Medical Science

pISSN 2321–7359; eISSN 2321–7367

Spectrum of chest High Resolution Computed Tomographic (HRCT) findings in coronavirus disease-19 (covid-19) patients

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To Cite:
Dhok A, Tripathi D, Dalvi V, Onkar P, Mitra K, Lakhani A. Spectrum of chest High Resolution Computed Tomographic (HRCT) findings in coronavirus disease-19 (covid-19) patients. Medical Science, 2022, 26, ms289e2080.
doi: https://doi.org/10.54905/disssi/v26i125/ms289e2080

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Peer-Review History
Received: 25 January 2022
Reviewed & Revised: 29/January/2022 to 09/July/2022
Accepted: 15 July 2022
Published: 18 July 2022

Peer-review Method
External peer-review was done through double-blind method.

URL: https://www.discoveryjournals.org/medicalscience

ABSTRACT

Background: After its emergence in Wuhan, China COVID-19 (Coronavirus 2019 disease) has spread across the world at the end of 2019. It has become important to study and understand the type and pattern involvement of lung in COVID – 19 to help diagnose and manage this disease. *Aim:* To study and describe the spectrum of High resolution computed Tomography (HRCT) chest findings in coronavirus disease-19 (COVID-19) infected patients at our institute. *Methods:* 111 RT-PCR (reverse transcriptase polymerase chain reaction) positive or Rapid Antigen Test (RAT) positive patients who underwent HRCT chest were included in this observational analysis. The prevalence, distribution, extent, and kind of abnormal lung findings were investigated. *Results:* Out of the 111 study subjects, 76 (67.87 %) male patients and 36 (32.14 %) female patients. Lung parenchymal abnormalities were found in 78.3%. Rest of the RT-PCR or RT positive cases had a normal chest CT. The most common findings in the lung parenchymal abnormalities on CT were major peripheral and posterior distributions of ground-glass opacities. Ground glass opacities (GGO) were noted in 87 (i.e. 100 %) cases. Ground glass opacities were purely observed in 32 % patients. Crazy paving patterns were noted in 20.67 % patients. In 47.1 % patients, GGO with consolidation was also noted. *Conclusion:* Patients who tested positive for RT-PCR or RAT were included in this cohort research had a predominantly bilateral and peripheral distribution of GGOs which were typical findings in 78.3 % of patients whereas normal chest CT was seen in the remaining patients.

Keywords: COVID-19, Computed tomography (CT), CT severity score, Reverse Transcriptase - Polymerase Chain Reaction (RT-PCR)

1. INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak began in Wuhan, Hubei Province, China, and has spread over the world. More than 77,000 cases of

SARS-CoV-2 infection were confirmed in China as of February 2020, with Wuhan accounting for 60% of these (Kong et al., 2020). It is caused by an enclosed single-stranded RNA virus known as SARS coronavirus 2 (SARS-CoV-2). Despite intense global containment and quarantine efforts, the incidence of COVID-19 continued to rise, with 90,870 laboratory-confirmed cases and over 3,000 deaths globally (Sohrabi et al., 2020). COVID-19 symptoms can range from being asymptomatic to being slightly symptomatic to being critically ill (Kong et al., 2020). COVID-19 on imaging looks remarkably like other viral pneumonias (Phan-Nguyen et al., 2022). GGO (ground glass opacities) predominantly in the peripheral and basal areas are the most common CT findings (Parry et al., 2020).

Consolidations are produced from GGOs later on. Peak CT findings are discovered 2 weeks after illness onset. After the second week fibrous stripes, reticulations and also peri-lobular opacities appear. Clinical healing occurs after the slow resorption of pulmonary opacities. In some individuals, complications including acute respiratory distress syndrome or pulmonary embolus are the causes of fatalities in majority (Hansell et al., 2008). To discuss the imaging findings on chest HRCT in patients with COVID-19 infection is the purpose of this article.

2. MATERIALS & METHOD

The patient cohort and the study's design

A prospective observational study was undertaken at our hospital from August 1, 2020 to October 31, 2020, after receiving approval from the institutional ethics committee. The Institutional Ethical Committee (IEC) of the hospital waived off the requirement of informed patient consent. 111 patients who were symptomatic were referred to our institute and who tested positive for RTPCR and RAT were subjected to HRCT chest study.

Selection criteria

Inclusion criteria

Patients who presented with cough, fever, throat discomfort and shortness of breath and were later diagnosed with COVID-19 infection by RT-PCR or RAT.

Exclusion criteria

Asymptomatic patients who tested positive on RT-PCR or RAT

Ct acquisition protocol

HRCT of the thorax performed on a TOSHIBA Activion 16 slice CT machine with the settings as follows: Voltage of the tube was 100–120 kVp, current of the tube was 90–130 mA s, collimation 16 0.6, and pitch 1.5. A single inspiration was used to obtain the CT pictures. Patient was asked breath-holding was during the scan. Images of 1 mm slice thickness 0 were reconstructed. Both lung window and mediastinal window were used for viewing images. 0.1 % sodium hypochlorite was used to decontaminate the CT suite.

Image analysis

Computed tomography images were examined individually by two radiologists with a combined experience of more than 12 years in the field of radiology. The number of lobes involved along with the location of the lesions in one or both lobes, was determined. The classifications of opacities were peripheral i.e. the outside 1/3rd of the lung and the inner 2/3rd of the lung tissue. The Fleischner society's thoracic imaging language was used to classify lung lesions (Hansell et al., 2008). An increase in density of the lung with the retention of bronchial and vascular borders is termed as ground glass opacity. Consolidation occurs when the edges of arteries and airway walls are obscured. Evaluation for the presence of other vascular, mediastinal and pleural abnormalities was also done. The percentage of total involvement of the lung was calculated visually by dividing each lung into three zones and then taking the average of the six zones to calculate the involvement of total lung in percentage (Seyed et al., 2020).

Statistical analysis

The statistical analysis was conducted by using the Statistical Package for the Social Sciences (SPSSInc. Chicago, IL, version 21.0). Data was expressed using continuous variables such as mean, standard deviation, and ranges, whilst categorical variables were expressed as counts and percentages. To determine the agreement between two interpreting radiologists for CT findings, the Kappa approach was applied, according to Landis and Koch. 0 means there is no agreement; 0.010.20 means

there is a modest agreement; 0.210.40 means there is a fair agreement; 0.410.60 means there is a moderate agreement; 0.610.80 means there is a significant agreement; 0.81–1.0 means there is virtually perfect agreement).

3. RESULTS

The whole research group consisted of 111 patients, with 76 (68.4%) men and 35 (31.6%) women, with a average age of 47.4 years (range 23–76 years) and a average age of 47.4 years (range 23–76 years). Table 1 summarizes the gender distribution of patients.

Table 1 shows the gender distribution of study participants.

SEX		
SEX	FREQUENCY	PERCENT
FEMALE	35	31.6
MALE	76	68.4
TOTAL	123	100

A total of 27 (24.3%) of the study participants were between the ages 51-60, followed by 26 (23.4 %) in the age group 21-30 years, 17 (15.3%) belonged to 31-40 as well as 41-50 years, 16 (14.4%) study subjects belonged to 61-70 years age group, 8(7.2%) belonged to 31-40 years and minimum 9 (7.3%) in 71-80 years. The age distribution of study volunteers is shown in Table 2.

Table 2 shows the age distribution of the study participants.

AGE		
Age	FREQUENCY	PERCENT
21-30	26	23.4
31-40	17	15.3
41-50	17	15.3
51-60	27	24.3
61-70	16	14.4
71-80	8	7.2

Fever was the most prevalent symptom, with 55 (49.5%) reporting it, followed by lethargy or malaise with 45 (40.5%), cough with 40 (36%), and sore throat with 30. (27 percent).15 (13.5%) of the patients were having breathlessness, 8 (6.9%) were tachypneic, and 8 (7.2%) experienced desaturation. In 15 (13.5%) of the patients, comorbidities were found. Lympopenia was found in 32 of the patients (28.8%), while lymphocytosis was seen in 11 of the patients (9.9 percent). In 56 (50.4%) of the patients, C-reactive protein was elevated. Table 3 summarizes the patient's demographics, clinical characteristics, and laboratory testing.

Table 3 COVID-19 infected patients' demographics, clinical features, and laboratory data.

DEMOGRAPHIC DATA OF PATIENT	NO OF PATIENTS (n = 111)	Percentage
MEAN AGE	47.4 yrs.	
GENDER		
Male	76.0	68
Female	36.0	32.12
CO-MORBIDITIES		
Hypertension	12	10.8
Diabetes Mellitus	8	7.2
CLINICAL FEATURES		
Fever	55.0	49.5
Cough	40	36

Sore Throat	30	27
Dyspnea	15	13.5
Malaise	45	40.6
Reduced oxygen saturation (<90%)	8	7.2
Increased Respiratory rate (>30/min)	8	7.2
LAB INVESTIGATIONS		
LYMPHOCYTE COUNT		
Increased	11	9.9
Decreased	32	28.8
Increased CRP	56	50.4

87 (78.3%) of the cases had lung parenchymal abnormalities, while 24 (21.6%) of the RT-PCR or RAT positive cases had a normal chest CT. Bilateral lung involvement was the most common among patients with abnormal CT scans. In 83/87 cases, both lungs were affected (95.4 percent). The presence of multiple lobe involvement was more common. All five lobes were involved in 55 (49.5%) of the patients, involvement in single and two lobes were observed in 18 (16.2%) and 14 (12.6%) of the cases, respectively. The most prevalent axial distribution was peripheral distribution, which was observed in all 87 (100%) cases. Only 49 people (56.3%) showed peripheral dispersion, while 38 people (43.6%) were having both peripheral and central distribution. All 87 (100) subjects had an anterior-posterior distribution (table 4).

Table 4 On a chest CT scan

Lung parenchymal abnormalities on CT	No of patients	Percent (%)
Bilateral	83	95.4
Unilateral	28	4.6
Present	87	78.3
Absent	24	21.6
Number of lobes involved		
1 lobe	14	12.6
2 lobes	18	16.2
5 lobes	55	49.5
Axial location of opacity		
Only Central (inner 2/3rd of the lung)	0	0
Only Peripheral (outer 1/3rd of the lung)	49	56.3
Central and Peripheral	38	43.6
Antero-posterior location		
Only Anterior	0	0
Only Posterior	48	55.1
Anterior and posterior	39	44.8

In terms of opacity type, GGO was the most common anomaly, appearing in all 87 (100%) cases. GGO alone was seen in 28 (32.1%) cases, Crazy-paving pattern i.e. Ground glass opacities with intra-lobular lines and interlobular septal thickening in 18 (20.8%) cases, and Ground glass opacities along with consolidation in 41 cases (47.1 percent). There was no complete consolidation in any of the patients. Twenty patients had reticulations (22.9 percent). Bronchial wall thickening was noted in 8 (9.2%) of the patients, while bronchodilation was seen in 3 of the patients (3.4 percent). In 13 there is an atoll or inverted halo symbol (14.9 percent). The many types of lung opacities are shown in Table 5, figure 1, 2 and 3.

Table 5 Lung opacities types and other CT findings

Type of lung opacity	No of patients	Percent (%)
Ground glass opacities	87	100
Pure Consolidation	0	0
Mixed pattern i.e. ground glass opacities with consolidation)	41	47.1
Pure GGO	28	32.1
GGO with crazy paving pattern	18	20.6
Cavitation	0	0
Halo sign	0	0
Nodules	4	4.5
Reticulations	20	22.9
Reverse Halo sign	13	14.9
Bronchial dilatation	5	5.7
Bronchial wall thickening	8	9.2
Air bronchogram sign	25	28.7
Pleural effusion	0	0
Pericardial effusion	0	0
Mediastinal lymphadenopathy	0	0
Findings of existing lung disease		
Sequelae of old healed tuberculosis	8	9
Fibrosis/ Interstitial Lung Disease	3	3.4
Emphysema	3	3.4

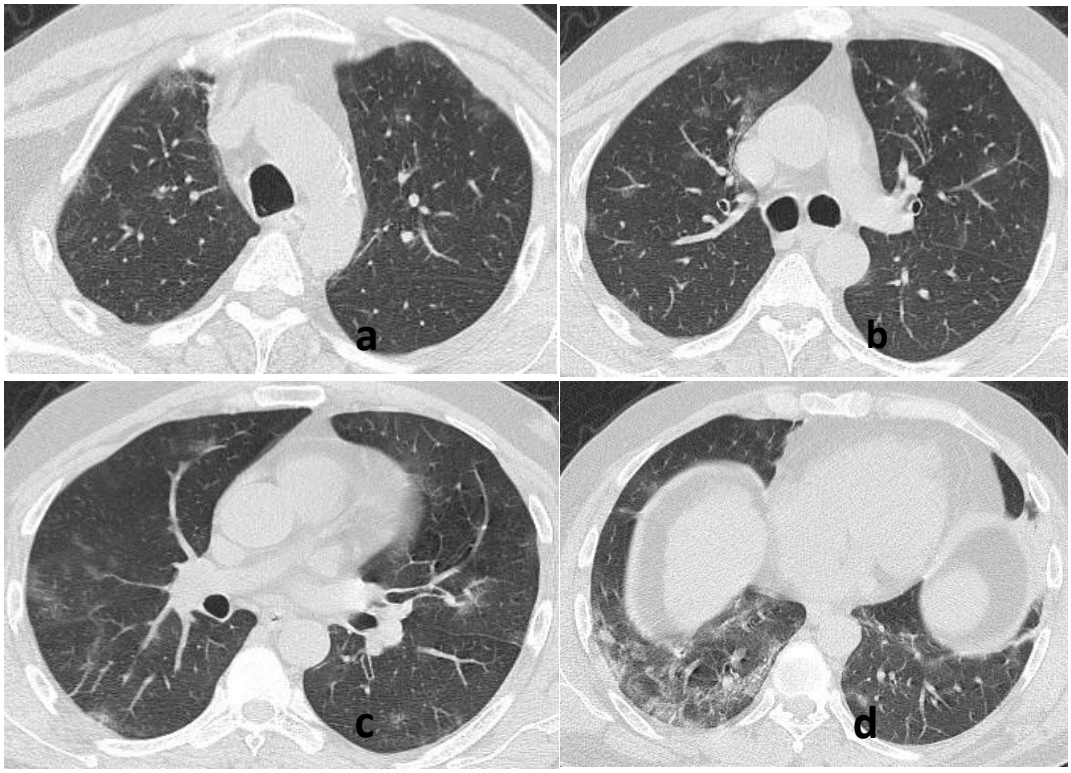

Figure 1 Axial chest CT non contrast images (lung window setting) in male of age 50 yr old who is COVID-19 positive patient. Multiple areas of ground glass opacities (GGO) involving the contralateral lung parenchyma predominantly in peripheral and basal areas are noted in this craniocaudal sequence (7 days following symptom start) (a, b, c, d).

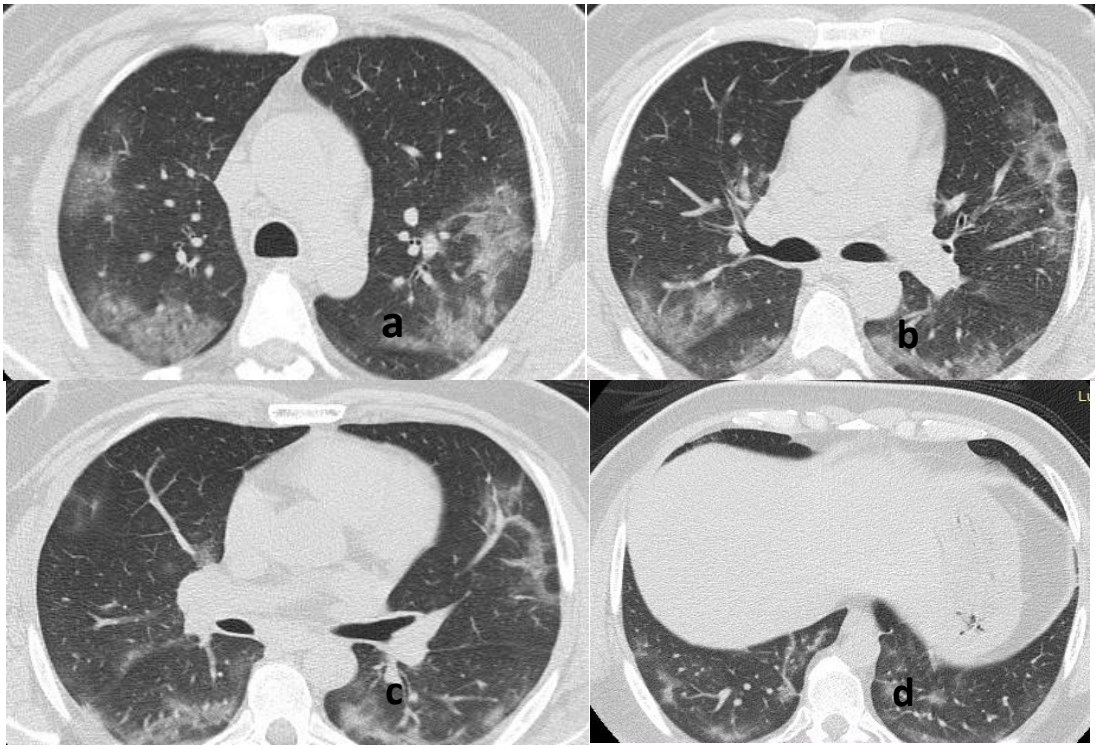

Figure 2 Axial chest CT non contrast images (lung window setting) in male of age 44 yr old who is COVID-19 positive patient. Multiple diffuse areas of ground glass opacities (GGO) with interlobar and interlobular septal thickening (crazy paving pattern) predominantly in peripheral and posterior areas are noted (Images taken 6 days following symptom start) (a- at the carinal region, b- sub carinal region, c-mid basal region and d- basal region)

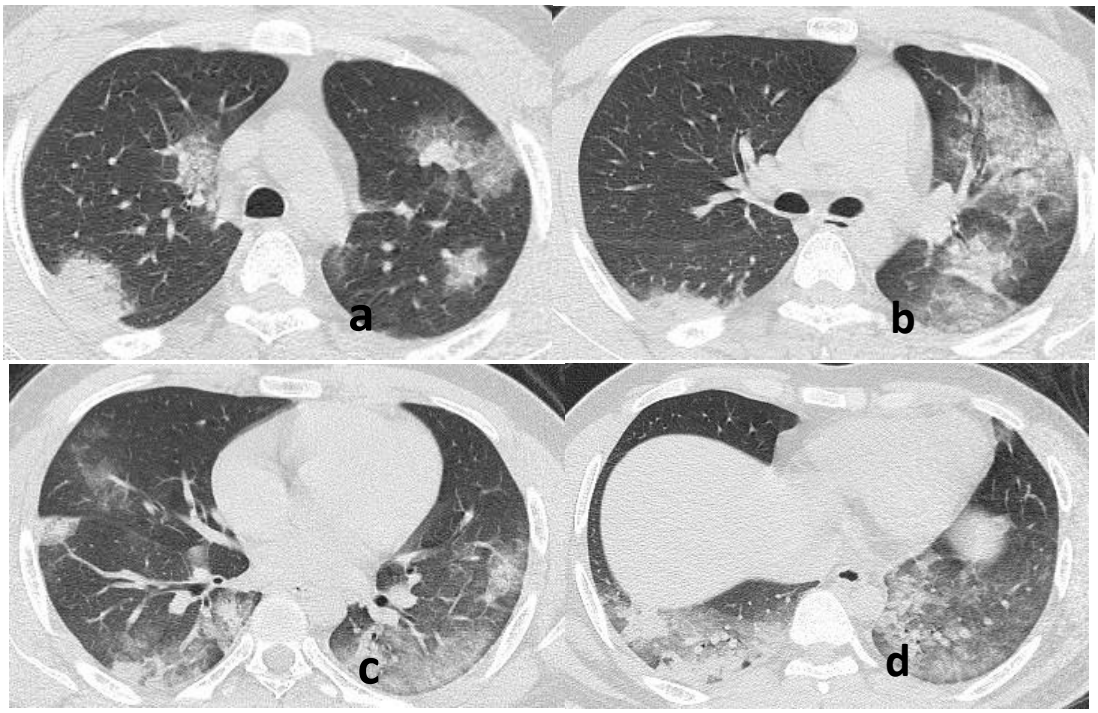

Figure 3 Axial section of non contrast chest HRCT images in lung window setting in a male aged 27-year old who is COVID-19 positive patient shows Multiple diffuse areas of ground glass opacities with interlobular and interlobar septal thickening (crazy-paving pattern) and consolidation involving the bilateral lung parenchyma predominantly in bilateral lower lung zones in subpleural and basal location. (Images taken 8 days following symptom start in craniocaudal sequence (a, b, c, d)

4. DISCUSSION

COVID-19 pneumonia HRCT chest results have been frequently documented. It has been observed that patients who are asymptomatic sometimes show positive chest CT findings. In symptomatic individuals, a negative CT scan was also documented, especially in the early stages of the illness (Parry et al., 2020). At our institute, observational research was done by us for the description of the COVID-19 chest HRCT findings. In 21.6 percent (24/111) of people with SARS-CoV-2 verified by RT-PCR, the HRCT chest study revealed no results(Li &Xia 2020).This study's findings are in line with those from Korea, Europe, and China, which identified abnormalities in the lung parenchyma in 60.9 percent to 100 percent of Reverse transcriptase-PCR positive people (Li & Xia, 2020).

According to Caruso et al., (2020) lung findings were in 96.6 % of symptomatic cases on HRCT. Fever (61 in symptomatic confirmed COVID-19 cases, Li et al., (2020) found a rate of 71.8 per cent HRCT positive cases. In this study, there were 30.8 percent cases of mild disease, 59 percent cases of moderate illness, and 10.2 percent cases of severe-critical illness. On CT, 96.6 percent of symptomatic subjects had lung abnormalities, according to Caruso et al., (2020). The most prevalent symptom was fever in 61%, cough in 56% and breathlessness in (6%) (33%).

In their cohort study, Yu et al., (2020) found a 100% HRCT positive rate, with roughly 2/3rds of the individuals having minor symptoms such as dyspnea (10%) and fever (86 percent). CT results were reported in 888 (88.7%) of the 1014 COVID-19 patients studied by Ai et al., (2020). 3% of RT-PCR positive symptomatic cases had a genetic mutation was also discovered. In comparison to other nations, our population has a low proportion of HRCT findings in symptomatic SARS-CoV-2 patients (laboratory-confirmed), raising the possibility of illness course divergence in distinct populations. This disparity could be due to five variables. First, the low rate of aberrant findings on HRCT scans in our cohort could be explained by the fact that all COVID-19 (RT-PCR positive SARS-CoV-2) patients with symptoms, regardless of severity, had HRCT scans.

The majority of patients who underwent HRCT chest had a mild disease. Second, our study individuals had a low prevalence of comorbidities, and there were no known immune-compromised patients, which may have contributed to the low CT positive rate. Severe COVID-19 disease is reported to be related with comorbid diseases (Zhou et al., 2020). Third, it could be due to our study's comparatively young cohort, with a mean age of 47.4 years. High HRCT positive for COVID-19 has been observed in many investigations with age cohort (50 years) (Yang et al., 2020). As seen by the low CFR in our sample thus far, it could be suggestive of a milder version of the disease in our cohort. The disease's severity is less severe this could be attributed to a less virulent viral strain or the population's strong immune system. Both of these theories, however, are speculative and should be treated with caution unless they are supported by adequate research.

Some individuals with a negative HRCT scan at the start of their illness may have had lung abnormalities later on. We can't rule out this option because we don't have any follow-up imaging. However, the percentage of patients in the negative HRCT group who had worsening respiratory symptoms throughout their hospital stay may indirectly indicate the patient’s proportion who had significant lung alterations during their stay at hospital. Distribution of pulmonary opacities was bilateral and multilobar in patients who showed abnormalities in lung parenchymal on chest HRCT, with a peripheral preponderance. The kind of pulmonary opacities and its distribution observed in COVID-19 pneumonia are similar with our findings.

In all of the cases, the most common lung parenchymal abnormality found was pure ground-glass opacities (GGO), followed by ground-glass opacities (GGO) with crazy paving pattern (20.6 percent), and ground-glass opacities (GGO) admixed with consolidation (32.1 percent) (47.1 percent). Patients with a severe form of the disease had a higher percentage of diseased lungs (32.6 11.3 percent) than those with a moderate form of the disease (10.1 5.3 percent) (Vogel et al., 2020). In accordance to German Radiological Society, HRCT imaging can help with determining the initial level of lung involvement, pneumonia-related consequences, and disease progression in severe patients (Vogel et al., 2020).

There are several limitations to our study. First, we were unable to do follow-up CT scans. This could lead to the exclusion of symptomatic individuals who have only recently developed lung abnormalities. Irrespective of the severity of the illness, a second imaging was conducted in all symptomatic patients. A selection bias may have resulted as a result of this.

5. CONCLUSION

Finally, we discovered that on the HRCT chest study, a large proportion of SARS-CoV-2 positive (laboratory-confirmed) patients (78.3%) exhibited lung involvement. Patients who had positive HRCT findings had the same HRCT features which were reported in other studies i.e. ground glass opacities predominantly in posterior and peripheral in bilateral lung parenchyma with multilobar distribution.

Abbreviations

COVID-19 (Corona Virus Disease), CRP (C - reactive protein), CT (computed tomography), GGO (ground glass opacity), HRCT (high-resolution computed tomography), RT-PCR (reverse transcription polymerase chain reaction), RAT (rapid antigen test), WHO (World Health Organization).

Acknowledgement

We are indebted to the participants for making this research possible and to all the physicians, faculty and junior residents, Dr. Dheeraj Tripathi, Dr. Vrushali Dalvi, Dr. Aisha Lakhani of radiology department and staff of NKP Salve Institute of Medical Sciences and Research Centre, Digdoh hills, Nagpur 440019, Maharashtra, India.

Author's contribution

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Ethical Approval

The study was approved by Medical Ethics Committee of NKP Salve Institute of Medical Sciences and Research Centre with the letter number: (NKPSIMS & RC & LMH/IEC/5/2020).

Funding

This study has not received any external funding.

Conflicts of interest

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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