

HIGH RESOLUTION COMPUTED TOMOGRAPHY (HRCT) CHEST FINDINGS IN COVID-19 PATIENTS IN RELATION TO DURATION OF INFECTION IN A TERTIARY CARE PRIVATE HOSPITAL IN CHITTAGONG, BANGLADESH**Dr. Justin Clump^{1*}, Dr. Diana Thecla D Rozario², Dr. Shabiha Quadir³, Dr. Kazi Mohammad Moin Uddin⁴, Dr. Fahmida Nahid⁵, Dr. Md Ubaidul Islam⁶ and Dr. Durga Devvee Sarker⁷**¹Radiologist, Department of Radiology and Imaging, Chittagong Medical College Hospital Chittagong, Bangladesh.²Assistant Professor, Department of Microbiology, Abdul Malek Ukil Medical College, Noakhali, Bangladesh.³Assistant Professor, Department of Radiology and Imaging, Chittagong Medical College Hospital, Chittagong, Bangladesh.⁴Assistant Professor, Department of Radiology and Imaging, Chittagong Medical College Hospital, Chittagong, Bangladesh.⁵Assistant Professor, Department of Radiology and Imaging, Rangpur Medical College Hospital, Rangpur, Bangladesh.⁶Radiologist, Department of Radiology and Imaging, 250 Bed Hospital, Moulvibazar, Bangladesh.⁷Medical Officer, Department of Radiology and Imaging, National Institute of Neuroscience and Hospital, Dhaka, Bangladesh.***Corresponding Author: Dr. Justin Clump**

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ABSTRACT

Purpose: To determine the radiological imaging features in chest HRCT of COVID-19 patients at different stages of the course of illness. **Materials and Methods:** This retrospective study included 70 patients with real-time polymerase chain reaction–confirmed COVID-19 who were admitted into a tertiary care private hospital in Chittagong, Bangladesh, between June 2020 to July 2020. HRCT chest of these patients were done and findings were evaluated in relation to different stages of the course of infection. **Results:** Seventy patients (45 men and 25 women with mean age of 53.5 years and SD 15.6) with confirmed COVID-19 were evaluated. The hallmarks of COVID-19 infection in HRCT included GGO, GGO and consolidation, GGO and crazy paving and consolidation with parenchymal bands. All patients in the early stage (0-4 days of symptoms), showed only GGO, in the progressive stage (5-8 days of illness) maximum patients showed GGO with crazy paving (36%), in the peak stage (9-13 days of illness) majority patients (48.3%) showed GGO and consolidation, while in the absorption stage (≥ 14 days of illness) maximum patients (66.67%) showed consolidation with parenchymal bands. Almost all patients included in this study showed bilateral, peripheral and multi-lobar lung involvement. **Conclusion:** Chest HRCT of COVID-19 patients shows significant patterns of opacity in different stages of the course of illness. These patterns of HRCT findings are very much helpful for detecting COVID-19 pneumonia.

KEYWORDS: High Resolution Computed Tomography (HRCT), Corona Virus Disease (COVID-19), Ground Glass Opacity (GGO), Crazy paving, Consolidation, Parenchymal bands.

INTRODUCTION

An outbreak of coronavirus disease 2019 (COVID-19) infection began in December 2019 in Wuhan, the city's Huanan Seafood Market, widespread human to human transmission has resulted in 19.7 million confirmed cases worldwide with a total of 728000 deaths. Disease was first reported in Bangladesh on March, 2020, and the total number of cases in Bangladesh has reached 205800 confirmed cases with 3399 deaths as on 9th August, 2020. The most common clinical symptoms at presentation are fever and cough in addition to other nonspecific symptoms including dyspnea, headache, muscle soreness, and fatigue.^[1] About 20% of cases are

severe, and mortality is approximately 3%.^[2] The World Health Organization declared a global health emergency on January 30, 2020.^[3] This is the seventh known coronavirus to infect humans.^[4] Two other notable examples include severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), the former of which began in southern China and resulted in 774 deaths in 8098 infected individuals in 29 countries from November 2002 through July 2003, and the latter of which originated in Saudi Arabia and was responsible for 848 deaths among 2458 individuals in 27 countries through July 2019.^[5,6] As clinical physicians, epidemiologists, virologists, phylogeneticists, and others

work with public health officials and policymakers to understand infection pathogenesis and control disease spread, some early investigators have observed imaging patterns on chest radiographs and CT scans.^[7] For instance, an initial prospective analysis in Wuhan revealed bilateral lung opacities on 40 of 41 (98%) chest CT scans in infected patients and described lobular and subsegmental areas of consolidation as the most typical findings.^[8] Other investigators examined chest CT scans in 21 infected patients and found high rates of ground-glass opacities and consolidation, sometime with a rounded morphology and peripheral lung distribution. Another group evaluated lung abnormalities related to disease time course and found that chest CT showed the most extensive disease approximately 10 days after symptom onset.^[9] Thoracic radiology evaluation is often key to the evaluation of patients suspected of COVID-19 infection. Prompt recognition of disease is invaluable to ensure timely treatment, and from a public health perspective, rapid patient isolation is crucial for containment of this communicable disease. In this study, we characterize chest CT findings in 70 patients infected with COVID-19 in Chattogram in relationship to the time between symptom onset and the initial CT scan.

MATERIAL AND METHODS

This retrospective study was approved by institutional review board of Chittagong Medical Centre (pvt.) Hospital. 70 adult patients admitted in Chittagong Medical Centre (pvt.) Hospital having RT-PCR confirmed COVID-19 and who underwent chest HRCT in the same hospital were enrolled in our study. Signed informed consent was exempted from the patients, due to retrospective nature of in this study. The study was conducted from 1st June 2020 to 30th July 2020. The inclusion criteria were patients with COVID-19 symptoms like fever, cough, shortness of breath, chest pain, sore throat and diarrhea. All patients were positive for COVID-19 at laboratory testing with real-time reverse transcriptase polymerase chain reaction (RT-PCR) of respiratory secretions obtained by nasopharyngeal swab or oropharyngeal swab. The RT-PCR was performed in government and private laboratories by the patients. Patients included in the study submitted a positive RT-PCR test report.

HRCT scanning protocol

Siemens SOMATOM Go Up (Siemens Healthcare), 32-slice spiral CT scanner was used. The patients were scanned in the supine position and with breath holding at end of inspiration. The scanning range is from the apex to the bottom of the lung. The scanning parameters were tube voltage- 120 kV; tube current- 200–300 mAs; pitch- 0.99– 1.22 mm; matrix- 512 × 512; layer thickness 1.25 mm; field 350 mm×350 mm; and reconstruction section thickness 2 mm. All of the patients underwent unenhanced CT scan without contrast agent administration.

HRCT image viewing and estimation

All HRCT images were reviewed using a viewing console. Images were reviewed independently, and final decisions reached by consensus. No negative control cases were examined. For each patient, the chest CT scan was evaluated for the following characteristics: (a) presence of ground-glass opacities; (b) ground glass opacity with a crazy-paving pattern, (c) presence of consolidation, (d) consolidation with ground glass opacity (e) presence of parenchymal bands/fibrosis (f) laterality of the opacities (g) axial distribution of disease (peripheral, central or diffuse) (h) lobar distribution of the opacity, (i) presence of nodules, cavitory lesions, opacities with reverse halo sign (j) presence of pleural effusion (k) presence of thoracic lymphadenopathy, (l) presence of other underlying lung and airway disease such as emphysema (COPD) and bronchiectasis.

Ground-glass opacifications was defined as hazy increased lung attenuation with preservation of bronchial and vascular margins, whereas consolidation was defined as opacification with obscuration of margins of vessels and airway walls. Parenchymal bands were defined as linear band like consolidations. Opacities in the outer 1/3rd of the lung was defined as peripheral and the peripheral and inner 2/3rd of the lung as central distribution and diffuse as opacities that spread out in both central and peripheral areas. Lymphadenopathy was defined as lymph nodes greater than 1.0 cm in short-axis diameter. The amount of time between the initial appearance of patient symptoms (eg- fever, cough) and the date of both the first positive real-time RT-PCR test as well as the date of the chest HRCT examination was noted for each patient.^[10]

Staging

If the time between the first clinical symptom and HRCT was 4 days or less, the patient was considered to have been imaged in the early phase of illness. If the time between symptom onset and HRCT was between 5 and 8 days, the patient was considered to have been imaged in the progressive stage. If the time between symptom onset and HRCT was between 9 and 13 days, the patient was considered to have been imaged in the peak stage of illness. If the time between symptom onset and HRCT was 14 days or more, the patient was considered to have been imaged in the absorption stage of illness.^[11]

Statistical analysis

Data were analyzed using SPSS, version 22.0 (IBM Statistics). Continuous variables were expressed as means ± standard deviations. The incidence of HRCT signs was expressed as number and percentage.

RESULTS

Seventy adult patients admitted in Chittagong Medical Centre (pvt.) Hospital with RT-PCR confirmed COVID-19 and who underwent chest HRCT were enrolled in our study. Table I shows, among the 70 patients, 45 (64.28%) were male and 25 (35.72%) were female with

mean age \pm SD of 53.5 \pm 15.6 years. Among the 70 patients 14 (20%) were between 20-40 years, 33 (47.15%) were in the age group of 41-60 years, 21 (30%) were between 61-80 years and 2 (2.88%) were between 81 – 100 years of age group. Among the 70 patients all the patients had fever and cough. 13 (18.57%) patients had only fever and cough with no other significant symptoms. The rest of the 57 (81.43%) patients had other associated symptoms like diarrhoea, throat pain, chest pain and shortness of breath.

Table II shows, out of the 70 cases, 07(10%) patients had symptoms for 0-4 days and were staged as early stage. 25 (35.72%) patients were in progressive stage and had duration of illness for 5-9 days. 29 (41.42%) patients had a duration of illness for 10-13 days and were staged as peak stage.

09 (12.86%) patients were in the absorption stage and had a duration of illness of 14 days and more.

HRCT showed only GGO in all the 7(10%) patients who were in early stage of disease. Among the 25 patients who were in progressive stage, 8 (32%) patients had only GGO, 5 (20%) patients had GGO and consolidations, 2 (8%) had only consolidations, 9 (36%) had GGO with crazy paving and 1(4%) patient had consolidation with parenchymal bands. Among the 29 patients who had a duration of illness for 10 -13 days (peak stage), 2 (6.9%) patients had only GGO, 14 (48.3%) had GGO and consolidations, 10 (34.5%) had only consolidation, 1 (3.5%) had GGO with crazy paving and 2 (6.8%) patients had consolidation and parenchymal bands. Among the 09 patients who had a duration of illness of 14 days and more (absorption stage), 1 (11.11%) had GGO and consolidation, 2 (22.22%) had only consolidation, and 6 (66.67%) patient had consolidation with parenchymal bands.

In all the 70 patients in our study there were bilateral and multiple lobe involvement. Of the 7 patients in early stage, 1 (14.28%) had 2 lobe involvement, 4 (57.15%) had 3 lobes involvement, 1 (14.28%) had 4 lobes involvement and 1 (14.28%) had 5 lobes involvement. In progressive stage, among the 25 patients, 1 (4%) had 2 lobes involvement, 3 (12%) had 3 lobes involvement, 15 (60%) had 4 lobes involvement and 6 (24%) had 5 lobes involvement. In peak stage, among the 29 patients, 2 (6.9%) had 2 lobes involvement, 6 (20.7%) had 3 lobes involvement, 16 (55.17%) had 4 lobes involvement and 5 (17.24%) had 5 lobes involvement. Among the 9 patients in absorption stage, 3 (33.33%) had 2 lobes involvement, 5 (55.55%) had 3 lobes involvement and 2 (22.23%) had 4 lobes involvement.

Among the 7 patients in early stage, 4 (57.15%) had peripheral lung involvement, 3 (42.85%) had both peripheral and central lung opacities. Among the 25 patients in progressive stage 4 (16%) had only peripheral lung involvement, 16 (64%) had peripheral and central involvement and 5 (20%) had diffuse lung opacities. In the peak stage, among the 29 patients, 17 (58.62%) had only peripheral lung involvement, 9 (31.03%) had both peripheral and central lung opacities and 3 (10.35%) patients has diffuse lung involvement. Among the 9 patients in absorption stage, 5 (55.56%) had only peripheral lung involvement, 4 (44.44%) had both peripheral and central lung involvement by opacities.

Among the 70 patients examined in our study no patient showed pleural effusion or thoracic lymphadenopathy in HRCT.

Among the 25 patients in progressive stage 2 (8%) had reverse halo sign opacity, 5 (20%) had COPD changes. 7 out of 29 patients (24.14%) in the peak stage had COPD, and among the 9 patients in absorption stage 4 (44.44%) had COPD and 2 (22.22%) had bronchiectasis.

Table-I: Demographic and clinical characteristics of 70 confirmed COVID-19 Pneumonia cases.

Sex	All patients(n=70)
Male	45(64.28%)
Female	25(35.72%)
Age	
mean	53.5
Standard deviation	\pm 15.6
Age Group	
20-40years	14(20%)
41-60 years	33(47.15%)
61-80 years	21(30%)
81-100 years	2(2.88%)
Symptoms	
Fever	70(100%)
Cough	70(100%)
Only fever and cough	13(18.57)
Other associated symptoms like sore throat, chest pain, shortness of breath	57(81.43%)

Table-II: HRCT features of COVID-19 pneumonia cases in different stages of illness.

CT features	Early stage(n=7)	Progressive stage(n=25)	Peak stage (n=29)	Absorption stage (n=09)
Nature of opacity				
GGO	7(100%)	8 (32%)	2(6.9%)	0
GGO+Consolidation	0	5 (20%)	14(48.3%)	1 (11.11%)
Consolidation	0	2 (8%)	10(34.5%)	2 (22.22%)
GGO+Crazy paving	0	9 (36%)	1 (3.5%)	0
Consolidation+Parenchymal bands	0	1 (4%)	2 (6.8%)	06 (66.7%)
Laterality of opacity				
Bilateral	07(100%)	25(100%)	29(100%)	09(100%)
Unilateral	0	0	0	0
Axial distribution of opacity				
Only Peripheral	4 (57.15%)	04 (16%)	17 (58.62%)	05 (55.56%)
Only Central	0	0	0	0
Peripheral and central	3(42.85%)	16 (64%)	09 (31.03%)	04 (44.44%)
Diffuse	0	05(20%)	03 (10.35%)	0
No of lobes involved				
2 lobes involved	1(14.28%)	1(4%)	2 (6.9%)	3 (33.33%)
3 lobes involved	4(57.15%)	3 (12%)	6 (20.7%)	5 (55.55%)
4 lobes involved	1(14.28%)	15 (60%)	16 (55.17%)	2 (22.23%)
5 lobes involved	1(14.28%)	6 (24%)	5 (17.24%)	0
Presence of Pleural effusion	0	0	0	0
Presence of Lymphadenopathy	0	0	0	0
Presence of other underlying lung and airway disease and opacities				
Pulmonary nodules	0	0	0	0
Cavitary lesions	0	0	0	0
Reverse halo sign	0	02/25 (8%)	0	0
Emphysema / COPD	0	05/25 (20%)	07/29 (24.14%)	4/9 (44.44%)
Bronchiectasis	0	0	0	2/9 (22.22%)



1,a

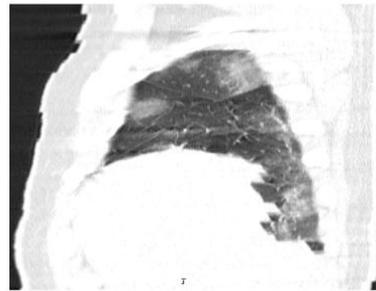


1b

Figure1 (a, b)-41 year old male COVID 19 patient with duration of illness for 4 days (early stage). HRCT shows bilateral multifocal GGO.



2a



2b

Figure 2 (a,b)-56 years old male COVID-19 patient with duration of illness 4 days (early stage). HRCT shows bilateral multifocal peripheral GGO, involving multiple lobes.

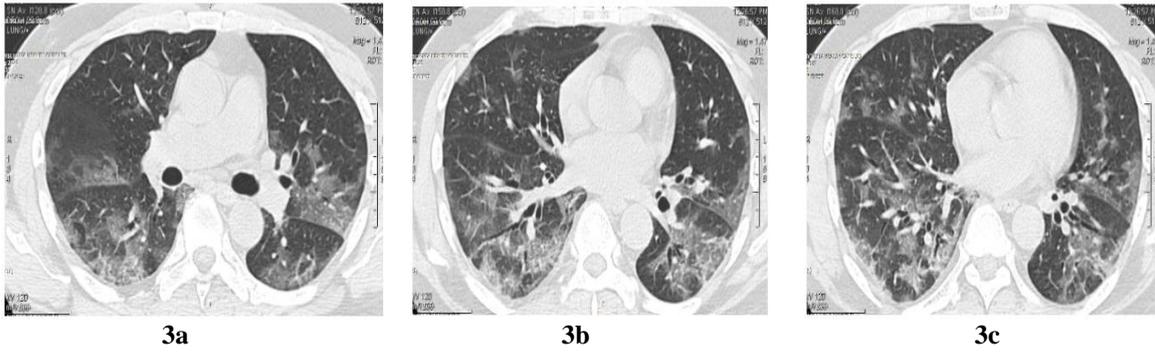


Figure 3 (a,b,c) 56 year old male COVID-19 patient with symptoms for 7 days (progressing stage) . HRCT shows GGO and some GGO in lower lobes with septal thickening (crazy paving).

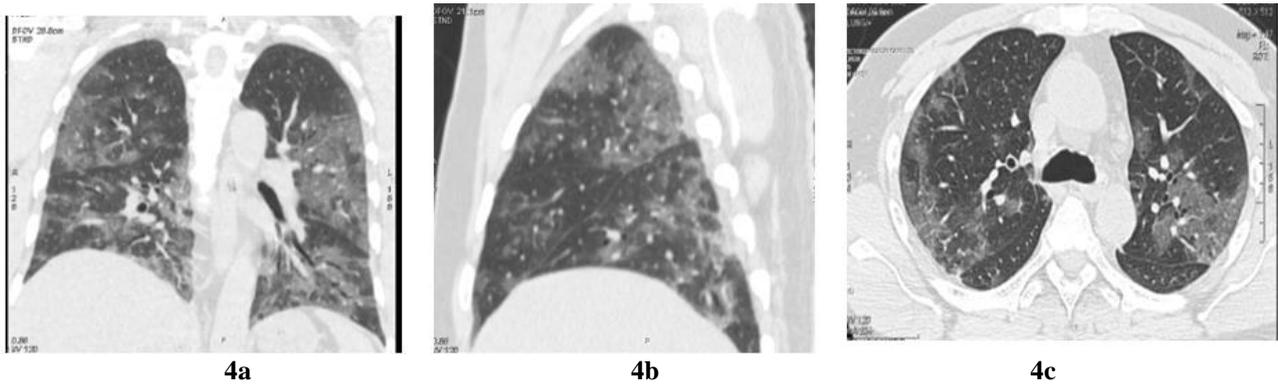


Figure 4 (a,b,c) Male COVID-19 patient with duration of illness for 8 days (progressive stage). HRCT shows bilateral GGO involving multiple lobes in both peripheral and central locations.

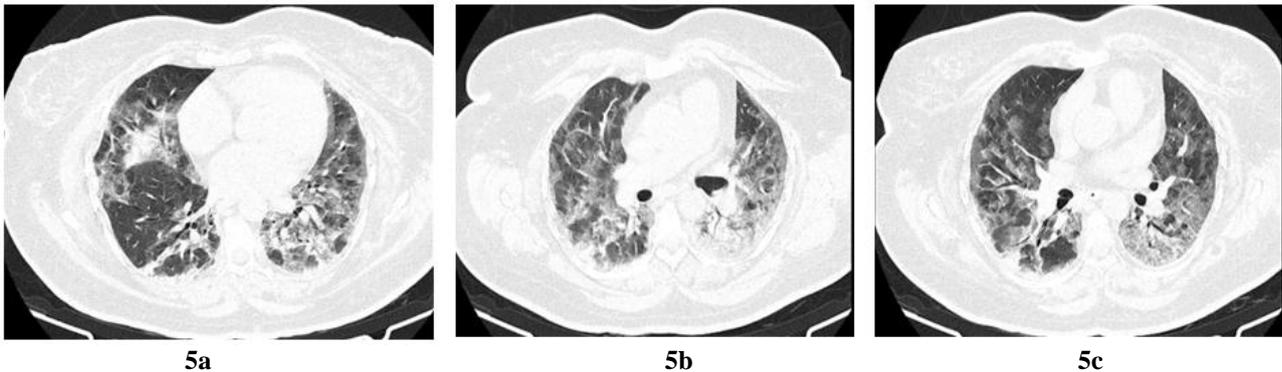


Figure 5 (a,b,c): 52 years old female COVID-19 patient with symptoms for 11 days (Peak stage). HRCT shows bilateral GGO and consolidations, involving multiple lobes and in a diffuse pattern.

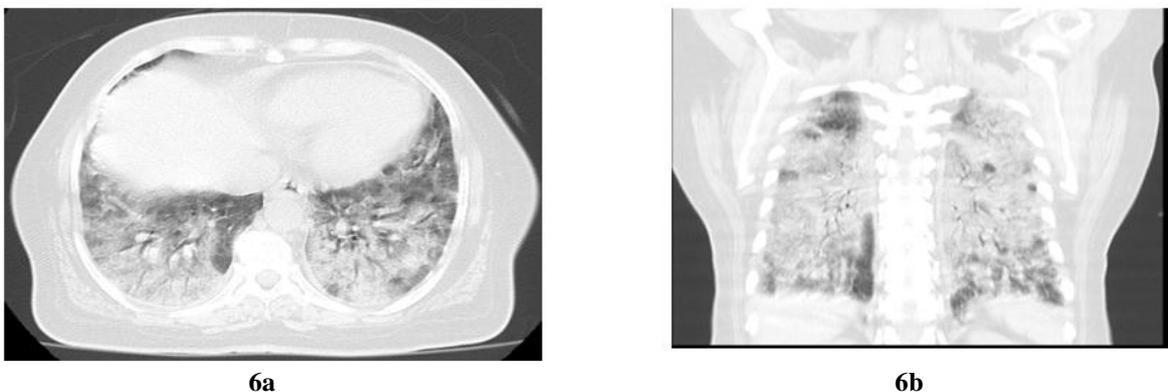


Figure 6(a,b) 58 years female COVID-19 patient with symptoms for 12 days (peak stage). HRCT shows bilateral consolidations, involving both lower lobes.

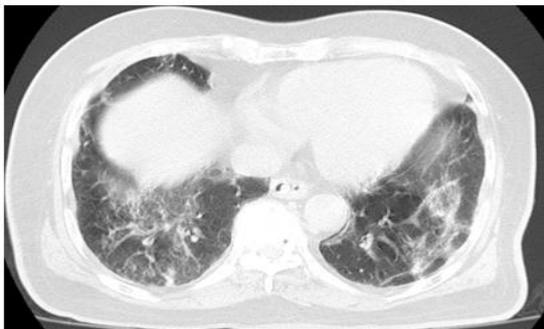


7a

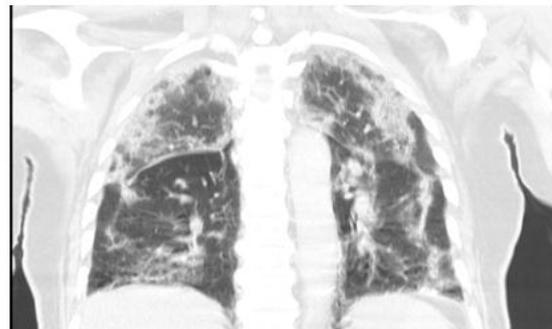


7b

Figure 7 (a,b) 36 years old female COVID-19 patient with duration of symptoms for 11 days (Peak stage). HRCT shows bilateral consolidations.



8a



8b

Figure 8 (a,b) 70 years old male COVID-19 patient with duration of illness for 18 days (absorption stage). HRCT shows bilateral areas of consolidation and parenchymal bands involving multiple lobes and in both peripheral and central locations.

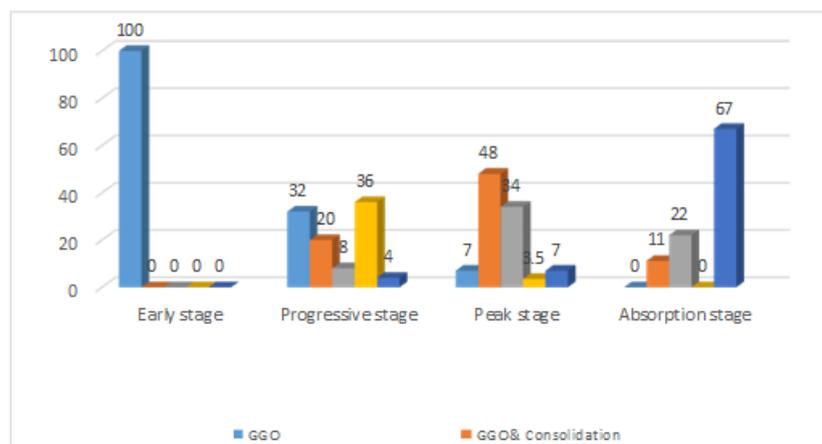


Fig-9: Bar graph shows frequency of chest HRCT findings in relation to duration of illness.

DISCUSSION

We investigated the HRCT imaging features of RT-PCR confirmed COVID-19 patients in relation to the disease course with a sample of 70 patients. The purpose of this study was to determine the radiological imaging features in chest HRCT of COVID-19 patients at different stages of the course of illness. The major pulmonary CT findings of COVID-19 patients were ground-glass opacities, crazy-paving pattern, and consolidation predominantly in peripheral locations in the lower lobes. The typical COVID-19 mainly starts as small subpleural unilateral or bilateral GGOs in the lower lobes, which then develops into the crazy-paving pattern and

subsequent consolidation. After more than 2 weeks, the lesions are gradually absorbed with residual consolidation and subpleural parenchymal bands. In COVID-19 patients, four stages of lung involvement were defined on HRCT scans.^[12,13,14,15] In Early stage (0–4 days after the onset of initial symptoms), GGO was the main radiological finding, as all the 7 patients of this stage in our study had GGO in their chest HRCT scan. In progressive stage (5–8 days after the onset of initial symptoms), the HRCT chest showed GGO, crazy-paving pattern, and consolidations.^[11] In our study we found 8 (32%) cases where GGO was present and 9 (36%) cases who had both consolidation and crazy paving and 5

(20%) cases with GGO and consolidation on HRCT scan. In Peak stage (9–13 days after the onset of the initial symptoms), findings included diffuse GGO, crazy-paving pattern, consolidation, and residual parenchymal bands.^[11] Our predominant findings are in concordance with this study as we also found 14 (48.3%) cases of this stage had GGO with consolidation and 10 (34.5%) patients had only consolidation. In absorption stage (14 days or more after the onset of initial symptoms), the infection was controlled and the consolidation was gradually absorbed. However, patients in this stage showed residual consolidations and parenchymal bands.^[11] Similarly in our study out of the 9 patients in this stage, HRCT scan of 6 (66.67%) showed consolidation with parenchymal bands.

In our study all the 70 patients had bilateral lung involvement and multiple (2 or more) lobe involvement by opacity. Maximum patients (57.15%) in the early stage had peripheral lung involvement, in the progressive stage majority of patients (64%) had both peripheral and central involvement, while in the peak stage and absorption stage most patients (58.6% and 55.56% respectively) had peripheral involvement, which coincides well with other previous studies.^[10,11] Few patients had previous underlying lung and airway diseases like COPD and bronchiectasis. The study had some limitations. The percentage of lung affected and CT severity scoring was not included in this study. The sample size of the study was small.

CONCLUSION

Chest HRCT of COVID-19 patients shows significant patterns of opacity in different stages of the course of illness. These patterns of HRCT findings are very much helpful for detecting COVID-19 pneumonia. The main HRCT findings of COVID-19 pneumonia on HRCT included GGO, GGO with crazy paving, GGO with consolidation, and consolidations with parenchymal bands.

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