Aboumarie H, Volpicelli G, Corradi F, Pastore MC, Cameli M. Why, when, and how to use lung ultrasound during the COVID-19 pandemic: enthusiasm and caution. Eur Heart J Cardiovasc Imaging. 2020;21(9):941-8.
4. Manna S, Wruble J, Maron SZ, Toussie D, Voutsinas N, Finkelstein M, et al. COVID-19: a multimodality review of radiologic techniques, clinical utility, and imaging features. Radiol Cardiothorac Imaging. 2020;2(3):e200210.
5. Xu B, Xing Y, Peng J, Zheng Z, Tang W, Sun Y, et al. Chest CT for detecting COVID-19: a systematic review and meta-analysis of diagnostic accuracy. Eur Radiol. 2020;30(10):5720-7.
6. Long C, Xu H, Shen Q, Zhang X, Fan B, Wang C, et al. Diagnosis of the Coronavirus disease (COVID-19): rRT-PCR or CT? Eur J Radiol. 2020;126:108961.
7. Wu J, Wu X, Zeng W, Guo D, Fang Z, Chen L, et al. Chest CT findings in patients with corona virus disease 2019 and its relationship with clinical features. Invest. Radiol. 2020;55:257–61.
8. Liu M, Zeng W, Wen Y, Zheng Y, Lv F, Xiao K. COVID-19 pneumonia: CT findings of 122 patients and differentiation from influenza pneumonia. Eur. Radiol. 2020;30:5463–9.
9. Fang Y, Zhou J, Ding X, Ling G, Yu S. Pulmonary fibrosis in critical ill patients recovered fromCOVID-19 pneumonia: preliminary experience. Am. J. Emerg. Med. 2020;38:2134–8.
10. Wei J, Yang H, Lei P, Fan B, Qiu Y, Zeng B, et al. Analysis of thin-section CT in patients with corona virus disease (COVID-19) after hospital discharge. J. Xray Sci. Technol. 2020;28:383–9.
11. Guler SA, Ebner L, Aubry-Beigelman C, et al. Pulmonary function and radiological features 4 months after COVID-19: first results from the national prospective observational Swiss COVID-19 lung study. Eur Respir J 2021;57(4):2003690.
12. Van Gassel RJJ, Bels JLM, Raafs A, et al. High Prevalence of Pulmonary Sequelae at 3 Months after Hospital Discharge in Mechanically Ventilated Survivors of COVID-19. Am J Respir Crit Care Med 2021;203(3):371–374.
13. Zhou S, Zhu T, Wang Y, Xia L. Imaging features and evolution on CT in 100 COVID-19 pneumonia patients in Wuhan, China. Eur Radiol 2020;30(10):5446–5454.
14. Liu M, Lv F, Huang Y and Xiao K. Follow-Up Study of the Chest CT Characteristics of

COVID-19 Survivors Seven Months After Recovery. Front. Med. 2021;8:636298.
15. Vijayakumar B, Tonkin J, Devaraj A, Philip KEJ, Orton CM, Desai SR, Shah PL. CT Lung Abnormalities after COVID-19 at 3 Months and 1 Year after Hospital Discharge. Radiology 2022; 303:444–454.
16. Han and Fan et al. Six-month Follow-up Chest CT Findings after Severe COVID-19 Pneumonia. Radiology 2021; 299:E177–E186.
17. Hui DS, Joynt GM, Wong KT, et al. Impact of severe acute respiratory syndrome (SARS) on pulmonary function, functional capacity and quality of life in a cohort of survivors. Thorax 2005;60(5):401–409.
18. Antonio GE, Wong KT, Hui DSC, et al. Thin-section CT in patients with severe acute respiratory syndrome following hospital discharge: preliminary experience. Radiology 2003;228(3):810–815.
19. Ng CK, Chan JW, Kwan TL, et al. Six month radiological and physiological outcomes in severe acute respiratory syndrome (SARS) survivors. Thorax 2004;59(10):889–891.