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(Research Article)

Spectrum of computed tomography manifestations post COVID

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Abstract

Introduction: Chest CT is an important diagnostic, prognostic and follow up technique used for COVID 19 infections. It can detect ground glass opacities (GGO) as early as 5th day following symptoms with maximum CT findings at around 10 days of symptoms. Initially detected as unilateral lesions, it acutely progresses bilaterally. Hence, in this study, we evaluated the CT findings in COVID 19 illness, and correlated the same with severity.

Methodology: It is a hospital based ambispective cross-sectional study conducted among 1544 patients attending the Department of Radio-diagnosis with symptomatic COVID-19 infections. Sociodemographic characteristics were taken, followed by history and HRCT imaging. This was followed by reporting of CT imaging with CO-RADS staging and CT severity scoring.

Results: The most common lesions noted were ground glass opacities (87.7%), consolidation (44.2%), hilar/mediastinal lymphadenopathy (20.1%), reticular opacities (14.3%), septal thickening (9.1%), pleural effusion (4.5%), bronchiectasis (4.5%), emphysematous changes (1.3%), pleural thickening (2, 1.6%) and reticulonodular opacities (0.6%).

Conclusion: Bilateral, multifocal, and peripheral distribution of lesions are common in HRCT of symptomatic COVID cases. GGO is the most common lesion noted.

Keywords: HRCT; COVID 19; Ground glass opacity; Distribution; CT severity score

1. Introduction

Coronavirus disease 2019 (COVID-19) is a global pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-COV-2). It is a highly contagious viral infection whose clinical spectrum can vary from asymptomatic infection to life-threatening severe acute respiratory failure with multi-organ dysfunction (1,2). Meta-analysis and systemic reviews have noted that fever, cough, fatigue, and headache are the most common manifestations; and dyspnoea is noted in less proportion of cases (3-5). However, dyspnoea is one of the few clinical parameters associated with the severity of COVID-19 infections (3). According to the Government of India, the rate of hospitalization in COVID-19 in India ranges from 5-10% (6). However, with India sharing 16% of the global burden of reported COVID-19 cases (7) with the second highest global reporting of cases, the number of hospitalized cases is high. India is also the third leading country in global death despite a low case fatality rate of 1.2%. Hence constant research on the diagnosis and evaluation of COVID-19 is a necessity in reducing this burden.

Nasopharynx and lung are the primary organs infected by the COVID-19 virus. The affinity of COVID- 19 virus to Angiotensin-converting enzyme-2 (ACE 2) receptors, which are found in abundance in alveolar, ciliated, and goblet cells of these structures are attributed to this cause (9). Downregulation of ACE 2 function in turn can lead to pneumonia and

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ARDS. In addition, infection of vascular ACE 2 receptors can lead to epithelial and endothelial damage causing vascular leakage10. Other mechanisms like cytokine storm can increase the severity of the disease (9-11). Microscopically, diffuse alveolar damage in the exudative and proliferative phases of disease is commonly seen. Features corresponding to the fibrotic phase of the disease like pleural involvement and honeycombing appearance are also noted (10). Hence, assessment of the lung is an important area in COVID-19 management, and HRCT is one of the common modalities widely studied for the same.

Chest CT is an important diagnostic, prognostic, and follow-up technique used for COVID-19 infections. It can detect ground glass opacities (GGO) as early as the 5th day following after symptoms with maximum CT findings at around 10 days of symptoms (12). Initially detected as unilateral lesions, it acutely progresses bilaterally. Dilated pulmonary bronchograms and air bronchograms are other common features of HRCT findings noted in COVID-19 infections (12). Based on the CT findings, COVID infections are classified as early, progressive, latent, and peak stage; where the disease progresses from mild ground glass opacity to consolidation and fibrosis (13).

While CT chest is not recommended for asymptomatic COVID-19 suspects or mild, studies have recommended chest CT in RT-PCR negative but clinically suspected COVID cases (14). They are found to be sensitive and moderately specific in the diagnosis of COVID cases (15). In addition, the CT severity scoring system (CTSSS) helps in the triage and prognosis of moderate and severe COVID infections (16). Among them, a 25-point CT severity score and CO-RADS (Covid 19 reporting and data system) correlate well with the clinical and laboratory parameters (17). Moreover, serial CT chest is used in the assessment of the evolution of COVID infection (18). The use of CT is extended for the evaluation of post-acute sequelae of COVID pneumonia (PASC) (19). Persistent interstitial damages are documented months after recovery in HRCT (19-20). Hence the role of HRCT in COVID-19 extends from diagnosis to post-acute sequelae. There is a need to study HRCT changes in COVID-19 infections in different study settings and different geographical areas to understand the patterns better and to provide consensus on the findings and evolution of these.

2. Methods and materials

This was an prospective + restrospective study was conducted in the Department of Radiodiagnosis at AJIMS, Mangalore. Confirmed cases of COVID infections who were sent for CT Lung were enrolled for the study during the period of . December 2020 to February 2022

Patients attending study area for CT Lung for post COVID infection evaluation (prospective), and previous COVID positive patients with HRCT derived from Medical record department

Asymptomatic patients with RT-PCR confirmed SARS-CoV-2 infection were excluded from the study.

Based on study conducted to see the Spectrum of CT findings in corona virus disease 19 (COVID 19) patients in India with assuming P= 34.7 with 95 % confidence interval and 10 % allowable error, sample size estimated is equal to 91.

2.1. Study instruments

Semi-structured questionnaire for socio-demographic characteristics

Non-contrast chest CT using somatom definition (Dual source, 64 x 2 slice).

2.2. Study methodology

After getting permission from Institutional ethical committee and other appropriate authorities, symptomatic post COVID infection cases who satisfied the inclusion and exclusion criteria were approached for the study. After informing the participants about the study using a Patient information sheet, informed consent to participate in the study was taken. For retrospective cases, the case list of patients who had HRCT was derived from the medical records department. Those whose HRCT files were available on the CT console were selected. For prospective cases, Cases were included as study subjects after obtaining detailed informed consent. Non-contrast chest CT was performed using somatom definition (Dual source, 64 x 2 slice).

2.3. HRCT chest protocol

- **Slice thickness:** 0.625-1.25 mm**Scan time:** 0.5-1second **kV:**120
- **mAs:**100-200
- **Collimation:** 1.5-3mm

- **Matrix size:** 768 x 768 or the largest available
- **FOV:** 35cm
- **Reconstruction algorithm:** high spatial frequency
- **Window:** lung window
- **Patient position:** supine (routinely) or prone (if suspected ILD)
- **Level of inspiration:** full inspiration (routinely recommended) expiratory HRCT scans in patients with obstructive lung diseases.

The location of lesions was specified with regards to involvement of one lung (right, left) or both the lungs. The number of lobes involved was determined. Zonal distribution of the opacities was classified as central (defined as the inner two-third of the lung tissue) and peripheral (defined as outer one-third of the lung). The distribution of lung abnormalities was also dichotomized according to bronchopulmonary segments as defined by ACR guidelines.

3. Results

Data was entered using MS-Excel and analysed using IBM-SPSS version 26. Qualitative data was measured by frequency and percentages and quantitative data was measured using measures of central tendency like mean and median and measures of dispersion like standard deviation. Student t test was done to assess association and $p < 0.05$ was taken as statistically significant. Graphical representation of data was done using tables and graphs.

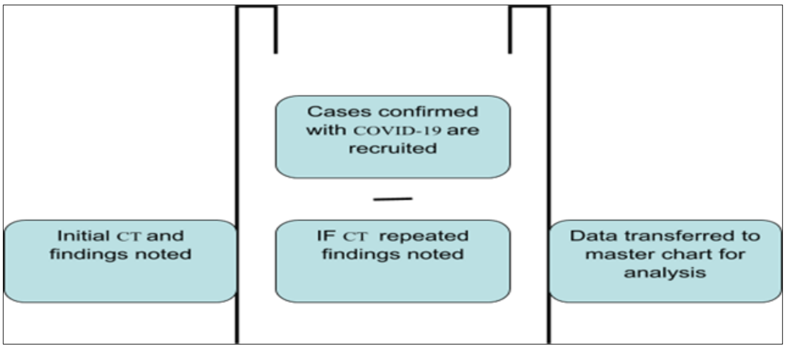

Figure 1 Schema for evaluation

The participants belonged to the age group of 18-91 years with mean age of 55.8±15.3 years.

Majority of the participants belonged to the age group of >60 years (59, 38.3%), followed by 46-60 years (56, 36.4%), 31-45 years (33, 21.4%) and 18-30 years (6, 3.9%).

Table 1 Distribution of cases based on CT severity index

CT severity score	Frequency	Percentage
0 - 5	31	20.1
6 - 10	49	31.8
11 -15	42	27.3
16 - 20	23	14.9
21 - 25	9	5.8
Total	154	100

Out of the 154 cases, 97 cases (63%) were males and the rest 57 (37%) were females.The most common presenting complaints among cases on admission were fever (122, 79.2%), cough (99, 64.3%), myalgia (92, 59.7%), breathlessness (86, 55.8%), gastro-intestinal symptoms(63, 40.9%), generalized weakness (59, 38.3%), loss of smell (32, 20.7%), loss of taste (22,14.3%) and others (17, 11%). Majority of the cases had multifocal lesion on HRCT lung (145, 94.2%) and the rest hadunifocal lung lesion (9, 5.8%). Majority of the cases (120, 77.9%) had peripheral lung involvement and the rest (34, 22.1%) hadcentral lesions in the lung.

The CT severity score of participants ranged from 0 - 25. The mean CT severity index score was10.5±6.1. Majority of the cases had CT severity score of 6 – 10 (49, 31.8%) followed by 11 – 15 (42, 27.3%), 0 – 5 (31, 20.1%), 16 – 20 (23, 14.9%) and more than 20 (9, 5.8%).64.3% (99) participants had CORAD stage of 6. This was followed by 29.2% (45) with CORAD 5. Among the rest; patients were classified under CORAD 1(7, 4.5%), CORAD 4 (2, 1.3%) andCORAD 3 (1, 0.6%) based on HRCT findings.

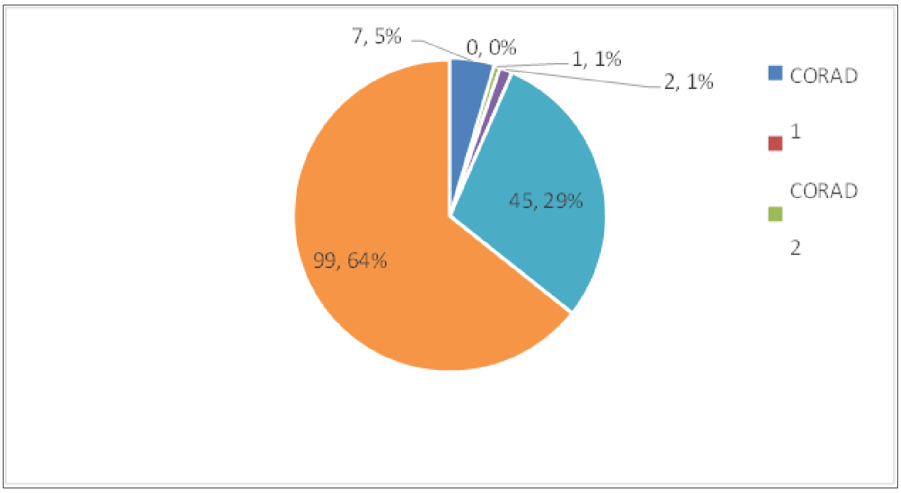

Figure 2 Distribution of CORADS score

Table 2 Distribution of cases based on spectrum of CT findings

Characteristics	Frequency	Percentage
Ground glass opacities	135	87.7
Consolidation	68	44.2
Hilar and mediastinal lymphadenopathy	31	20.1
Reticular opacities	22	14.3
Septal thickening	14	9.1
Pleural effusion	7	4.5
Bronchiectasis	7	4.5
Emphysematous changes	2	1.3
Nodular opacities	2	1.3
Pleural thickening	2	1.3
Reticulonodular opacities	1	0.6

Ground glass opacities (135, 87.7%) was the most common HRCT changes noted in the current study. Consolidation (44.2%), hilar and mediastinal lymphadenopathy (20.1%), reticular opacities (14.3%), septal thickening (9.1%), pleural effusion (4.5%), bronchiectasis (4.5%), emphysematous changes (2, 1.3%), nodular opacities (2, 1.3%), pleural thickening (2, 1.6%) and reticulonodular opacities (1, 0.6%) were the other HRCT lung changes noted.

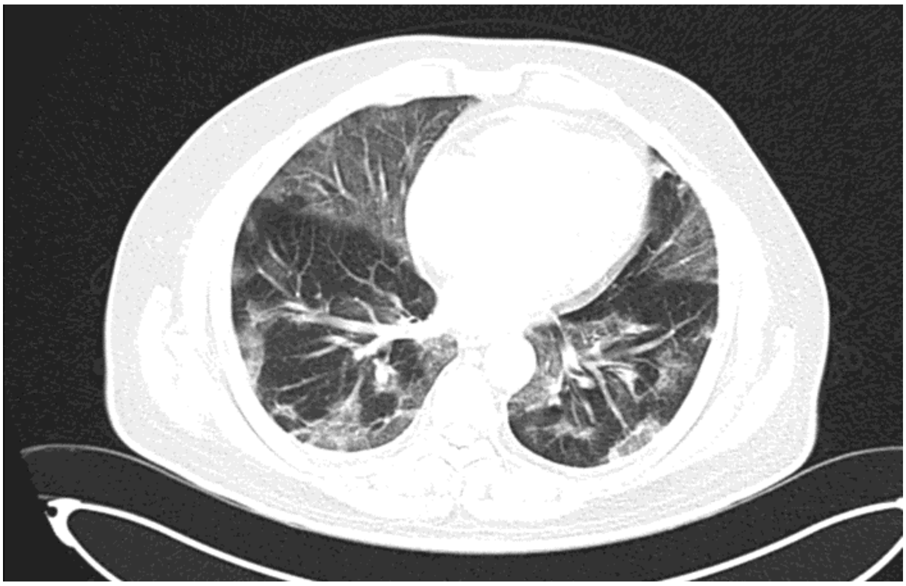

Figure 3 COVID patients HRCT image showing multifocal ground glass opacity with patchy consolidation in bilateral lung fields predominantly in subpleural and basal distribution

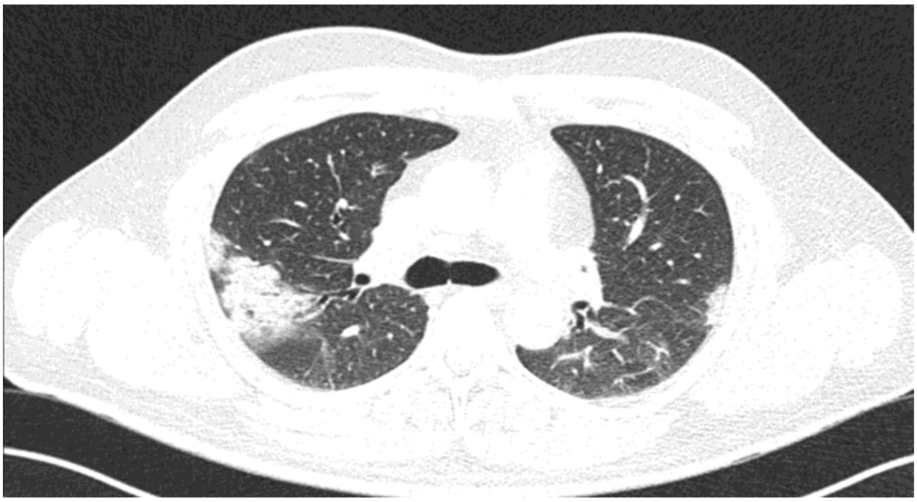

Figure 4 44 year old male with diffuse ground glass opacities and patchy consolidation inposterior segment of right upper lobe

4. Discussion

COVID 19 disease is a pandemic of public health importance with catastrophic effect on world demographics with more than 6 million deaths[1]. The role and need of technology in such conditions were widely understood and appreciated across the globe[55]. High resolution computerized tomography (HRCT) is one such technology studied across the world for diagnosis, evaluation and for prognostic importance[56-57]. To provide uniformity and standardisation of results across the world, scoring systems have also been developed. The current study was made to further the evidence-based knowledge on CT spectrum in COVID patients.

The study included 154 symptomatic COVID patients with age ranging from 18 – 91 years and mean age of 55.8±15.3 years. In a meta-analysis and systemic review on 118 studies across 19 countries by Thakur B et al[14], the mean age of COVID cases was noted to be 56.2 years (95%CI: 52.6 – 59.8 years)[14]. Hence the study participants represented the global age distribution of COVID cases. In addition, in our study, 63% of cases were male and the rest were females. Previous systemic review and meta-analysis by Fabião J et al[15] noted that men are at higher risk of the disease and are at higher risk of mortality. Bwire GM[16] noted that lifestyle and gender behaviour was the main reason for the difference.

In our study, the main presenting complaints of the participants were fever (79.2%), cough (64.3%), myalgia (59.7%), breathlessness (55.8%),gastro-intestinal symptoms (40.9%), generalised weakness (38.3%), loss of smell (20.7%), loss of taste (14.3%) and others (11%). Similar presenting complaints were noted in previous studies[17-19].

The main objective of the study was to CT manifestations in symptomatic COVID infections. In the current study, majority of the cases had bilateral (98.2%), multifocal (94.1%) and peripheral (77.9%) lesions. In a systemic review of 4410 patients by Ojha V et al[20], bilateral, peripheral/subpleural, and posterior with predilection for lower lobes were the most common CT findings in COVID cases. Similarly, in another systemic review by Salehi S et al[21]; bilateral, peripheral or posterior distribution with lower lobe involvement were the most common findings.Similarly, bilateral and multi-lobar involvement was the most common distribution noted in a systemic review by Zhu J et al[66]. Finally, in another meta-analysis by Yang H et al[22]; bilateral (83%), multi-focal (57%) and peripheral (74%) distribution was most commonly noted. This peripheral and lower lobe predilection may be due to the ability of the virus to reach the terminal bronchioles and alveoli[23]. It should also be noted that Altmayer D et al[24], in their systemic reviewand meta-analysis comparing radiological images in COVID and non-COVID viral pneumonia, peripheral distribution was one of the very few differentiating features between the same. Abundance of ACE 2 receptors in alveolar epithelial cells and capillary endothelial cells may contribute for the same[25].

In our study, the most common signs noted were ground glass opacities (87.7%), consolidation (44.2%), hilar and mediastinal lymphadenopathy (20.1%), reticular opacities (14.3%), septal thickening (9.1%), pleural effusion (4.5%), bronchiectasis (4.5%), emphysematous changes (2,

1.3%), nodular opacities (2, 1.3%), pleural thickening (2, 1.6%) and reticulonodular opacities (1, 0.6%). Even though GGO are not specific for COVID infections and can be noted in other viral pneumonia, it was one of the most common manifestations on CT images in COVID cases[26]. It presents as hazy increase in lung density but without obscuration of the underlying vessels or bronchial walls and are caused by filling of alveolar space with fluids, or by thickening of alveolar walls[27]. Even though GGO remains a diagnostic challenge, it is recommended to be assessed along with clinical findings[28]. Similar results were noted by Wu J et al where GGO (91%), consolidation (63%) and interlobular septal thickening (59%) were the most common symptoms. In a systemic review and meta-analysis by Wan S et al[30], GGO (69%), consolidation (47%), air bronchogram sign (46%) and crazy-paving pattern (15%) were the most common signs. In a similar study by Yang H et al[23]; GGO (79%), consolidation (34%), mixed GGO and consolidation (46%), air bronchogram sign (41%), crazy paving pattern (32%), interlobular septal thickening (55%) and vascular enlargement (74%) were commonly seen[24]. In a meta- analysis by Zhu J et al[23]; GGO (68.1%), air bronchogram (44.7%) and crazy-paving pattern (35.6%) were the most common signs[23].

The different proportion of signs may be due to various stages of presentation and various severity of disease. RSNA[13] has classified findings on CT images based on different stages of disease. In early stage (0-5 days), there mayn't be any signs or mild GGO may be seen. In the progressive stage, GGO and crazy-paving appearance may be noted. In the peak stage (9-13 days), progressive consolidation may be noted. Consolidation is differentiated from GGO by obscuration of vessels and bronchial walls by the lesion. In the late stage, signs of fibrosis may be seen[13]. Hence there is a need to study CT images at different stages of the disease. However, care should be taken regarding the radiation dose of CT. With advent of low dose CT, this limitation can however be reduced. In addition, rapid-scan, low-dose and single-phase images can further reduce this limitation[31]. Furthermore, good inter-observer reliability and predicting values for CTSS and other scores are promising results in providing uniformity in assessment of COVID using CT images[32]. Hence, overall, the CT images are promising as a diagnostic, prognostic imaging technique in evaluating COVID cases and is recommended for the same.

5. Conclusion

CT imaging in COVID patients commonly show bilateral, multifocal and peripheral lesions. Ground glass opacities is the most common lesion noted in COVID patients. Other common lesions noted are consolidation, hilar/mediastinal lymphadenopathy, reticular opacities and septalthickening.

Recommendations

Based on the current study, we would recommend the use of HRCT as an imaging technique in the evaluation of symptomatic COVID patients. We would further recommend the use of ground glass opacities as a specific change in COVID infection. Further RCT with different clinical severity of disease, and at different stages of disease is recommended to further enhance the evidence-based knowledge on temporal CT image changes in COVID infection.

Studies on radiation dose need to be done to assess the use of CT images for follow up evaluation and study of post covid sequalae.

Limitation

One of the major limitations with the use of HRCT is the radiation dose associated with this imaging technique. However, with advancement of technology and presence of low dose techniques, this limitation can be reduced. However, for follow up of patient and assessment of post COVID sequalae, this needs to be studied. As the current study was a time bound study, the patients were not followed up to study the temporal changes. In addition, there was no comparison group in the study. Moreover, pre-COVID lung changes weren't assessed. Hence whether changes like emphysematous changes and cavitations were due to present COVID infection couldn't be assessed.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study

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