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Temporal changes of CT findings in patients with Covid- 19 pneumonia: A cross-sectional Study in south India

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Abstract
Background: Currently the diagnosis of COVID-19 is based on RT-PCR which is gold standard. The drawback of this is that it is time consuming and has a very high false negative rate at the early stage of infections. As a supplement, chest CT examination may be an important and effective tool for screening, diagnosing, triage, prognostication and evaluating the disease progression and monitoring the response to therapy in patients with COVID-19 infection. With this background we aimed to describe the changes in chest CT in COVID-19 patients in our setting.
Settings and Design: It is a cross-sectional study carried out in 150 patients who had undergone non-contrast chest CT. Patients with abnormal CT were divided into two groups: clinically stable (in-ward admission) and clinically unstable (ICU admission).
Results: Lung parenchymal abnormalities were present in 48.7% of patients and remaining 51.3% patients had a normal chest CT. Age of the clinically stable group (47.8 ± 9.6) was significantly lower than the unstable group (65.6 ± 5.2). Central-peripheral and antero-posterior lung involvement was significantly more common among unstable group. GGO was the dominant opacity found in all 73 (100%) cases. The crazy paving pattern was more significantly seen in unstable patients than in stable patients (73.3% and 22.4% respectively).
Conclusions: Chest HRCT scan plays an important role in the early diagnosis and disease stratification of COVID-19.

Keywords: Covid-19, chest CT, ground glass opacity, SAR-CoV, crazy paving pattern

Introduction

Large outbreaks of Coronavirus disease 2019 (COVID-19) occurred globally. According to World Health Organisation (WHO), as on June 10, 2021, the world has reported 174,061,995 confirmed cases of COVID-19 including 3,758,560 deaths and India reported 29,183,121 cases with 359,676 deaths [1].

The professional consensus, guidelines, and criteria have been established steadily to facilitate the diagnosis and treatment of COVID-19 pneumonia [2].

To date, the diagnosis of COVID-19 depends on the detection of viral nucleic acid in the respiratory secretions using reverse transcriptase polymerase chain reaction (RT-PCR) which is gold standard. The drawback of this is that RT-PCR is time consuming and has a high false negative rate at the early stage of infections.3 Inspite of all this, COVID-19 infection is confirmed in many countries by RT-PCR on nasopharyngeal and throat swabs, with a positive rate of 30-70% [4, 5].

Chest CT scan was found to be more sensitive than RT-PCR in confirming the diagnosis of COVID-19 reaching 98% [5]. CT features of COVID-19 closely resemble other viral pneumonias and include ground glass opacities, crazy paving pattern, consolidations with peripheral and basal predominance which are well documented [6-8].

Non-contrast chest CT scan may be an effective tool for screening, diagnosing, triage, prognostication and evaluating the disease progression and monitoring the response to therapy in COVID-19 patients [9, 10]. With the continuing global health pandemic, a thorough knowledge of the chest imaging findings of COVID-19 is need of an hour to make accurate and early diagnosis of this deadly virus.

There are only a few studies on COVID-19 describing the temporal changes in chest CT. In this study, we have studied temporal changes on CT scan in patients with COVID-19 pneumonia.

Materials and Methods

Patient selection and study design

It is a cross-sectional study carried out in the department of Radiology at KVG Medical College, Sullia, Dakshina Kannada, Karnataka during March 2021 to June 2021. We included patients with at least one positive RT-PCR result for SARS-CoV-2 was obtained with oropharyngeal or nasopharyngeal swabs and at least one non-contrast chest CT scan done before or after admission. Patients with preexisting lung disease were excluded from the study.

We reviewed chest CT scans of 150 RT-PCR positive patients in our department. Patient demographics and specific clinical information were obtained from case sheets. Patients were divided into two groups based on chest CT reports. This decision was based on the WHO interim guidance for clinical management of patients with COVID-19 [11].

Table 1

Group 1 (clinically stable patients) with mild disease admitted in ward	Group 2 (clinically unstable patients) with severe disease admitted in Intensive Care Unit (ICU)
a. Respiratory rate <30 breaths /min	a. Respiratory rate ≥30 breaths/min, or
b. Oxygen saturation (SPO2) >90% and	b. Oxygen saturation (SPO2) ≤90%,or
c. Absence of signs of respiratory failure, acute respiratory distress syndrome (ARDS), or shock.	c. Respiratory failure needing mechanical ventilation, or
	d. ARDS, or
	e. Shock.

CT protocol

Non-contrast chest CT scans were performed with the patient in the supine position, and at end-inspiration with breath-holding. The image was acquired in 5 mm thickness and reconstructed using reconstruction increment of 0.7 mm into 1 mm thick slices using a sharp kernel (B70s) algorithm. The CT scans obtained before admission for each patient were also used for analysis.

HRCT image interpretation

Two radiologists with more than 5 years of experience evaluated CT images. Imaging was reviewed independently and final decisions reached by consensus. CT images were interpreted in accordance with the terms defined by the Fleischner Society and peer-reviewed literature on viral pneumonia [12, 13]. The CT images were assessed for the presence of ground-glass opacity consolidation, reticular pattern, mixed pattern and honeycomb pattern.

The ground-glass opacity was subcategorized into

a. Pure ground-glass opacity,
b. Ground-glass opacity with smooth interlobular septal thickening,
c. Ground-glass opacity with intralobular lines (crazy-paving pattern), and
d. Irregular lines and interfaces with architectural distortion superimposed on ground-glass opacity.

The distribution of pulmonary changes was furthermore identified as unilateral vs. bilateral and central vs. peripheral distribution. Lobar distribution was reported as upper, middle/lingular, lower, and multi-lobar distribution (two or more lobes). The distribution of abnormalities was also classified as predominantly subpleural, central, or diffuse. Each zone was evaluated for percentage of lung involvement on a scale of 0 to 4, where 0 = 0% involvement, 1= less than 25% involvement, 2 = 25% to less than 50% involvement, 3 = 50% to less than 75% involvement, and 4 = 75% or greater involvement. Overall CT scores were the summation of scores from all six lung zones. The maximum possible score was 24.

Statistical analysis

Statistical analysis was performed using SPSS 22.0. Measurement data were expressed as mean ± standard deviation, and numerical data are described as frequency. Illness day 0 was defined as the day of initial symptom onset. The median values of total CT scores and number of zones involved as a function of time were plotted. The temporal changes of main CT patterns, subtypes of ground-glass opacity, and distribution of lung abnormalities were also analyzed. The Kruskal-Wallis rank sum test was used for the difference in the median values of CT lung quantification in different periods, and the chi-square test was applied to compare the frequency of CT patterns in different periods. $P<0.05$ was considered to indicate a statistically significant difference.

Results

Clinical characteristics and demographics

Among the total 150 patients, 68% (102/150) were males and 32% (48/150) were females with a mean age of 49.03± 10.6 years. 51.3% (77/150) patients had a normal chest CT. The remaining (73/150: 48.7%) had abnormal chest CT and were divided into two groups based on disease severity. 79.5% (58/73) were clinically stable and were admitted in the ward. 20.5% (15/73) were clinically unstable and were admitted to ICU and got intubated.

Age of the clinically stable group (47.8 ± 9.6) was significantly lower than the unstable group (65.6 ± 5.2). There was statistically significant difference in gender between the two groups (*p*-value <0.001). The most common symptoms on admission were fever, chills, cough, sore throat and myalgia. Gastrointestinal symptoms were less common. (Table 2)

Table 2: Summary of Demographic Characteristics and Initial Symptoms of study participants

Variables		Normal CT (n=77)	Clinically stable group (n=58)	Clinically unstable group (n=15)
Age		46.8± 9.3	47.8 ± 9.6	65.6 ± 5.2
Gender	Male	44 (57.1%)	44 (75.9%)	14 (93.3%)
	Female	33 (42.8%)	14 (24.1%)	1 (6.7%)
Initial symptoms	Fever	32 (41.02%)	58 (100%)	9 (60%)
	Cough	11 (14.1%)	47 (81.03%)	11 (73.3%)
	Chest tightness	-	5 (8.6%)	-
	Sore throat	25 (32.05%)	28 (48.3%)	7 (46.7%)
	Chills	13 (17.8%)	15 (25.9%)	3 (20%)
	Diarrhea	5 (6.4%)	3 (5.2%)	0
	Muscle pain	12 (15.4%)	41 (70.7%)	8 (53.3%)
	Abdominal pain	2 (2.6%)	1 (1.7%)	0

Chest CT findings

Lung parenchymal abnormalities on chest CT imaging were observed in 73 patients. Bilateral lung involvement was significantly more common in the unstable group (93.3%: 14/15) than stable group (72.4%: 42/58).

In terms of axial distribution, peripheral lung involvement was seen in both the stable and unstable group of patients with significantly higher involvement of central lung in the clinically unstable group (80%: 12/15) ($p < 0.001$) (Figure 1 and 2).

Similarly, with regards to AP distribution, combined involvement of posterior and anterior lung was seen in a significantly higher number of patients in unstable group (*p*-value = 0.02). A significantly higher percentage of total lung involvement was noted in the clinically unstable group (39.1 ± 13.2) than the stable group (17.1 ± 7.3) (*p*-value = 0.003).

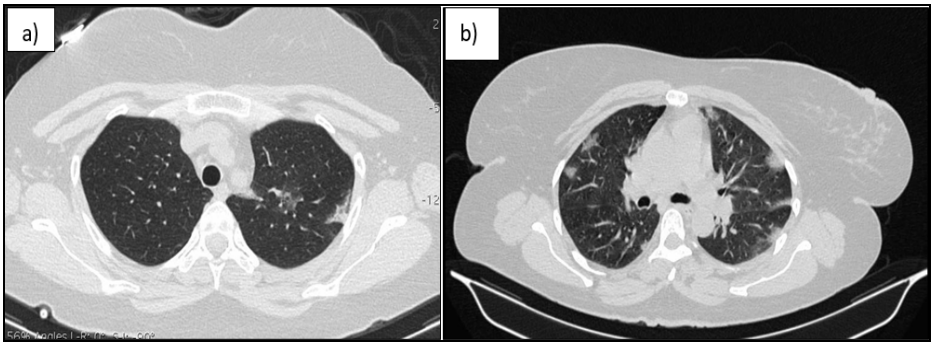

Fig 1: Non-Contrast Axial chest CT image A. in lung window settings of a 49-year-old COVID-19 patient showing multifocal sub- pleural ground glass opacities (GGOs) in both lungs at the time of hospital admission B. in lung window settings of a 36-year-old COVID-19 patient showing a multifocal peripheral GGO at admission

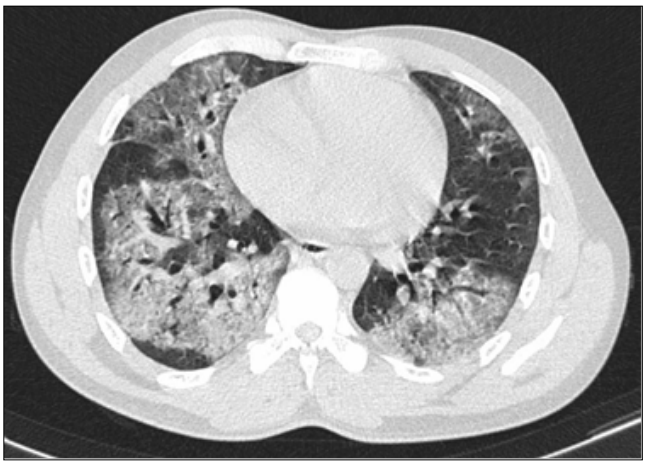

Fig 2: Multiple peripheral subpleural, lobular and peribronchiolar GGO in the back ground of interstitial and interlobular septal thickening

With regards to the type of opacity, GGO was the dominant abnormality found in all 73 (100%) cases (Figure 2).The crazy paving pattern was seen in 73.3% (11/15) of unstable patients and in 22.4% (13/58) of clinically stable group with a statistically significant difference between the two groups (*p*-value < 0.001). Consolidation patches were seen in 46.6% (34/73), significantly more frequent in the clinically unstable group when compared to the stable group (*p*-value=0.03) (Figure 3a). Paralleling the consolidative pattern, air bronchogram was seen in a high percentage of the clinically unstable group (Figure 3a).Perilesional and/or intralesional segmental/subsegmental pulmonary vessel dilatation was seen in significantly higher proportion (93.3%) in clinically unstable patients requiring ICU admission (*p*-value =0.015) (Figure 3b).

Reticulations (22/73: 30.1%), atoll or reverse halo sign (13/73: 17.8%) and subpleural curvilinear lines (13/73: 17.8%) were seen slightly more frequently in the clinically stable group of patients than the unstable group. However, the difference between the two groups was not statistical significant (Figure 4). Bronchial wall thickening, bronchodilatation, nodules, halo sign, pleural effusion and mediastinal lymphadenopathy were seen very infrequently. None of the patients showed pericardial effusion, centrilobular nodules or cavitation (Table 3).

Table 3: Lung parenchymal abnormalities in CT

CT Pattern		Overall (n=73)	Clinically stable group (n=58)	Clinically unstable group (n=15)	p-value
Laterality	Bilateral	56 (76.7%)	42 (72.4%)	14 (93.3%)	0.08
	Unilateral	17 (23.3%)	16 (27.6%)	1 (6.7%)	
Axial Distribution	Peripheral	55 (75.3%)	52 (89.6%)	3 (20%)	<0.001
	Peripheral+ Central	18 (24.7%)	6 (10.4%)	12 (80%)	
AP Distribution	Posterior	43 (58.9%)	38 (65.5%)	5 (33.3%)	0.02
	Antero-posterior	30 (41.1%)	20 (34.5%)	10 (66.7%)	

% of total lung involvement (CT Severity Score) on admission		21.3±8.4	17.1±7.3	39.1±13.2	0.003
Pulmonary parenchymal damage	Pure GGO	73 (100%)	58 (100%)	15 (100%)	-
	Crazy paving pattern	24 (32.8%)	13 (22.4%)	11 (73.3%)	<0.001
	Consolidation	34 (46.6%)	22 (37.9%)	12 (80%)	0.003
	Air Bronchogram Sign	18 (24.6%)	8 (13.8%)	10 (66.7%)	<0.001
	Vessel Enlargement	49 (67.1%)	35 (60.3%)	14 (93.3%)	0.015
	Subpleural curvilinear lines	13 (17.8%)	10 (17.2%)	3 (20%)	0.8
	Reticulations	22 (30.1%)	18 (31.03%)	4 (26.7%)	0.7
	Reverse Halo Sign	13 (17.8%)	12 (20.7%)	1 (6.7%)	0.2

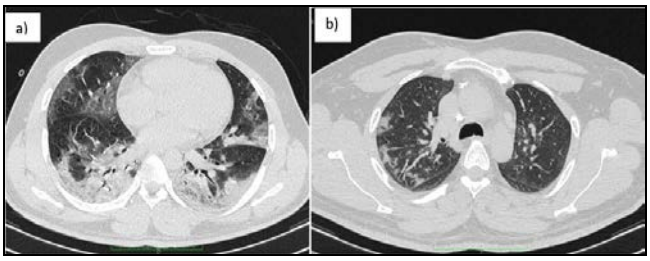

Fig 3: Axial chest CT image A. in lung window settings of a 51-year-old COVID-19 patient at the level of carina obtained at admission reveals consolidation with air bronchogram B. in lung window settings of a 64-year-old COVID-19 patient with pulmonary vessel dilatation

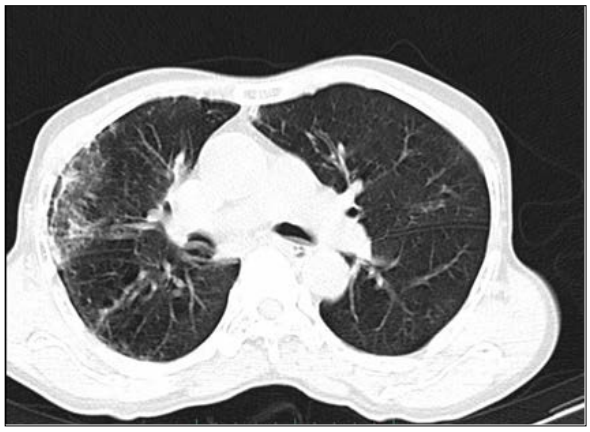

Fig 4: Axial chest CT image in lung window settings of a 61-year-old COVID-19 patient at the level of carina obtained at admission reveals sub pleural fibrotic bands

Discussion

The COVID pandemic has caused public panic and resulted in numerous suspected patients waiting for pathogenic diagnosis of 2019-nCoV infection. Chest imaging plays an irreplaceable role in the diagnostic workflow for the patients suspected with virus pneumonia, especially for patients at the very early stage of the disease, when the virus replicate might not be high enough to be detected by the nucleic acid test [3].

To the best of our knowledge, very few imaging data of Indian patients is available, and none are from south India and the majority of results available have come mostly from China. We found that 51.3% of our COVID-19 positive cases had no lung parenchymal abnormalities at admission as per CT. Among these, 32.5% (25 patients) were symptomatic and asymptomatic were 67.5% (52 patients) at admission. Parry AH *et al*. reported 57.8% with normal CT and 36.9% as symptomatic and 63.1% as asymptomatic in their study done in Jammu and Kashmir [14]. This is lower than as reported by studies from China, Korea and Italy, which was 61 to 100% [15-22]. The majority of COVID-19 cases in our study showed bilateral lung involvement with predominance of GGOs with posterior and peripheral predilection. This result is in concordance to systematic reviews of imaging findings of COVID-19 patients done by Salehi *et al* [22]. Arshed H Parry *et al* [23]. and Vineeta Ojha *et al* [24]. Our results are in agreement with 2 Indian studies by same author Arshed Hussain Parry *et al* [25, 26]. Iraq study by Omar Muayad Sultan *et al* [7]. and many Chinese studies [6, 9, 21, 27-31] We observed segmental or subsegmental intralesional or perilesional pulmonary vessel enlargement in 93.3% of the clinically unstable patients which was significantly different from the clinically stable group. Our findings are in concurrence with Yan Li *et al* [17]. (82.4%), Caruso *et al* [22]. (89%). Reticulations, atoll or reverse halo sign and subpleural curvilinear lines were seen slightly more frequently in clinically stable group of patients than unstable group with no significant statistical difference.

Study Limitations

1. We did not perform follow-up CT examinations to look for temporal change.
2. We did not study the long-term outcome of COVID-19 pneumonia.
3. We did not collect data on comorbidities
4. The small sample size

Conclusion

CT scan play an important role in the early diagnosis and disease stratification of COVID-19. Patchy ground-glass opacities and large consolidation located in the peripheral part of both lungs are the typical CT manifestations.

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