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ORIGINAL RESEARCH

Typical and atypical chest CT findings in COVID–19 RTPCR positive patients

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ABSTRACT

Introduction:COVID-19 usually manifests clinically as pneumonia with predominant imaging findings of an atypical or organizing pneumonia. The standard technique for confirming COVID-19 is molecular testing by RT-PCR however chest imaging by CT scan can show signs of pneumonia in patients with negative RT-PCR and results can be achieved significantly faster, thus offering a potential role in supporting rapid decision making. CT scan has been shown to have more sensitivity than RT-PCR and Chest X-ray. CT Severity scoring also helps in better assessment of severity of disease.

Aim: To estimate typical and atypical chest CT findings in COVID-19 RTPCR positive patients for better assessment of the role of chest CT in COVID-19 management.

Materials andMethods:100 patients with confirmed COVID-19 were included in study. Findings like ground glass haze (GGO), reticulations, crazy paving appearance, consolidation, subpleural curvilinear line, bronchiectasis, subpleural transparent line, vascular enlargement, mediastinal lymphadenopathy, nodules, pleural effusion, Inverted halo sign, Halo sign and pericardial effusion were documented in them and analysis was done.

Results: The typical Chest CT features present in our COVID-19 cases were GGO in 93 patients (93%), reticulations in 71 patients (71%), crazy paving appearance in 59 patients (59%), consolidation in 47 patients (47%), subpleural curvilinear line in 39 patients (39%), bronchiectasis in 37 patients (37%) and subpleural transparent line in 30 patients (30%). Most cases had bilateral (98%), peripheral (57%) and patchy involvement (86%) by GGO and lower lobe predominance (55%) by consolidation.

Conclusion:GGO, reticulations, crazy paving and consolidation involving bilateral lung, in a peripheral and patchy distribution with lower lobe predilection are the typical findings on chest CT in COVID-19. Chest CT scan may act as a quick diagnostic tool with high sensitivity taking into consideration that almost all COVID-19 patients demonstrate typical features.

Keywords: Consolidation, Crazy paving appearance, Ground glass haze, Reticulations, Subpleural curvilinear line, Subpleural transparent line.

Introduction: The novel human coronavirus disease COVID-19 was first reported in Wuhan, China in December 2019.The disease rapidly spread throughout the world and was declared a pandemic by the World Health Organization (WHO) on March 12, 2020 [1,2].It is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [3].It affects both upper as well as lower respiratory tract. It usually manifests clinically as pneumonia with predominant imaging findings of an atypical or organizing pneumonia[4].

The chest imaging findings of COVID-19 were first published in January 2020 and included bilateral lung involvement and ground-glass opacities in the majority of hospitalized patients [5].Many patients affected with SARS-CoV-2 are asymptomatic. It is highly infectious and asymptomatic patients may act as super spreaders [6]. Rapid detection of COVID-19 is therefore vital for early treatment of patients and more importantly for quick isolation of the patients to stop the chain of contamination.

Nowadays, the standard technique for confirming COVID-19 is molecular testing by real-time polymerase chain reaction (RT-PCR)[7].It is used in both symptomatic and asymptomatic subjects. However, its relatively long processing time can interfere with the control of the pandemic. Additionally, several elements may influence RT-PCR test results such as specimen type (upper or lower respiratory tract) and collection procedures, as well as the performance of the detection kits [8,9,10].Many countries also don't have resources to conduct RT-PCR at large scale in pandemic. Conversely, imaging can show signs of pneumonia in patients with negative RT-PCR and results can be achieved significantly faster, thus offering a potential role in supporting rapid decision making [10,11].

The choice of imaging technique in COVID-19 is still a matter of debate. Chest X-Ray (CXR) as a screening modality not only gives faster results but bedside CXR also reduces COVID-19 exposure to other patients and staff. In times of global pandemic when patient load is high, CXR is helpful as a quick tool for screening, to assess severity of disease and follow up in severely ill patients [11,12].

CXR however has its limitations as a normal CXR does not rule out COVID pneumonia.CXR are usually of limited value in the diagnosis of early stages especially in mild disease; however, the CT findings may be present early even before the onset of the symptoms [11].CT scan has been shown to have more sensitivity than RTPCR and CXR. CORADS andCT Severity scoring also helps in early diagnosis and better assessment of severity of disease than CXR [9,11].Chest CT provide benefit for diagnosis of COVID-19 taking into consideration that almost all COVID-19 patients demonstrate typical features including ground glass opacities (GGO), peripheral multifocal patchy consolidation, and/or interstitial changes [13,14].

CT scan also has its own limitations as availability of CT scan machine islimited and CT scan machine also requires extensive disinfection measures. It also cannot be used on frequent basis for follow up of ICU patients [15].CT scan is also costly investigation as compare to CXR. However CT scan may act as a quick diagnostic tool with high sensitivity in clinically suspected patients. Therefore the purpose of our study was to estimate typical and atypical Chest CT findings in COVID-19 positive patients for better assessment of the role of CT in COVID-19 management.

Material and methods: This prospective study was conducted from 1 April 2021 to 30 June 2021 in Muzaffarnagar Medical College & Hospital, after approval from institutional ethical committee on COVID-19 RTPCR positive patients admitted in the isolation and ICU ward who underwent CT scan on request of clinician. A total of 100 patients (55 male, 45 female; mean age 50.8 years) were included in the study. Patients were excluded if previous known structural lung disease waspresent to avoid overlap from previous lung diseases.

All patients underwent non-contrast-enhanced chest CT in the radiology department using a Siemens 16-channel scope. All volumetric chest CT were assessed at lung window of 1500 WW and − 500 WL and mediastinal window of 400 WW and 60 WL using 2D coronal and sagittal planes for better assessment of the extent of the disease.

Imaging findings were analyzed independently by two radiologists with experience of 10 years and 6 years respectively. Findings in patients i.e. ground glass haze (GGO), reticulations, crazy paving appearance, consolidation, subpleural curvilinear line, bronchiectasis,subpleural transparent line, vascular enlargement, mediastinal lymphadenopathy, nodules, pleural effusion, Inverted halo sign, Halo sign and pericardial effusion were documented.

The GGO were classified as regards peripheral or central predominance, bilateral or unilateral involvement, patchy or diffuse involvement and anterior or posterior predominance. Consolidation was classified as bilateral or unilateral involvement and lower lobe or upper lobe predominance.

The CT severity score was calculated based on the extent of lobar involvement. Each of the five lung lobes was visually scored on a scale of 0–5, with 0 indicating no involvement, 1 indicating less than 5% involvement, 2 indicating 5–25% involvement, 3 indicating 26–49% involvement, 4 indicating 50–75% involvement, and 5 indicating more than 75% involvement. The total CT score was the sum of the individual lobar scores and ranged from 0 (no involvement) to 25 (maximum involvement)[14].

Statistical analysis: Data was collected and subjected to statisical analysis using SPSS software version 24.

Results: A total number of 100 patients were taken for the study. All patients were confirmed positive for COVID-19 through RT-PCR test. The age of patients ranged from 22 years to 86 years with mean age 50.8 years. Total male patients were 55 & female patients were 45 in our study. Most common age group was 50-59 years (23%) in our study [Table/Fig-1].

Table/Fig-1: Age and sex wise distribution of the patients.

Age (years)	Male	Female	Total
0-19	0	0	0
20-29	7	7	14
30-39	6	3	9
40-49	12	11	23
50-59	16	7	23
60-69	3	10	13
70-79	10	5	15
80-89	1	2	3
Total	55	45	100

96 patients showed abnormal findings out of 100 patients. Among the abnormal findings; most common was GGO in 93 patients (93%) followed by reticulations in 71 patients (71%), crazy paving appearance in 59 patients (59%), consolidation in 47 patients (47%), subpleural curvilinear line in 39 patients (39%), bronchiectasis in 37 patients (37%), subpleural transparent line in 30 patients (30%), vascular enlargement in 13 patients (13%), mediastinal lymphadenopathy in 5 patients (5%), nodules in 4 patients (4%), pleural effusion in 2 patients (2%) and Inverted halo sign in 2 patients (2%). Halo sign and pericardial effusion were not noted in any patients [Table/Fig-2].

Table/Fig-2: Imaging Characteristics on Chest CT Scans.

Characteristic	No. of patients(n = 100)
Ground glass opacity	**93**
Peripheral predominance Central predominance Neither	53 (57%) 1 (1%) 39 (42%)
Bilateral Unilateral	91 (98%) 2 (2%)
Patchy Diffuse	80 (86%) 13 (14%)
Anterior Posterior Both	1 (1%) 18 (19%) 74 (80%)
Consolidation	**47(47%)**
Upper/middle lobe predominance Lower lobe predominance Neither	2 (4%) 26 (55%) 19 (41%)
Bilateral Unilateral	42 (89%) 5 (11%)
Reticulations	**71 (71%)**
Crazy paving appearance	**59 (59%)**
Subpleural curvilinear line	**39 (39%)**
Bronchiectasis	**37(37%)**
Subpleural transparent line	**30 (30%)**
Vascular enlargement	**13 (13%)**
Mediastinal lymphadenopathy	**5 (5%)**
Nodules	**4 (4%)**
Pleural effusion	**2 (2%)**
Inverted halo sign	**2 (2%)**
Halo sign	**0 (0%)**
Pericardial effusion	**0 (0%)**

The mean total lung severity score for the 100 patients was 14.11 (range 0–25). The mean lung severity score for RUL, RML, RLL, LUL and LLL were 2.65, 2.41, 3.27, 2.6 and 3.16 respectively. 94 of the 96 patients (98%) had bilateral lung disease and 2 patients (2%) had unilateral lung involvement. 87 patients (91%) had involvement of all five lobes, 5 patients (5%) had involvement of four lobes, 2 patients (2%) had involvement of three lobes, 1 patient (1%) had involvement of two lobes and 1 patient (1%) had involvement of one lobe. The right upper lobe was involved in 94 patients (98%), right middle lobe was involved in 88 patients (92%), right lower lobe was involved in 96 patients (100%), left upper lobe was involved in 91 patients (95%) and left lower lobe was involved in 94 patients (98%) [Table/Fig-3].

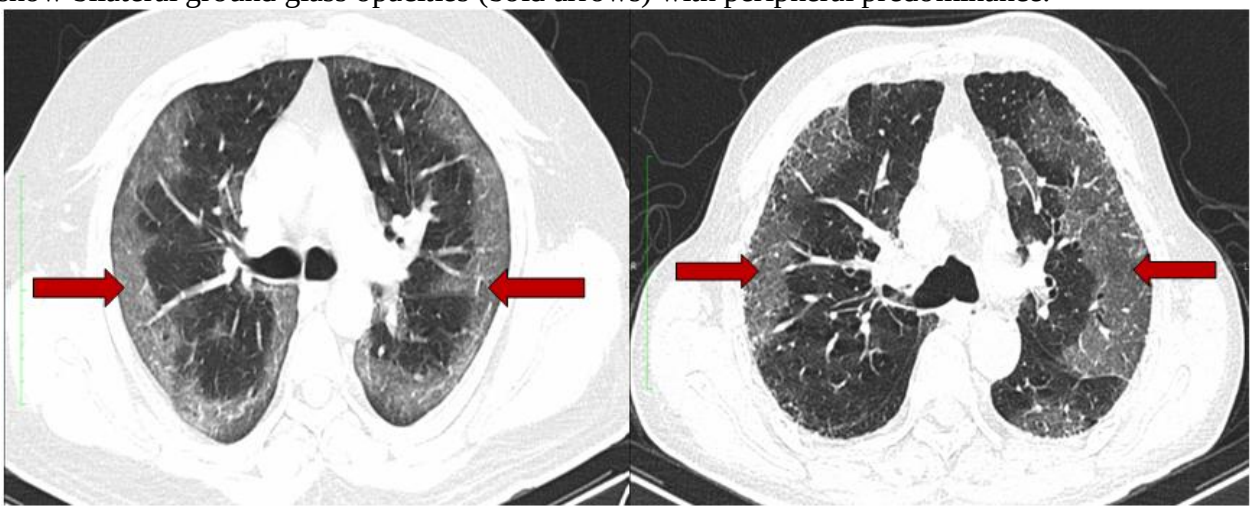
Table/Fig-3: Findings on Chest CT scans

Findings	No. of patients(n = 100)
Chest Findings	
Abnormal	96
Normal	4
GGO and consolidation	
Presence of either or both GGO consolidation	94

Presence of GGO without consolidation	47
Presence of GGO with consolidation	46
Presence of consolidation without GGO	1
Absence of both GGO and consolidation	6
No. of lobes affected	
1	1 (1%)
2	1 (1%)
3	2 (2%)
4	5 (5%)
5	87 (91%)
Bilateral lung disease	**94 (98%)**
Unilateral lung disease	**2 (2%)**
Frequency of lobe involvement	
Right upper lobe	94(98%)
Right middle lobe	88(92%)
Right lower lobe	96(100%)
Left upper lobe	91(95%)
Left lower lobe	94(98%)
CT severity score(Mean)	
Right upper lobe	2.65
Right middle lobe	2.41
Right lower lobe	3.27
Left upper lobe	2.6
Left lower lobe	3.16
Total	14.11

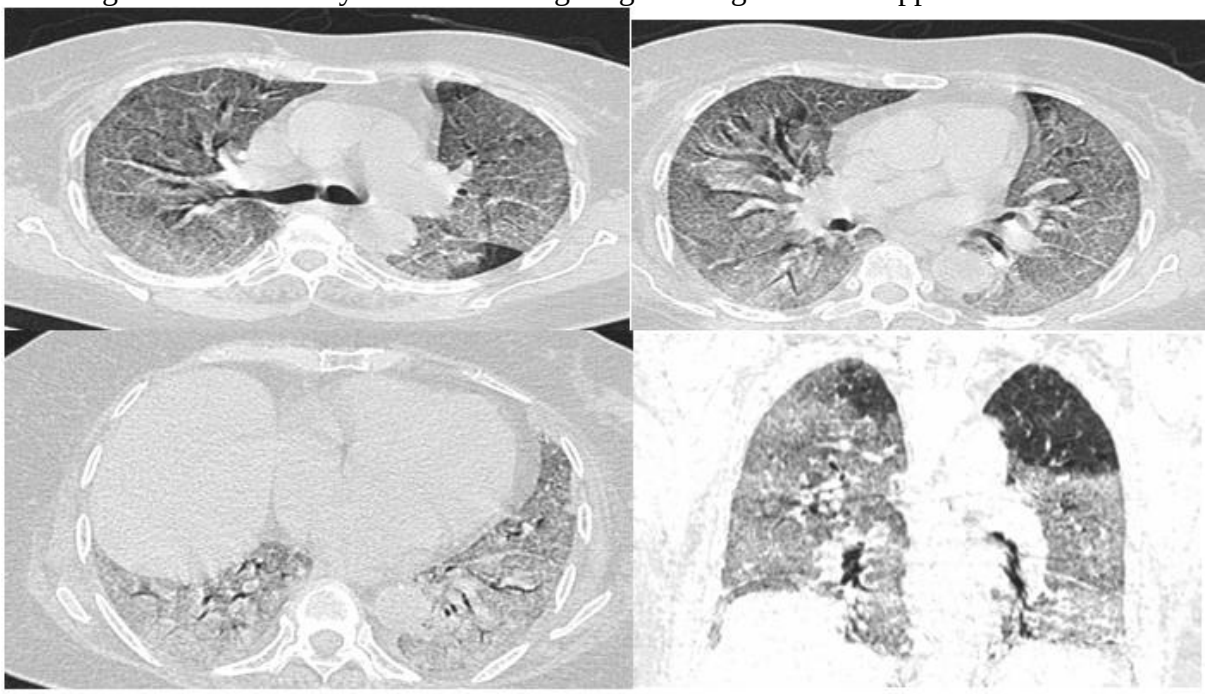
GGO was seen in 93 patients. Most cases showed peripheral predominance (53 patients, 57%) [Table/Fig-4], while 1 patient (1%) had central predominance and 39 patients (42%) had neither predominance [Table/Fig-5], 91 patients (98%) showed bilateral involvement and 2 patients (2%) showed unilateral involvement. 80 patients (86%) had patchy involvement and 13 patients (14%) had diffuse involvement of lung [Table/Fig-5].

Table/Fig-4: (A) 61-year-old female and (B) 77-year-old male COVID 19 RT-PCR positive patients complain of fever with cough and shortness of breath. Axial unenhanced CT images show bilateral ground glass opacities (bold arrows) with peripheral predominance.



(A) **(B)**

[Table/Fig-5]: A 72-year-old female COVID 19 RT-PCR positive patient with white lung. Axial and coronal unenhanced CT images show ground glass infiltration diffusely affecting both lungs with CT severity score of 24/25 giving the lung white out appearance.



Most cases showed both anterior and posterior predominance (74 patients, 80%), while 1 patient (1%) had anterior predominance and 18 patients (19%) had posterior predominance [Table /Fig 2].

Consolidation was seen in 47 patients, 42 patients (89%) showed bilateral involvement and 5 patients (11%) showed unilateral involvement. Most cases showed lower lobe predominance (26 patients, 55%), while 2 patients (4%) had upper/middle lobe predominance and 19 patients (41%) had neither predominance [Table/Fig-2].

Out of the 100 patients, 94 patients had either or both GGO or consolidation, 47 patients had only GGO without consolidation, 46 patients had GGO with consolidation and only 1 patient had consolidation in the absence of GGO [Table/Fig-3].

Discussion: RT-PCR has been the gold standard test for diagnosing COVID-19, however due its limited availability and delay in reporting in high patient load scenarios, the usefulness of other diagnostic method was sought [7].Chest CT is a vital component in the diagnostic algorithm for patients suspected of having COVID-19 infection. Indeed, given the limited number of RT-PCR kits in some centers and the possibility of false-negative RT-PCR results, the National Health Commission of the People's Republic of China has encouraged diagnosis based on clinical and chest CT findings alone [15]. Chest CT scan is more sensitive diagnostic tool even in asymptomatic patients with sensitivity reaching 98% as compared to RTPCR and CXR sensitivity of about 71% and 69% respectively [10,16].Chest CT also helps in better assessment of severity of COVID-19 pneumonia by CT severity scoring.

In this study, we evaluated Chest CT findings in the COVID-19 RT-PCR positive patients. Chest CT was normal in 4 out of the total 100 patients. Ai et al also reported 21 out of 601 (3%) RT-PCR-positive patients with clinical symptoms had normal CT scan [9].

Total male patients were 55 & female patients were 45 in our study. This agreed with study by Jacob O'Brien et al who concluded that females have a lower COVID-19 incidence and fatality rates [17]. Most common age group was 50-59 years (23%) in our study. This

concurred with studies conducted in the past that COVID-19 cases are much more common in older age than younger age groups [17].

The most common finding in our study was GGO in 93% patients. Bao et al conducted a meta-analysis of 13 studies and found that GGO was the most common finding and present in 83.31% of COVID-19 cases [18]. Another meta-analysis by Zhu et al involving 4121 patients also showed that GGO was most common finding and present in 68.1% of COVID-19 cases [19]. Most cases of GGO in our study showed bilateral (98%), peripheral (57%) and patchy involvement (86%) of lung. GGO is usually described in literature as patchy, peripheral, bilateral, and subpleural in cases of COVID-19 [20].

Reticulations were seen in 71% patients in our study. It appears as linearinterlobular or intralobular density. It is a relatively late finding in patients with COVID-19, and its reported incidence is 48.5–59% [21].The reticulations are probably caused by lymphocyte infiltration of the interstitial tissues with interlobular and septal thickening.

The crazy paving sign was seen in 59 patients (59%) in our study. It represents thickened interlobular or intralobular septa superimposed on GGO. Guan et al. reported 89.4% incidence of crazy paving sign in his study [22]. The crazy paving sign is a sign of progressive disease and its appearance may indicate that the disease is entering the peak stage, yet it is the first CT sign to resolve in the absorptive stage while the consolidation and GGO may persist for up to 26 days [22].

Consolidationwas seen in 47 patients (47%) in our study. Most cases of consolidation showed bilateral involvement (89%) with lower lobe predominance (55%). These findings are largely similar with previous studies where peripheral and bilateral pattern of ground-glass and consolidative pulmonary opacities emerged as the chest CT hallmark of COVID-19 infection [23]. This also agreed with Lomoro et al. study on 32 patients of COVID-19 disease; they found bilateral lung affection (78.1%) and lower zone involvement (52%) [24].

Subpleural curvilinear line [Table/Fig-11] appears as thin linear shadow 1–3 mm in thickness, parallel to and lying within 1 cm from the pleural surface. Subpleural curvilinear line was seen in 39 patients (39%) in our study. Zhou et al study reported subpleural curvilinear line in 33.9% patients, and it was more common in advanced disease than early disease [25,26].

Bronchiectasis [Table/Fig-5]was seen in 37 patients (37%) in our study. Zhao et al. [27] reported bronchiectasis in 52.5% of their patients, and they considered this sign, together with architectural distortion and pleural effusion, a reflection of the severity of the disease.

Subpleural transparent linewas present in 30 patients (30%) in our study. It is defined as thin and transparent line between the areas GGO or consolidation and the visceral pleura. Another study by Zhou et al.involving100 patients described transparent line in 45.3% patients in the early stage, 47.7% in the advanced stage, and 6.5% in the absorption stage[26].

Vascular enlargement was seen in 13 patients (13%) in our study. Vascular enlargement has been correlated to hyperemia induced by acute inflammatory response and the disruption of the capillary wall inflammatory mediators [28].It was seen in 23.8% patients in study by Lomoro et al [24].

Chest CT findings such as mediastinal lymphadenopathy (5%), nodules (4%), pleural effusion (2%) and Inverted halo sign (2%)were not typically observed in our study. Halo sign and pericardial effusion were also not noted in any patient. It is consistent with previous research like Ng et al. study who reported that solid pulmonary nodules, cavitation, pleural effusions, and mediastinal and hilar lymph node enlargement were not typically observed in COVID-19 [29].

There were some limitations to our study. First, many patients in our study had received treatment before CT scan (antibiotics, iv fluid administration, or steroid therapy that may affect chest CT findings). Our study also had selection bias in terms of which patients

underwent CT. Clinically ill patients were more likely imaged to know the severity of disease.

Conclusion: Chest CT scan is a sensitive tool for diagnosing COVID-19. It also helps in better assessment of severity of COVID pneumonia. GGO, reticulations, crazy paving and consolidation involving bilateral lung, in a peripheral and patchy distribution with lower lobe predilection are the typical findings on chest CT in COVID-19. Subpleural curvilinear line, bronchiectasis, subpleural transparent line and vascular enlargement are also frequently seen in COVID-19. Mediastinal lymphadenopathy, nodules, pleural effusion, Inverted halo sign, Halo sign and pericardial effusion are not typically observed in COVID-19 cases. Hence chest CT scan may act as a quick diagnostic tool with high sensitivity taking into consideration that almost all COVID-19 patients demonstrate typical features.

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