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Role of High-Resolution Chest CT in the Evaluation and Prognosis of COVID-19 Patients: A Retrospective Study

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Abstract: ***Background: A wide variety of computed tomography (CT) findings in COVID-19 have been reported in different studies, and the CT findings differ according to the stage of the disease and disease severity and associated co-morbidities. The study aimed to determine the role of HRCT chest in the evaluation of COVID 19 patients. Methods: This is a retrospective study done at K. J. Somaiya Medical College & Hospital, Sion, Mumbai. The Present Study was on 160 hospitalized patients who underwent HRCT CHEST with symptoms of COVID 19. Results: Most of the patients in the fifth and sixth decade of age group with a mean age of 58.36±15.36 years. There was a male preponderance (68.13% male and 31.88% female). Out of 160 patients, 145 patients (90.6%) were symptomatic, while 15 patients (9.4%) were asymptomatic. 53.8% of patients had some or the other underlying comorbid disease in the sample population. HRCT chest of the study population showed the variety of opacity characteristics. Out of 160 patients, 61 (38.13) patients had pure Ground glass opacities (GGO) while another 82 (51.25) patients had both mixed GGO. In early phase of the CT scan, 66.67% patients had GGO while in the intermediate phase high percentage of (56.1%) of the patients had mixed GGO & consolidation. The lobe involvement was measured using the Ct severity scoring system. In this study majority (59.38%) of the patients had a CT severity score between 1-7 indicating mild disease, 35.63% patients had CT score 8-15 indicating moderate disease while only 5.00% had CT severity score 16-20 indicating severe disease. Conclusion: HRCT chest in COVID-19 patients had significant diagnostic and prognostic importance as positive CT findings more prominent in symptomatic patients and comorbid patients. CT imaging was found to be useful in predicting a patient's clinical recovery or disease progression.***

Keywords: HRCT chest, COVID-19, CT severity score, RT PCR

1. Introduction

Late in December 2019, an outbreak of pneumonia with no known origin was reported in Wuhan City, Hubei Province, China. The WHO announced the outbreak of a worldwide health emergency on January 30, 2020 (1). On February 11, 2020, the pneumonia brought on by SARS-CoV-2 was formally referred to as coronavirus illness 2019 (COVID-19) (2). The most typical clinical presentation of COVID-19 is an acute febrile respiratory infection with a dry cough, dyspnea, fatigue, and myalgia. Mild fever, mild cough, malaise, body aches, arthralgia, myalgia, and sudden loss of taste or smell are examples of minor symptoms. (3, 4). The current preferred method for diagnosis of COVID-19 is the clinical symptoms and a positive nasopharyngeal and/or oropharyngeal Real-Time Reverse Transcription Polymerase Chain Reaction (RT-PCR) assay (5). Since the COVID-19 largely affects the respiratory system, chest imaging is highly advised in suspected instances for both initial examination and follow-up (6). A chest X-ray is of little value for early diagnosis, but a computed tomography (CT) scan can provide early findings before symptoms appear. It may be helpful in moderate-to-advanced COVID-19 with features of acute respiratory distress syndrome (ARDS) (7, 8). The sensitivity of the RT-PCR assay is approximated to around 60-71% (9). High Resolution Computed Tomography (HRCT), a promising technique advocated by the diagnosis and treatment program (7th trial edition) of the National Health Commission of the People's Republic of China (10). Ground Glass Opacities (GGOs) and patchy consolidations are the major CT manifestations of COVID-19, and they have been recognized as markers of the early and advanced stages of the disease, (11) is crucial to the diagnosis and prognosis monitoring of COVID-19 patients. The purpose of our Study was to assess the role of HRCT Chest in evaluation of COVID-19 patients.

2. Methods

The present Study is a retrospective analysis done on 160 COVID-19 patients admitted at Our institute from July 2020 to September 2020. We retrospectively collected the clinical and chest imaging data. The Study included demographic data, clinical manifestation, co-morbidities of patients, CT chest characteristics, CT severity score. The CT images were evaluated for the presence of ground glass haziness (seen as increased attenuation with visible broncho-vascular markings), "crazy-paving" (Ground Glass Opacities with interlobular thickening), consolidation (increased attenuation of air space opacification). The distribution of lesions centrally and peripherally, and anteriorly and posteriorly was also

noted. The 3 lung lobes on the right and 2 lobes on the left were individually assessed and lobe's percentage involvement was noted based on visual assessment. A CT Severity Score was assigned out of based on the percentage area involved in each of the 5 lobes.

3. Results

Serial data from COVID-19 positive patients were collected, evaluated, interpreted, and correlated with each other to know the severity of disease by their clinical and radiological imaging in order to determine prognostic and diagnostic importance of HRCT chest. A total of 160 laboratory-confirmed COVID-19 patients by RT-PCR were assessed. In the study group, female patients (31.88%) were lesser than males (68.13%). The mean age was 58.36±15.36 years. Percentage distribution of patients according to age group was ranging from 18 yrs. to >80 yrs. (figure 1).

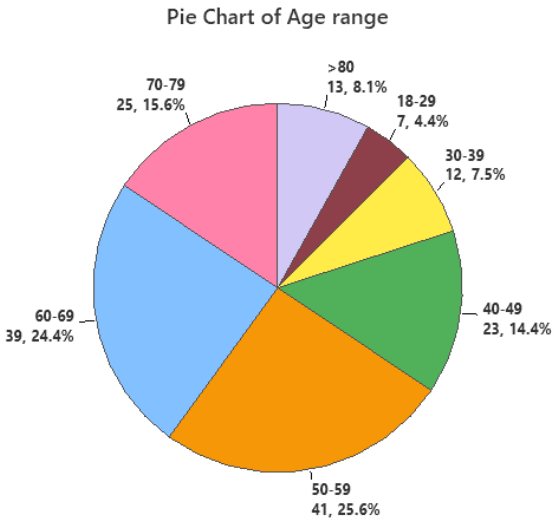


Figure 1: Age distribution of total cohort

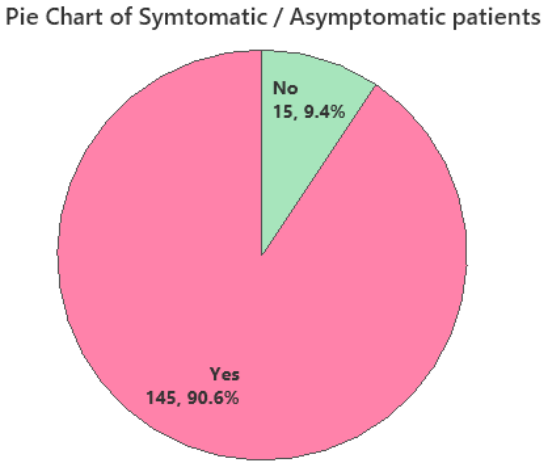


Figure 2: Clinical presentation of total cohort

Out of the total analyzed patients, 145 patients (90.6%) were symptomatic, while 15 patients (9.4%) were asymptomatic in our study population. (Figure 2). In symptomatic patients, fever (87.35%), cough (82.7%), shortness of breath (36.78%), and sore throat (20.69%) were the most common presenting clinical manifestations, while a few patients 91 (56.88) also had other symptoms like body aches, diarrhea, abdominal pain, headache, chest pain, pain abdomen, loss of appetite, etc.

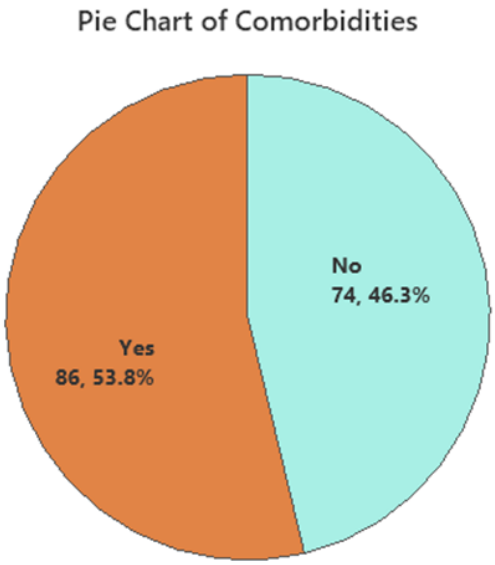


Figure 3: Co-morbidities in total cohort

53.8% of patients had some or the other underlying comorbid disease in the sample population (figure 3). The most prevalent co-morbidity among the sample population was noted as follows: Diabetes mellitus in 63.13%, Hypertension in 38.75 %, Stroke in 12.3% (table 1).

Table 1: Baseline characteristics and investigations of the total cohort

Variable		Unit	N =160 n (%)
Age		mean±SD	58.36±15.36
Sex		Female	51 (31.88)
		Male	109 (68.13)
Recent history of Travel		No	160 (100)
Exposure to COVID		No	148 (92.50)
		Yes	12 (7.50)
Co-morbidities	Hypertension	Yes	62 (38.75)
		No	98 (61.25)
	Diabetes Mellitus	Yes	59 (36.88)
		No	101 (63.13)
	Chronic Kidney Disease	Yes	7 (4.38)
		No	153 (95.63)
	Ischemic Heart Disease	Yes	7 (4.38)
		No	153 (95.63)
	Cerebro vascular accident	Yes	1 (0.63)
		No	159 (99.38)
	Cirrhosis	Yes	1 (0.63)
		No	159 (99.38)
	Tuberculosis	Yes	2 (1.25)
		No	158 (98.75)
Clinical History	Fever	No	56 (35.00)
		Yes	104 (65.00)
	Cough	No	74 (46.25)
		Yes	86 (53.75)
	Breathlessness	No	69 (43.13)
		Yes	91 (56.88)
	Other symptoms	Yes	91 (56.88)
		No	69 (43.13)
	Oxygen	No	96 (60.00)
		Yes	64 (40.00)
	Oxygen saturation	mean±SD	95.17±5.47
RT-PCR	0-2 days	Negative	89 (55.63)
		Positive	71 (44.38)
	3-5 days	Negative	86 (53.75)
		Positive	74 (46.25)
	6-12 days	Negative	148 (92.50)
		Positive	12 (7.50)
CT-Scan	Early	No	94 (58.75)
		Yes	66 (41.25)
	Intermediate	No	91 (56.88)
		Yes	69 (43.13)
	Late	No	153 (95.63)
		Yes	7 (4.38)

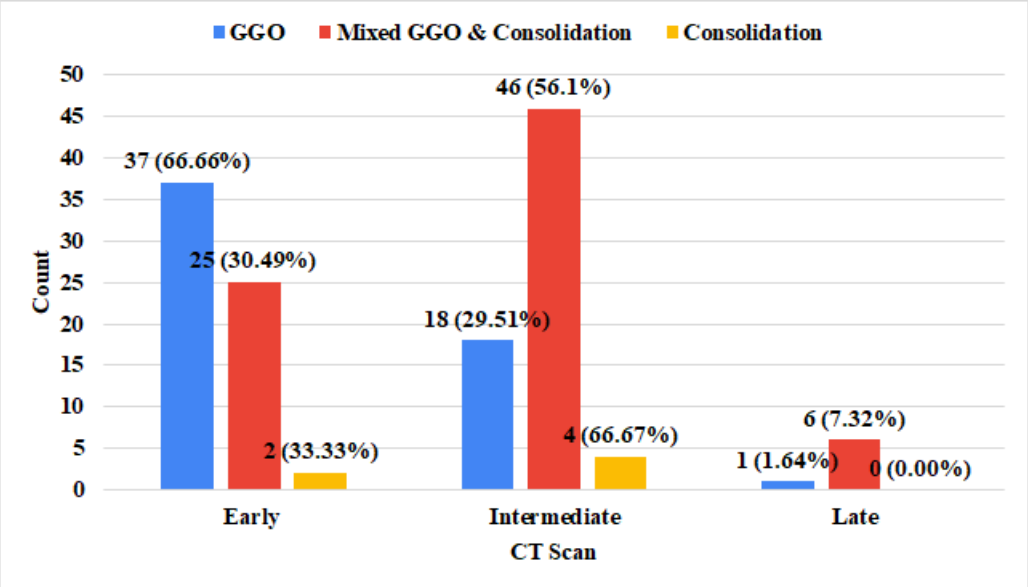


Figure 4: Opacity characteristics according to duration of disease

In early phase (<5 days) of the CT scan, 66.67% patients had GGO while intermediate phase showed 29.51% remaining 30.49% and late phase showed 1.64% only.

In the intermediate phase (6-10 days) high percentage of (56.1%) of the patients had mixed GGO & consolidations compared to early (30.49%) and late phase (7.32%).

In the intermediate phase high percentage of (66.67%) of the patients had consolidation compared to early (33.33%) and late phases (0.00%).

Table 2: Density scoring system of the COVID-19 on computed tomography.

Variable	Unit	N =160 n (%)
Patchy to confluent lesions	No	153 (95.63)
	Yes	7 (4.38)
Nodular lesions	No	160 (100)
Pure Ground glass opacities (GGO)	No	99 (61.88)
	Yes	61 (38.13)
Mixed Ground glass opacities & consolidation	No	78 (48.75)
	Yes	82 (51.25)
Part solid	No	160 (100)
Consolidation	No	154 (96.25)
	Yes	6 (3.75)
Solid	No	160 (100)
Crazy paving	No	159 (99.38)
	Yes	1 (0.63)

According to expert consensus the initial and follow up CT abnormalities were assessed mainly based on the following features: (1) presence of Ground glass opacities (GGO) or consolidation, (2) presence of other abnormalities (reticulation, interlobular septal thickening, and bronchiectasis), (3) lesion shape (patchy, nodular etc).

HRCT chest of the study population showed the variety of opacity characteristics. Out of 160 patients, 61 (38.13) patients had pure Ground glass opacities (GGO) while another 82 (51.25) patients had both mixed GGO, 7 (4.38) of patients had Patchy to confluent lesions and none of the patients showed nodular lesions (table 2).

Table 3: Per lesional analysis of chest CT findings

Variable	Unit	N =160 n (%)
Axial location		
Central	No	156 (97.50)
	Yes	4 (2.50)
Peripheral	No	103 (64.38)
	Yes	57 (35.63)
Central & Peripheral	No	71 (44.38)
	Yes	89 (55.63)
Antero-posterior location		
Anterior	No	160 (100)
Posterior	No	153 (95.63)
	Yes	7 (4.38)
Ant and posterior	No	157 (98.13)
	Yes	3 (1.88)
Shape		
Wedge	No	160 (100)
Round	No	160 (100)
Elongated	No	160 (100)
Confluent	No	160 (100)
Margins		
ILL-Defined	No	159 (99.38)
	Yes	1 (0.63)
Well Defined	No	160 (100)
Predilection for particular location		
Upper Lobe	No	147 (91.88)
	Yes	13 (8.13)
Lower Lobe	No	64 (40.00)
	Yes	96 (60.00)
Pleural attachment	No	159 (99.38)
	Yes	1 (0.63)
Bronchovascular bundle	No	160 (100)
Internal characteristics		
Air bronchogram	No	160 (100)
Fibrotic streaks	No	105 (65.63)
	Yes	55 (34.38)
Septal thickening	No	101 (63.13)
	Yes	59 (36.88)
Subpleural fibrosis	No	129 (80.63)
	Yes	31 (19.38)
Traction bronchiectasis	No	154 (96.25)
	Yes	6 (3.75)
Reverse halo sign	No	150 (93.75)
	Yes	10 (6.25)
Cavity	No	159 (99.38)
	Yes	1 (0.63)
Lymphadenopathy	No	150 (93.75)
	Yes	10 (6.25)

HRCT chest of the study population had a variable axial distribution of opacities; among them, 4 patients had central distribution, 57 patients had peripheral distribution, 89 patients had both central and peripheral distribution. CT chest imaging also showed some specific findings of antero posterior locations, shape, margins, Predilection for particular location, and Internal characteristics.55 (34.38) of patients had Fibrotic streaks, 59 (36.88) had Septal thickening, 31 (19.38) patients had Subpleural fibrosis (table 3).

Table 4: Frequency of lobe involvement

Variable	Right Upper Lobe	Right Middle Lobe	Right Lower Lobe	Left Upper Lobe	Left Lower Lobe
0 (None)	19 (11.88)	31 (19.38)	16 (10.00)	16 (10.00)	11 (6.88)
1 (Minimal)	88 (55.00)	80 (50.00)	61 (38.13)	85 (53.13)	71 (44.38)
2 (Mild)	28 (17.50)	33 (20.63)	45 (28.13)	36 (22.50)	44 (27.50)
3 (Moderate)	19 (11.88)	11 (6.88)	24 (15.00)	18 (11.25)	26 (16.25)
4 (Severe)	6 (3.75)	5 (3.13)	14 (8.75)	5 (3.13)	8 (5.00)

The lobe involvement was measured using the Ct severity scoring system: None (0% = 0), Minimal (1-25% =1), Mild (26-50% = 2), moderate (51-75%=3), severe (76-100%=4) (table 4).

Table 5: CT severity index

Severity index	N =160 n (%)
1-7 (Mild)	95 (59.38)
8-15 (Moderate)	57 (35.63)
16-20 (Severe)	8 (5.00)

In this study majority [95 (59.38)] of the patients had a CT severity score between 1-7 indicating mild disease, 57 (35.63%) patients had CT score 8-15 indicating moderate disease while only 8 (5.00%) had CT severity score 16-20 indicating severe disease (table 5).

4. Discussion

According to the guideline of diagnosis and treatment program on COVID-19 (trial version 7) issued by China's National Health Commission (12), patients infected with SARS-CoV-2 can be divided into common, severe and critical clinic types based on symptoms, laboratory examination and imaging.

A total of 160 patients were analyzed along the course of the Study. Most of the COVID-19 patients of our study group were in their fourth to sixth decades of life and males were effected more than females which is alignment with the reports of other studies (13).

In symptomatic patients, fever and cough were the most common presenting features, followed by breathlessness. as noted in the rest of the World. Stokes et al. reported that among 373, 883 COVID-19 cases in the United States, 70% of them had fever, cough, shortness of breath, 36% had myalgia and 34% reported headache (14).

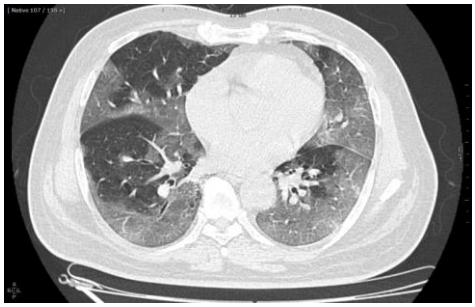
Patients with at least one or more co-morbidity have been reported with poor clinical outcomes. In agreement with the Amprilli et al (15) who reported 60.8 % of patients had an underlying comorbid disease, the present study population also had observed 53.8 % of comorbid disease.

HRCT chest of our study population showed a variety of opacity characteristics, nearly half of patients showed typical GGO while another half showed a mixed pattern of GGO and consolidation. Mostly early CT on admission characterized by GGO, and in late-stage, consolidation tends to be more dominating than GGO. Bao et al. (16) in a meta-analysis of 13 studies found that GGO was the most common manifestation, reported in 83.31% of cases. The meta-analysis involved 13 studies; GGO was the main finding in 11 of them. The data of present study indicates that CT findings vary according to the time of scan from the onset of illness. This reiterates the results observed by Bernheim A et al., who suggested progression of disease in the form of GGOs in early stage to crazy paving/reticulation and consolidation in later stages (17).

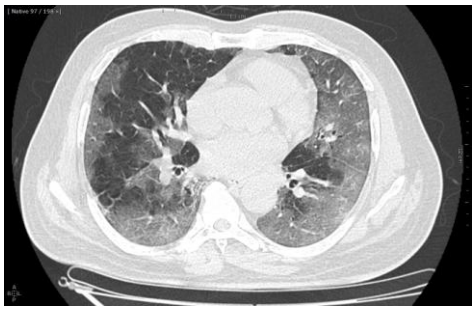
The severity score of HRCT chest may be used to easily identify patients with severe forms of coronavirus disease 2019. Firdose et al (18) reported 36.7% patients had CT severity index of 20 or above. This again highlights the higher percentage of moderate and severe cases in their study population. However, the current study showed majority (59.38%) of the patients had a CT severity score between 1-7 indicating mild disease.

5. Study Limitations

Limitation (s) Study was being conducted in a single centre which covered patients from a defined geographical area. So, this study needs further exploration by taking into account multiple centres and patients from different geographical areas.



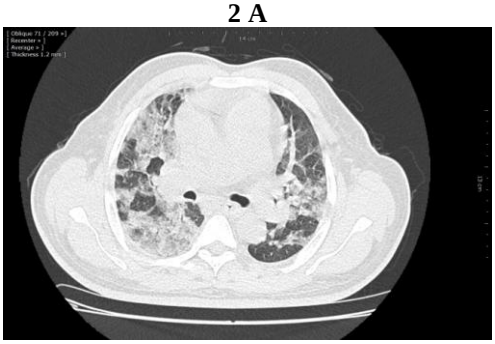
1 A



1 B

Image 1A & 1B: Bilateral lung parenchyma show extensive ground glass opacities with predominantly peripheral involvement compatible with acute phase of covid-19

2 A

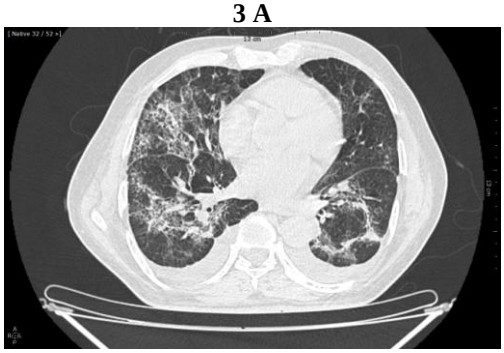


2 B

Image 2A & B: Bilateral lung parenchyma shows extensive GGO's mixed with consolidation in peri-

bronchovascular as well as peripheral distribution compatible with acute phase of covid-19.

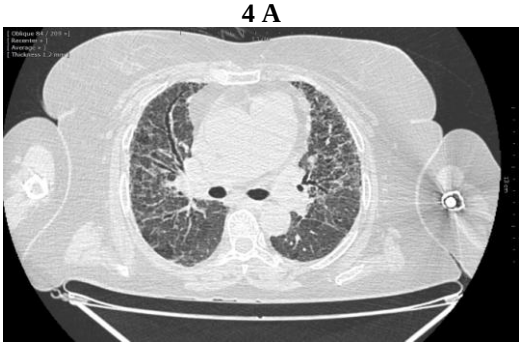
3 A



3 B

Image 3 A & B: Bilateral lung fields shows GGO's mixed with interlobular septal thickening and mild traction bronchiectasis in a known case of covid-19, which is compatible with intermediate to delayed phase. There is associated bilateral mild pleural effusion, septal thickening and mild traction bronchiectasis in a known case of covid-19, which is compatible with intermediate to delayed phase. There is associated bilateral mild pleural effusion.

4 A



4 B

Image 4 A & B: Bilateral lung fields shows diffuse moderate to severe intra and interlobular septal thickening with mild bronchiectasis & none to minimal GGO's, in a known case of covid-19 compatible with delayed sequelae of COVID-19. Note that no honey-combing or apico-basal gradient is seen differentiating it from "UIP type" of ILD.

5 A

5 B

Image 5A & B: In a follow-up case of covid-19, bilateral lung fields show multiple linear and curvilinear subpleural atelactatic bands with mild interstitial thickening in basal segments compatible with delayed phase. The previously seen GGO's were completely resolved.

6. Conclusion

The varied spectra of COVID-19 presented with fever, cough, breathlessness. Diabetes Mellitus, Hypertension, were found as major co-morbid conditions. HRCT chest in COVID-19 patients had significant diagnostic and prognostic importance. Despite meticulous treatments, most patients demonstrated progressions in the early stage from illness onset, according to the follow-up CT examinations being familiarized with the clinical and CT features and the early changes of the COVID-19 infection is of paramount importance.

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