International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2019): 7.583

HRCT Evaluation in COVID 19 Patients and Correlation with Disease Progression, Clinical Outcome

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Abstract: ***Our Study aimed to determine the diagnostic accuracy of HRCT chest in COVID 19 and to evaluate the performance of HRCT chest in early diagnosis and management and correlation with disease severity. This is a retrospective study done at Government general hospital(tertiary care center), Kakinada, Andhra Pradesh. The Present Study was on 120 hospitalized patients who underwent HRCT CHEST with symptoms of COVID 19. A total of 120 patients of laboratory - confirmed COVID-19 test by RT-PCR at Government general hospital, Kakinada was assessed. Among the confirmed cases, most of the patients in the fifth and sixth decade of age group with a mean age of 53.65 years. There was a male preponderance (69.25% male and 30.8% female). Out of the total analyzed patients, 87 patients (72.5%) were symptomatic, among them fever (87.35%), cough (82.7%), shortness of breath (36.78%), and sore throat (20.69%) were the most common presenting clinical manifestations. A few patients (17.24%) also had other symptoms like headaches, chest pain, pain abdomen, alteredsensorium, etc. 60.8% of patients had some underlying co -morbid disease in the sample population. The most prevalent co-morbidities were Diabetes mellitus (52.05%), Hypertension (43.8%), Stroke (12.3 %), CAD (10.9%), and others (17.8%) like hypothyroidism, anemia, COPD, etc. The pathological lung changes were evaluated by HRCT imaging and by assigning with CT severity score. Proportional GGO was higher (63.37%) in the early phase and it was lower (22.2%) in the later stage of disease. HRCT is helpful in the diagnosis, treatment planning, and followup of covid 19 patients. 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

1. Introduction

A worldwide outbreak of viral pneumonia named Coronavirus Disease 2019 (COVID-19) is considered a global health threat due to its rapid spread, unavailability of approved medication or vaccines, and surging mortality Infection by COVID-19 can result in a range of clinical outcomes, from asymptomatic to severe life-threatening course or death. Current estimates are that the incubation period is generally 3 to 7 days and up to 14 days.[2]As per literature median age of patients is 47–59 years, with around 41.9–45.7% being female gender[3].

The elderly and those with underlying diseases are more seriously ill after infection[4]. Children and infants can also be infected. Persons with co-morbidities were adversely affected. Symptoms resulting from COVID-19 infection in the prodromal phase include fever, dry cough, and malaise, which are nonspecific.[4, 7]Some patients may not have symptoms at all. Therefore, chest computed tomography (CT), in particular high-resolution computed tomography (HRCT), represents valuable tools in identifying patients with COVID-19 infections in an early stage when clinical symptoms may be unspecific or sparse.[8] The purpose of our Study was to characterize the clinical and HRCT features in patients with COVID-19 infection retrospectively and to facilitate early identification and early isolation. We also aimed to explore the change in HRCT on a spectrum of the duration of disease. Recovery and mortality of patients from COVID-19 was influenced by their respiratory system involvement and other systemic co-morbidities.

2. Methods

Study Design
The present Study is a retrospective analysis done on 120 COVID-19 positive patients admitted at Rangaraya Medical College Hospital, Kakinada, from August 15 to September 2, 2020. we included 120 patients with COVID-19 who had been admitted to our institution to ensure the clinical and imaging data quality and integrity.

Data Collection
We retrospectively collected the clinical and chest imaging data. The Study included epidemiological data, clinical manifestation, co-morbidities of patients, CT chest characteristics, CT severity score. After collecting all the required data and careful medical chart review, laboratory-confirmed patients'clinical data were compiled and tabulated. The diagnosis of COVID-19 was made based on the World Health Organization interim guidance, wherein confirmed cases denoted were patients whose RT-PCR assay findings for nasal and pharyngeal swab specimens were positive.[3] The epidemiological data (age, sex, residence) was recorded, clinical data, clinical symptoms and signs, co-morbidities, was obtained. In very few cases, RT PCR was negative. All 120 patients underwent an initial CT scan of the chest despite the RT PCR result. A dedicated CT scan machine was used for scanning of COVID patien, and followed proper disinfection protocol. To assess the temporal changes of CT findings date of onset of illness of each patient and the date of CT acquisition for each patient were noted.

Review of CT images

Thin section CT images were acquired on a 16 slice GE machine. 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. Note was also made of any additional findings such as nodules, cavities, cysts, pleural effusion and mediastinal lymphadenopathy. Any other preexisting lung diseases such as TB, bronchiectasis, and emphysema were separately noted.

Typical features are those that are reported in the literature to be frequently and more specifically in COVID-19 pneumonia-like bilateral, peripheral GGOs with or without consolidation or crazy paving, multifocal, diffuse, perihilar, or unilateral GGOs. Atypical features are reported to be uncommon or not occurring in COVID-19 pneumonia-like lobar or segmental consolidation without GGOs or small nodules or cavitation or pleural effusion. Negative for pneumonia implies that there are no parenchymal abnormalities that can attribute to infection[15].Reports were given as per CO-RADS classification.

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.

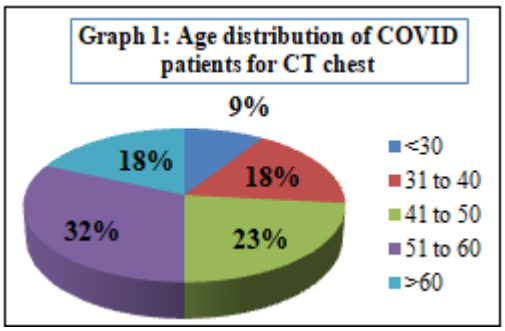
A CT Severity Score was assigned out of 40 based on the percentage area involved in each of the 5 lobes.

In the early phases, we saw areas of pure ground glass haziness with visible underlying broncho vascular markings. The density of lesions in the intermediate and late phases of disease was higher and was seen as areas of consolidation along with few areas of pure GGOs. Noted both rounded and linear patterns of opacities with peripheral and/or central distribution of opacities. Based on the time of onset of illness (time of onset of symptoms in symptomatic patients or time of positive RT-PCR in asymptomatic patients) to time of scan duration, our sample population were classified as early, intermediate and late phases. Patients were considered to be in the (I) early stage of illness if this duration was <5 days, (II) intermediate stage of disease for 5-10 days period time, and late if the scan was done 11 days after the date of onset of disease.

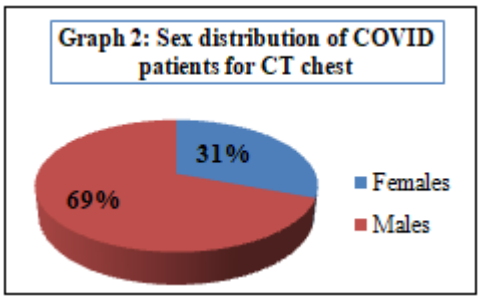
3. Results

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 120 laboratory-confirmed COVID-19 patients by RT-PCR admitted at Rangaraya Medical College, Government General Hospital, till September 2, 2020, were assessed.

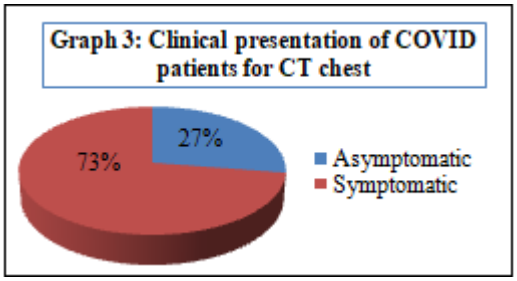
In our study group, most of the patients were in fifth and sixth decades with a mean age of 53.65 years. Percentage distribution of patients according to age group was found as <30 year 9 %, 30-40 year 18 %, 40-50 year 23 %, 50-60 years 32%, >60 year 18 % 9(graph 1).



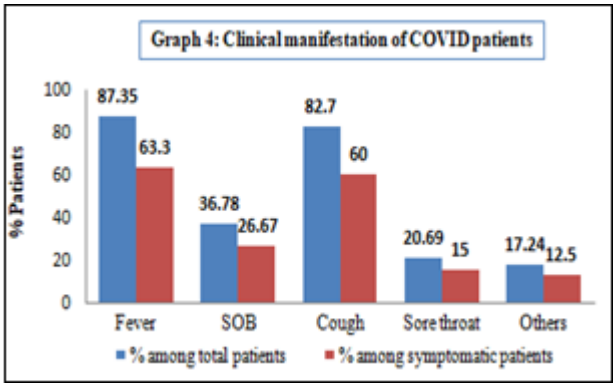
Females patients (30.8%) were lesser than males (69.2%), with an average sex ratio of female: male being 0.44 in our Study (graph 2).



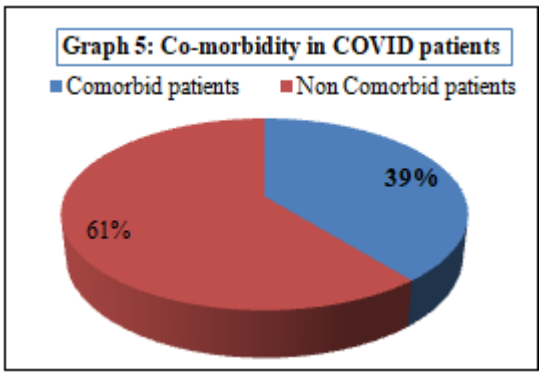
Out of the total analyzed patients, 87 patients (73%) were symptomatic, while 33 patients (27%) were asymptomatic in our study population. (graph 3)



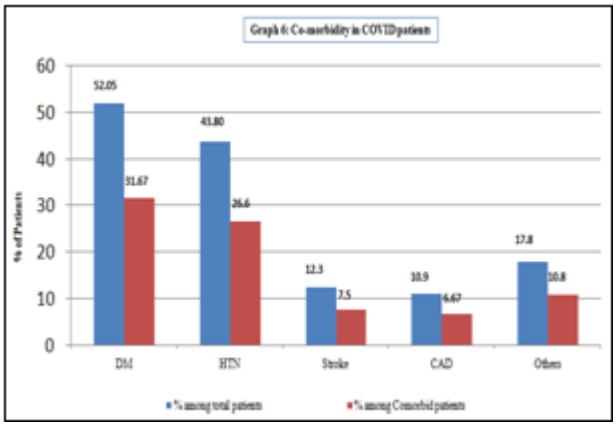
In symptomatic patients, fever (87.35%), cough (82.7%), shortness of breath (36.78%), and sore throat (20.69%) were the most common presenting clinical manifestations, while a few patients (17.24%) also had other symptoms like headache, chest pain, pain abdomen, alteredsensorium, etc. Prevalence of various clinical presentation in our study sample population distributed as fever in 63.3%, cough in 60%, SOB in 26.67%, sore throat in 15%, and other manifestation in 12.5%(graph 4).



61% of patients had some or the other underlying comorbid disease in the sample population (*graph 5*).



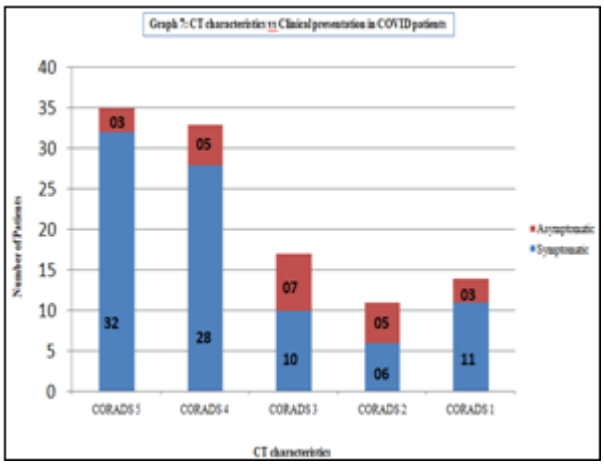
The most prevalent co-morbidity among the sample population was noted as follows: Diabetes mellitus in 52.05%, Hypertension in 43.8 %, Stroke in 12.3%, Coronary artery disease (CAD) in 10.9 %, and other diseases like hypothyroidism, anemia, CVA, COPD in 17.8%. The percentage prevalence of the comorbid disease among total comorbid patients was found as Diabetes mellitus at 31.67%, Hypertension at 26.6%, Stroke at 7.5%, CAD at 6.67%, and other diseases at10.8% (graph 6).



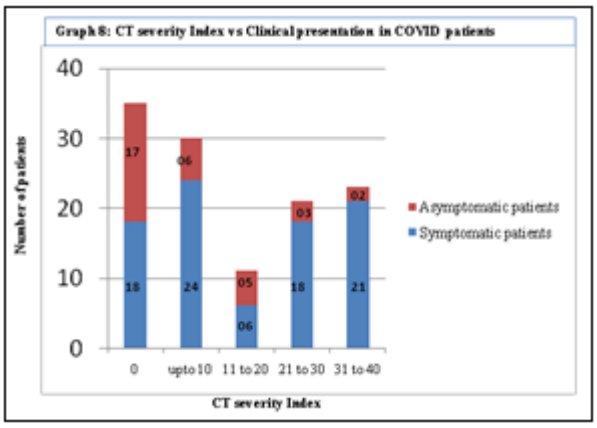
Out of 120 patients, 85(70.8%) patients were found to be radiologically positive on HRCT chest imaging, while 35 patients (29.1%) had normal or non-COVID CT findings.

The pathological lung changes were evaluated on HRCT and CORADS given along with imaging severity score for 40.In our study population 85 patients are radiologically positive, accounting for 70.8%.

Out of the radiologically positive patients, 35 (29.16%) were given CORADS 5; 33(27.5%) were given CORADS 4, 17 (14.16%) were given CORADS 3, 11 patients (9.16%) were given CORADS 2 and 24 (20%) patients were given CORADS 1 (graph 7).



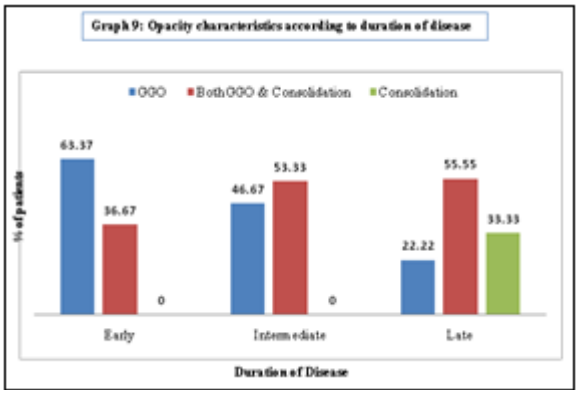
HRCT chest of our study population showed the variety of opacity characteristics. Out of radiologically positive patients, 41patients (51, 25 %) had isolated Ground glass opacities (GGO) while another 44 patients (51.75%) had both GGO and consolidation and two patients (2.35 %) had isolated consolidation. HRCT chest had different lobe distribution of opacities in which10 patients (11.76%) had only one lobe affection, 16 patients (18.8 %) had two lobes affection, 9 patients (10.58 %) had three lobes affection, 8 patients (9.41 %) had four lobes affection and 42 patients (49.4%) had all five lobes affection while none of lobe of lungs affected in 35 patients (41.17 %). In total radiologically affected 85 patients, 59 patients (69.4 %) had more than two lobe affection, 69 patients (81.1%) had bilateral lung involvement, 16 patients(18.8%) had unilateral lung involvement.



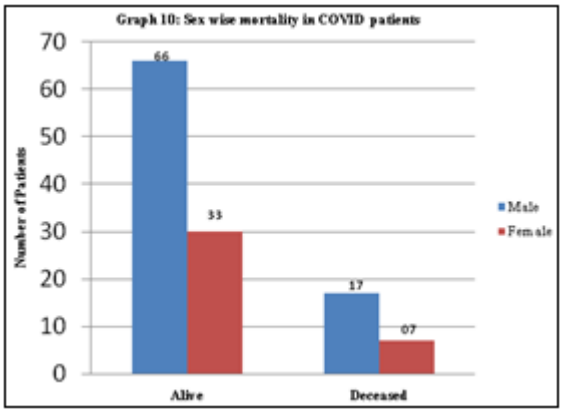
Out of the study population, 51 patients had right upper lobe involvement 49 patients had right middle lobe involvement, 71 patients had right lower lobe involvement, 61 patients had left upper lobe involvement, 73 patients had left lower lobe involvement. Out of total radiological affected 85 patients, an the average of 85.88 % patients had predominant lower lobe involvement in COVID-19. Among the study population, 51 patients had a predilection towards the involvement of the posterior surface of the lung, 5 patients had anterior surface involvement, while 29 patients had both

anterior and posterior surface involvement. HRCT chest of the study population had a variable axial distribution of opacities; among them, 7 patients had central distribution, 48 patients had peripheral distribution, 28 patients had both central and peripheral distribution, while 2 patients had no axial distribution. Out of total radiologically affected patients, 45 patients (88.23%) had a propensity towards the lungs' periphery. CT chest imaging also showed some specific findings which, includes pleural effusion in 11 patients (9.16 %), thoracic lymphadenopathy in 5 patients (4.16 %), granuloma in 7 (5.8%) and other nonspecific findings like a cyst, hemangioma, etc. in 4 patients (3.33 %) (*table 1*). In our study population, CT chest was done at various stages of the disease with average time duration from onset of illness to date of CT imaging was found to be 6-7 days.

In early phase of the disease (<5 days), among radiologically positive patients(48out of 72) 63.37% patients had GGO while remaining 33.67% had both GGO and consolidation in imaging of HRCT chest. In the intermediate phase of disease (6-10 days), among radiologically positive patients (14 out of 30) 45.67 % patients had GGO while remaining 53.33 % had both GGO and consolidation in imaging of HRCT chest. In the late phase of disease (>10 days), among radiologically positive patients (4 out of 18) 22.22% of patients had GGO, 55.55 % patients had both GGO and consolidation, while the remaining 33.33 % patients had the only consolidation in imaging of HRCT chest.



In our study population, mortality was higher in men when compared to women. Elderly, comorbities were the risk factors contributing to mortality. The overall mortality accounts for 20% in our study.



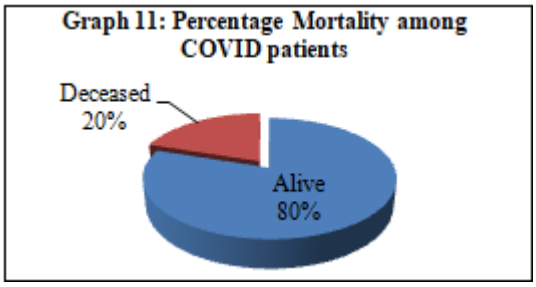


Table 1: Imaging characteristics on HRCT-CHEST

CT features	Number of patients	% among total patients (N=120)	% among radiologically positive patients (N=85)
Opacity distribution (Axial)			
No axial	02	1.67	2.35
Central	07	5.8	8.23
Peripheral	48	40.0	56.4
Both	25	23.3	32.9
Underlying lung disease			
Pulmonary emphysema	01	0.83	1.17
Atelectasis	05	4.16	5.88
Bronchiolitis	11	9.16	12.94
K-chest	07	5.8	8.23
Other findings			
Pleural effusion	11	9.16	12.94
Pulmonary nodules	05	4.16	5.88
Thoracic Lymphadenopathy	07	5.8	8.23
Other findings	07	3.33	4.7
Ground glass opacity & consolidation			
Both absent	35	29.16	41.17
GGO present	41	34.16	51.25
GGO & Consolidation present	44	36.67	51.76
Consolidation present	02	1.67	4.7
Number of lobes affected			
0	35	29.16	41.17
1	10	8.33	11.76
2	16	13.33	18.8
3	09	7.5	10.58
4	08	6.67	9.41
5	42	35	49.4
>2	59	49.16	69.4
B/L lung disease	69	57.5	81.1
U/L lung disease	16	13.3	18.8
Frequency of lobe involvement			
Right upper lobe	57	42.5	60
Right middle lobe	49	40.8	57.6
Right lower lobe	71	59.1	83.52
Left upper lobe	61	50.83	71.76
Left lower lobe	73	60.83	85.88
Involved surface of lungs			
Anterior	05	4.16	5.88
Posterior	51	42.5	60
Both	29	24.16	34.11
CT chest characteristics			
CORADS 5	35	29.16	41.17
CORADS 4	33	27.5	38.82
CORADS 3	17	14.16	20
CORADS 2	11	9.16	12.96
CORADS 1	24	20	28.2

CT severity Index			
0	35	29.16	41.17
Upto 10	30	25	35.29
10 TO 20	11	9.16	12.94
21 TO 30	21	17.5	24.7
31 TO 40	23	19.16	27.5

4. Discussion

The specter of COVID-19 made its first appearance in Wuhan, China, and it has spread like wildfire out and across precincts of China and across the globe. Confirmed cases of COVID-19 are being reported from all corners of the world, and subsequently, the World Health Organization (WHO) officially declared COVID-19 a pandemic on March 11, 2020. Research is underway to understand more about transmissibility, severity, and other features associated with COVID-19.12The SARS-related coronaviruses are covered by spike proteins that contain a variable receptor-binding domain (RBD). RBD binds to the angiotensin-converting enzyme-2 (ACE-2) receptor found in the heart, lungs, kidneys, and gastrointestinal tract, facilitating viral entry into target cells. Viral entry and cell infection trigger the host's immune response, and the inflammatory cascade is initiated by antigen-presenting cells (APC). It is apparent that COVID-19 infection occurs through exposure to the virus, and both immune suppressed and normal populations appear to be susceptible. It has been suggested that the population most at risk may be people with poor immune function, such as older people and those with renal and hepatic dysfunction 13. In the present Study an attempt was made to outline the distribution of age, gender, clinical features at presentation, co-morbidity of patients, HRCT chest findings in COVID-19 patients, the severity of patients based on the CT imaging, and their correlation with symptomatology and co-morbidity of patients to put diagnostic, therapeutic and prognostic tools for COVID-19 disease. A total of 120 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, with the male gender affected more than females, with an average sex ratio being 0.44 in our study group. In symptomatic patients, fever and cough were the most common presenting features, followed by shortness of breath, sore throat, and headache, while few patients also presented with chest pain and non-respiratory symptoms like pain abdomen, fatigue, joints pain, altered sensorium, etc. It was observed in the present study co-morbidities have a tangible impact on clinical characteristics and course in COVID-19 positive patients. Patients with at least one or more co-morbidity have been reported with poor clinical outcomes. In the present study population, 60.8 % of patients had an underlying comorbid disease, with multiple comorbid disorders being was more prevalent. The prominent radiological feature of COVID-19 is bilateral ground-glass opacity in the chest CT scans. In this Study, we assessed the involvement of lungs with CT chest images, in which nearly two third patients (70.8% patients) had positive CT findings while less than half of patients (72.5%) were symptomatic. In the present Study, more than three-fourths of patients among radiologically positive patients had typical CT chest image findings including GGO in bilateral, peripheral and lower lobe predominance. The severity of the clinical status of COVID-19 patients correlated with CT severity index As CT severity index raised, the clinical status of patients deteriorated hence this shows poor prognostic indicator for COVID-19 patients.

At present, the patient's condition mainly depends on symptoms and signs, blood oxygen saturation, etc., while CT images are not used as a main reference index. When the disease develops rapidly, the probability of death greatly increases. However, we found that CT imaging changes in some patients, especially young patients, appears before the onset of signs and symptom due to the differences in tolerability. We scored the chest CT imaging and found that clinically severe patients showed higher CT imaging score compared to that in non-severe patients. These data suggested that CT imaging score may be an informative indicator of the disease's severity and thus, the treatment plan..In the early stages, single or multiple small ground glass infiltration, consolidation, and interstitial thickening could be seen. As the disease progressed, severe cases had more consolidation and air bronchograms in the involved lobes. The diffuse lesions, shown as "white lungs, " were seen in the most severely affected patients. Fibrous bands could be seen during the remission. Cautious attention to symptoms and CT examination are helpful for early detection of COVID-19infection.

HRCT chest of our study population showed a variety of opacity characteristics, ;among radiologically positive patients, 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. The distribution of these lesions in our Study was mostly peripheral and posterior, involving the lower lobes more frequently. Subsequently, subpleural sparing and curvilinear bands appeared likely due to the etraction process suggesting the resolution stage.

Our Study indicates that CT findings vary according to the time of scan from the onset of illness. This concurs with Bernheim et al. and Pan et al.'s results which suggested disease progression in the form of GGOs in the early stage to "crazypaving" and consolidation in later stages. Besides, the CT findings also correlate with clinical status, showing a higher CT severity score in clinically worse patients. Thus, the percentage involvement of lung and CT severity score can help predict and tailor the patients' clinical management. In radiologically positive patients, multiple lobe affection by COVID-19 has been more popular compared to other bacterial or lobar pneumonia. Most of the radiologically positive COVID-19 patients had complete or some posterior surface involvement. CT chest imaging also showed some specific findings which includes pleural effusion, pulmonary nodules, thoracic lymphadenopathy and other nonspecific findings like granuloma, cyst, hemangioma, etc. In the present study, duration of disease correlated with CT chest characteristics and CT severity index. In these patients, the average CT severity index remainedthe same in each phase of the disease while opacities characteristics, especially GGO and consolidation varied in different phases of the disease. GGO, a characteristic feature of initial stage of disease found maximum in early phase of disease while in

intermediate and late phase of the disease, proportional pure GGO reduced. In intermediate phase early half of patients had both GGO and consolidation on CT images while rest half had pure GGO pattern. In the late stage, nearly three fourth patients had GGO and consolidation while remaining patients had pure GGO or consolidation in equal proportion. These characteristic changes were in favor of resolving pneumonia.

HRCT Findings in COVID 19 Patients

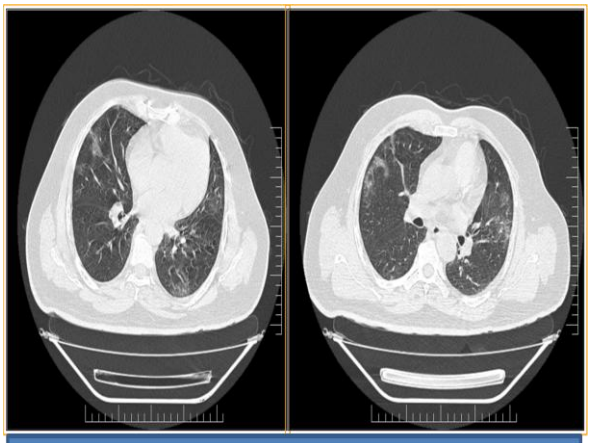


Figure 1:Axial section through CT chest of a 34 year old male patient show peripheral ground glass opacities in bilateral upper and middle lobes

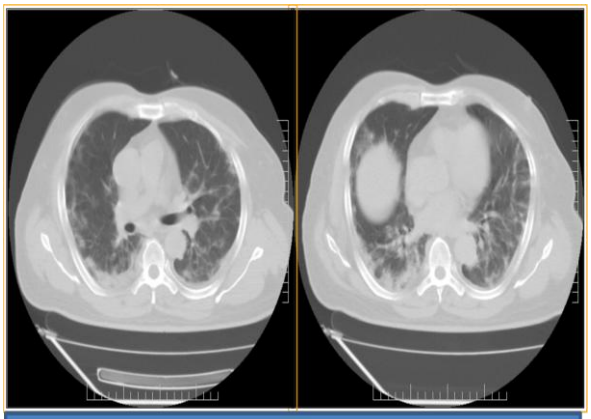


Figure 2 :HRCT chest of COVID 19 patient in early phse shows presence of peripheral Ground glass opacities predominant in lower lobes.

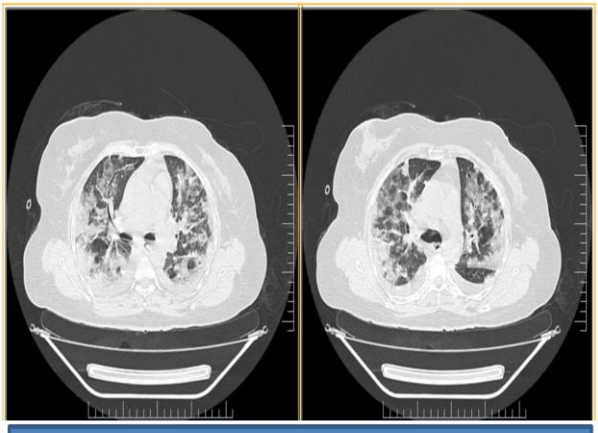
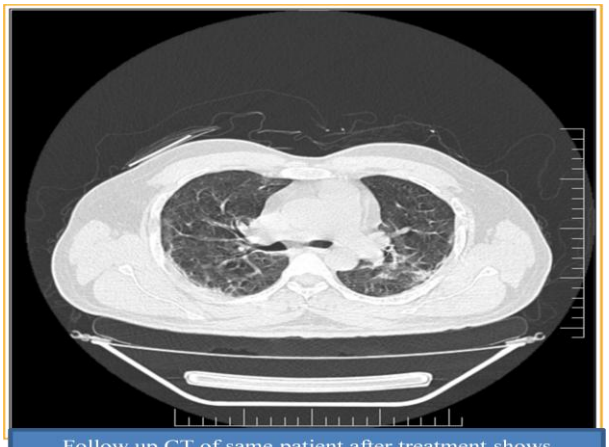


Figure 3: Axial sections of CT chest in a 55 year old patient reveal mixed pattern of both ground glass opacities and consolidation diffusely in both lung fields.



Follow up CT of same patient after treatment shows resolving findings in the form of fibrotic opacities

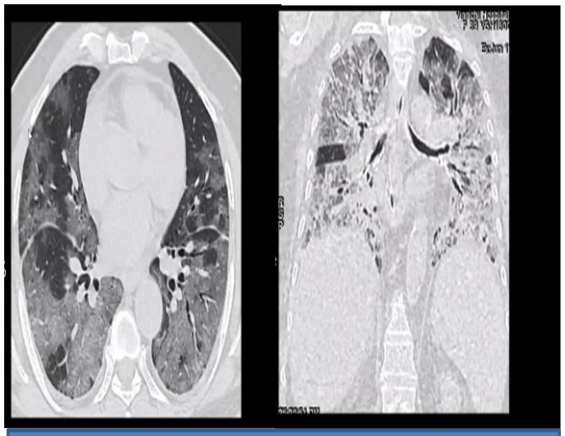


Figure 4:Axial and Coronal CT images of 46 year old co morbid patient showing the progression from Ground glass opacities to organized pneumonia

5. Conclusion

1) The varied spectra of COVID-19 presented with fever, cough, shortness of breath, sore throat, etc.
2) Diabetes Mellitus, Hypertension, COPD/K-Chest, and CAD were found as major co-morbid conditions. Clinical severity of disease was higher in patients that had underlying co-morbid disease, especially in patients with multiple co- morbid conditions.
3) HRCT chest in COVID-19 patients had significant diagnostic and prognostic importance as positive CT findings more prominent in symptomatic patients and co-morbid patients. CT severity index also directly correlated with clinical symptoms of patients. CT imaging useful to see the clinical recovery of patients.
4) The results of this Study confirmed that chest CT is important in the diagnosis and management of the COVID-19 infection. Despite meticulous treatments, most patients demonstrated progressions in the early stage from illness onset, according to the follow-up CT examinations
5) Our clinical findings show that radiological features positively correlate with the severity of lung abnormalities quantified on initial CT. 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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