ORIGINAL ARTICLE

Myriad thoracic computed tomography manifestations of coronavirus disease 2019 with assessment of its evolving abnormalities: A retrospective study

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Introduction: Coronavirus disease 2019 (COVID-19), has caused havoc in the world after originating from the Wuhan, China in December 2019 and was declared as global pandemic by World Health Organization (WHO) in March 2020. The WHO's records say that there have been 233,136,147 confirmed cases of COVID-19, including 4,771,408 deaths upto September 30, 2021. In India there have been 33,739,980 confirmed cases of COVID-19, including 448,062 deaths. This study is aimed at characterizing the typical and atypical radiological manifestations of COVID-19. COVID-19 is an evolving abnormality and imaging manifestation have an indispensable role in management and diagnosis in addition to the molecular tests. **Aims and Objectives:** To identify different high-resolution computed tomography (HRCT) features in typical and atypical radiological features in pulmonary COVID-19 infection. To correlate computed tomography findings with clinical profile for assessment of prognosis. **Materials and Methods:** It was a retrospective observational study done on 100 patients who presented in the department of Radiodiagnosis, Rohilkhand Medical College and hospital, Bareilly, Uttar Pradesh, which was designated level III COVID-19 Care Centre with separate inpatient, intensive care unit and quarantine facilities. **Results:** In our study, we found that ground glass opacities (GGO) was the major finding in the HRCT thorax with involvement of 70 (70%) cases. Mixed consolidation and GGO was seen in 16 (16%) cases and consolidation with minimal GGO was seen in 9 (9%) cases. Presence of acute respiratory distress syndrome was seen in the 2 (2%) cases. Presence of atypical features like pneumothorax, pleural effusion and nodules was seen in 2 (2%) cases and only 1 case showed the presence of cavitatory lesions along with consolidation and GGO. **Summary and Conclusion:** The typical imaging appearance of COVID-19 pneumonia is bilateral peripheral ground-glass opacities with a lower lobar predominance. In conclusion we can say that radiological correlation helps in better understanding of clinical course of COVID-19 pneumonia and provides a better insight towards the pathophysiology and clinical manifestations along with its prognostic implications.

KEY WORDS: COVID 19, HRCT, GGO

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INTRODUCTION

Coronavirus disease 2019 (COVID-19), has caused havoc in the world after originating from the Wuhan, China in December 2019 and was declared as global pandemic by World Health Organization (WHO) in March 2020.[1] WHO's records say that there have been 233,136,147 confirmed cases of COVID-19,

including 4,771,408 deaths upto September 30, 2021. In India there have been 33,739,980 confirmed cases of COVID-19, including 448,062 deaths.

COVID-19 is an ongoing pandemic. We have already witnessed two waves with slightly different radiological manifestations. Moreover, new computed tomography (CT) manifestations are being increasingly recognized. Recent Medical literature is replete with articles discussing the imaging manifestations of COVID-19 [Figures 1-3]. Symmetrical peripheral ground-glass opacities in a suspected patient who has history of lower respiratory tract infection has been described as a prototype imaging manifestations.

Consolidation in addition to ground-glass abnormalities is another common imaging manifestation [Figure 4]. The presence of nodules, cavitatory lesions and pleural effusions are less commonly seen. Primarily, imaging has been used in assessment of the disease burden and to assess the extent of lung involvement. In certain circumstances, high-resolution CT (HRCT) thorax was also used for diagnosis of COVID-19 infection. This study is aimed at characterizing the typical and atypical radiological manifestations of COVID-19. COVID-19 is an evolving abnormality and imaging manifestation have an indispensable role in management and diagnosis in addition to the molecular tests.

Aim

To identify different HRCT features in typical and atypical radiological features in pulmonary COVID-19 infection.

Objectives

- To evaluate CT findings in typical and atypical radiological features in pulmonary COVID-19 infection
- To correlate CT findings with clinical profile for assessment of prognosis [Figures 5 and 6].

MATERIALS AND METHODS

It was a retrospective observational study done on 100 patients who presented in the department of Radiodiagnosis, Rohilkhand Medical College and hospital, Bareilly, Uttar Pradesh, which was designated level III COVID-19 Care Centre with separate inpatient, intensive care unit and quarantine facilities.

RESULTS AND OBSERVATIONS

Demographics, Clinical and Laboratory Parameters

Among 100 patients, mean age was 42 years with 62 (62%) males and 38 (38%) females. All were in the range of 21–65 years. Eighty patients (80%) had recent history of contact with COVID-19 patient or travel to zones which were categorized as high risk. Fever with involvement of 58 (58%) cases was the most common clinical feature seen followed by malaise/fatigue (42%), cough (40%), increased respiratory rate of more than 30/min (38%), reduced oxygen saturation of <90% (32%), dyspnea (31%) and sore throat (30%).

On analyzing the associated comorbities, diabetes mellitus was associated with maximum patients (40%) followed by hypertension (20%), chronic liver disease (10%) and rheumatoid arthritis (5%). Among laboratory investigations, lymphopenia was observed in 30 cases (30%) and 12 (12%) cases showed

Table 1: Patient characteristics, clinical parameters and laboratory findings for covid-19 infected patients

Patient demographics (*n*=100)	
Mean age (years)	42
Gender	
Male	62
Female	38
History of contact with patient of COVID-19 or travel to high risk zone	
Present	80
Absent	20
Associated comorbidity	
Hypertension	20
Diabetes mellitus	40
CLD	10
Rheumatoid arthritis	5
Clinical features	
Fever	58
Cough	40
Sore throat	30
Dyspnea	31
Malaise/fatigue	42
Increased respiratory rate (>30/min)	38
Reduced oxygen saturation (<90%)	32
Lab investigations	
Lymphocyte count	
Increased	12
Decreased	30
Increased CRP	51

CLD: Chronic liver disease, CRP: C-reactive protein

Table 2: Findings on chest CT-scans

Findings (*n*=100)	
GGO's and consolidation	
Presence of only GGO	70
Presence of mixed consolidation and GGO	16
Presence of consolidation with minimal GGO	9
Typical pattern of acute respiratory distress syndrome	2
Presence of cavitatory lesions with consolidation and GGO	1
Presence of atypical features (pneumothorax, pleural effusion and nodules)	2
Total lung severity score	
Mean	8

CT: Computed tomography, GGO: Ground glass opacities

Table 3: Distribution of lung findings on chest CT

Laterality of lung involvement	
Bilateral	70
Right lung	16
Left lung	14
Number of lobes involved	
1	11
2	12
3	7
4	22
5	48
Lobar involvement	
Right upper lobe	72
Right middle lobe	50
Right lower lobe	80
Left upper lobe	70
Left lower lobe	75

CT: Computed tomography

Table 4: Imaging characteristics on chest CT scans

Findings (*n*=100)	
Opacity characteristics	
Linear opacities	10
Round shape opacities	48
Lung cavitation	1
Crazy-paving pattern	6
Reverse halo sign	3
Opacity distribution	
Central distribution	2
Peripheral distribution	65
Airways	
Bronchial wall thickening	20
Bronchiectasis	5
Airway secretions	7
Other findings	
Pulmonary nodules	1
Pleural effusion	1
Thoracic lymphadenopathy	0

CT: Computed tomography

lymphocytosis. Elevated C-reactive protein was observed in 51 (51%) cases [Table 1].

Chest CT Findings

In our study, we found that ground glass opacities (GGO) was the major finding in the HRCT thorax with involvement of 70 (70%) cases. Mixed consolidation and GGO was seen in 16 (16%) cases and consolidation with minimal GGO was seen in 9 (9%) cases. Presence of acute respiratory distress syndrome was seen in the 2 (2%) cases. Presence of atypical features like pneumothorax, pleural effusion and nodules was seen in 2 (2%) cases and only 1 case showed the presence of cavitatory lesions along with consolidation and GGO.

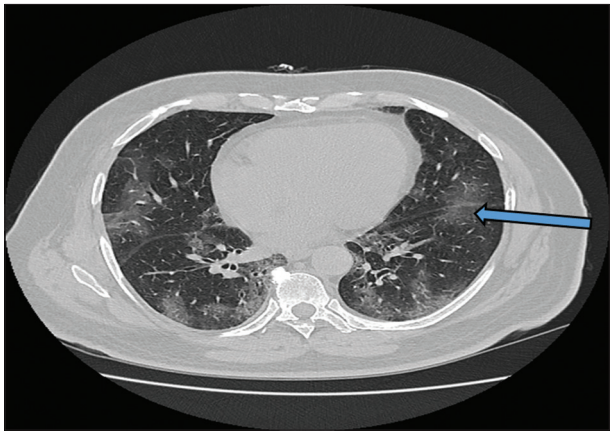

Figure 1: A 21 year old male patient presented with fever and cough for last 5 days. Axial high-resolution computed tomography image (lung window) shows bilateral patchy ground-glass opacities predominantly in the peripheral regions in left upper lobe and right upper and middle lobes

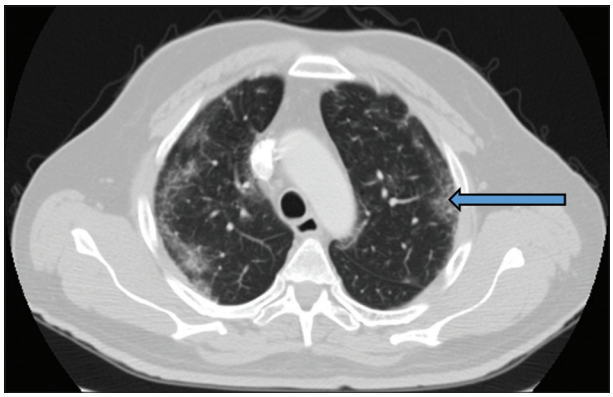

Figure 2: A 35 year old male patient presented with a history of fever, cough and dyspnea for last 7 days. Axial high-resolution computed tomography image (lung window) shows peripherally diffuse ground-glass opacities in both the lung fields

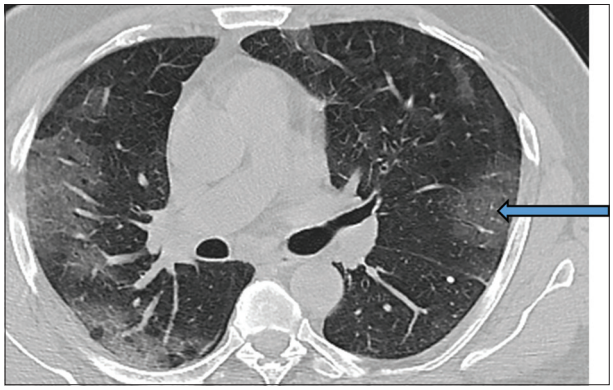

Figure 3: A 30 year old female patient presented with cough, myalgia and shortness of breath for last 7 days. Axial high-resolution computed tomography image (lung window) shows peripherally diffuse ground-glass opacities involving both the lung fields predominantly in right lung field

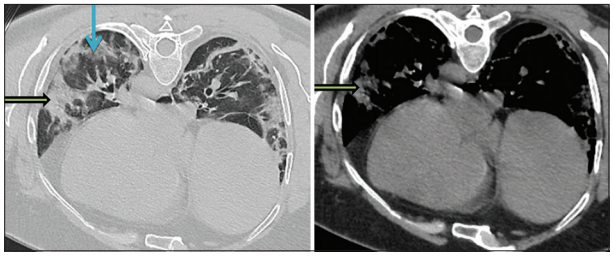

Figure 4: A 45 year old male patient presented with cough, myalgia and shortness of breath for last 7 days. Axial high-resolution computed tomography image in prone position (lung window) shows consolidation(green arrow) in bilateral lung fields posteriorly and subtle ground-glass opacities(blue arrow) located peripherally in both the lung field

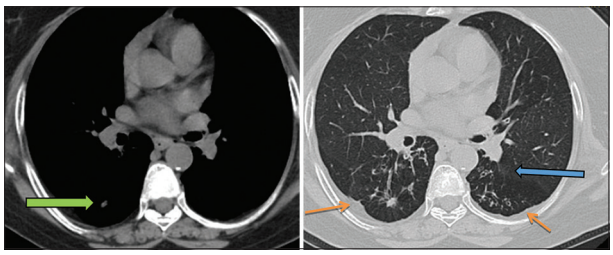

Figure 5: A 40 year old female patient presented with a history of fever and dyspnoea for last 8 days. Axial high-resolution computed tomography image (lung window) shows consolidation (green arrow) in bilateral lung fields posteriorly and subtle ground-glass opacities (blue arrow) located peripherally in left lung field. Bilateral minimal pleural effusion (orange arrows) is also seen in the both lower lobes

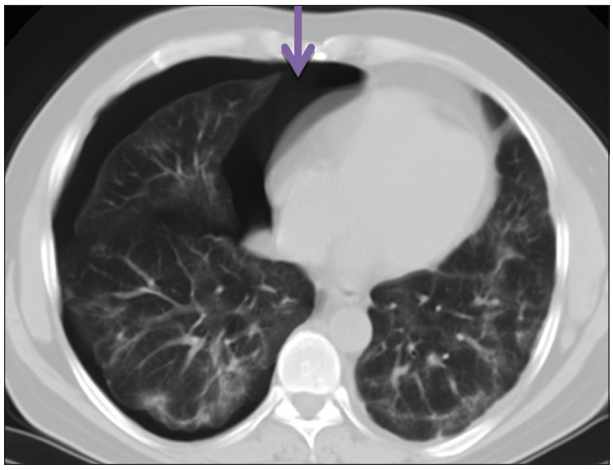

Figure 6: A 30 year old male patient presented with a history of fever, cough, fatigue, chest pain and dyspnea for last 4 days. Axial high-resolution computed tomography image (lung window) shows right sided pneumothorax (purple arrow) and subtle areas of ground glass opacities in bilateral with surrounding subtle areas of ground-glass opacities in bilateral lung fields

CT severity score was assessed out of a total of 40 points. In this system, the 18 segments of both lungs were divided into 20 regions, in which the posterior apical segment of the left upper lobe was subdivided into apical and posterior segmental regions, while the antero-medial basal segment of the left lower lobe was subdivided into anterior and basal segmental regions.[2]

Then, the lung opacities in all of the 20 lung regions were subjectively evaluated on chest CT. Each region was scored 0, 1, or 2 points depending on the parenchymal opacification involved: 0%, 1-50%, or 51-100%, respectively. The overall CT severity score was defined as the sum of the points scored in each of the 20 lung segment regions, which ranges from 0 to 40 points. The mean of total lung CT severity score was observed to be 8 [Table 2].

Majority of the cases (70%) showed bilateral lung involvement with individual right and left lung were 16% and 14% respectively. 48 cases (48%) showed the involvement of 5 lobes followed by 4 lobes involvement in 22 (22%) cases, 2 lobes in 12 (12 %) cases, 1 lobe in 11 (11%) cases and 3 lobes in 7 (7%) cases with majority of cases showed predominant right lower lobe (80%) and lower lobe of left lung (75%) involvement [Table 3].

DISCUSSION

Based on the consensus given by Simpson *et al*.[3] typical features of COVID 19 on CT are the peripheral and bilateral distribution of GGO with or without the presence of consolidation or visualization of intralobular lines; or multifocal GGO having round shape with or without the presence of consolidation or visualization of crazy paving pattern; or features of oraganizing pneumonia like reverse halo sign. On the other hand, atypical features of COVID-19 on CT include features like the presence of isolated segmental or lobar consolidation in the absence of GGO; or the presence of discrete small centrilobular nodules which may coalesce to give tree-in-bud pattern; or the presence of cavitatory changes; or the presence of smooth interlobular septal thickening alongwith the presence of pleural effusion; and the absence of typical CT features of COVID-19.

Our study showed that the presence of GGO is the most common feature as evidenced by 70% cases seen with this feature on CT. Prominence of other features like peripheral distribution of opacities, presence of consolidation, linear opacities, crazy-paving appearance are also consistent with typical features of COVID-19 seen on CT.[4] We also observed that there is a temporal change in the morphology of opacities. Initially in the 1st week to 10 days, ground-glass opacification and consolidation were seen. In the following 2nd and 3rd week, reticular opacities were increasingly seen.

Presence of vascular dilatation in the opacified lung areas was another feature seen. Atypical features like the presence of cavitatory changes in lung parenchyma, centrilobular nodules, pleural effusion and pneumothorax was seen in 2% cases [Table 4]. We suggest a pattern recognition approach has been adopted for description of imaging findings, which are detailed below: [5]

- GGO
- Mixed consolidation and ground glass pattern
- Consolidation with minimal GGO
- Typical pattern of acute respiratory distress syndrome

- Cavitatory lesions in addition to consolidation and GGO
- Atypical features like pneumothorax, pleural effusion and nodules.

Pattern of Cases

Pattern 1: GGO

Out of 100 cases, 71 cases presented with diffuse GGO in bilateral lung fields predominantly in the peripheral regions. No specific lobar involvement was seen. The ground-glass opacities varied from multiple small discrete opacities to large confluent areas.

Pattern 2: Mixed consolidation and ground glass pattern

Out of 100 cases, 16 cases had with mixed consolidation and GGO involving bilateral lung fields. Consolidation was predominantly is seen in the peripheral subpleural regions.

Pattern 3: Consolidation with minimal GGO

Out of 100 cases nine cases presented with consolidation with minimal GGO involving bilateral lung fields.

Pattern 4: Typical pattern of acute respiratory distress syndrome

Out of 100 cases two cases presented with typical pattern of acute respiratory distress syndrome.

Pattern 5: Cavitatory lesions in addition to consolidation and GGO

Out of 100 cases one case presented with cavitatory lesions in addition to consolidation and GGO.

Pattern 6: Atypical features such as pneumothorax, pleural effusion and nodules

Out of 100 cases 2 cases presented with atypical features such as pneumothorax, pleural effusion and nodules.

Parry *et al*.[6] reported pulmonary features on CT in 34.7 % cases among which GGO was the predominant finding seen in all (100%) cases. Their study also showed that among the CT characteristics, peripheral distribution of GGO was seen in all cases, crazy paving appearance was seen in 29.4% cases.

Bernheim *et al*.[7] in their study showed that the 76% cases had history of travel to high risk area or exposure to infected people with predominant complaints of fever (61%), cough (48%) and sputum production (17%).

SUMMARY AND CONCLUSION

The typical imaging appearance of COVID-19 pneumonia is bilateral peripheral ground-glass opacities with a lower lobar predominance. Intermixed areas of consolidation with or without ground-glass attenuation are second most common imaging appearance. Presence of reticular opacities and an organising pneumonia pattern is seen in the later stages of infection, in the 2nd and 3rd weeks. Cavitatory lesions, nodules, pleural effusions and pneumothorax are uncommon imaging manifestations. Presence of these findings should suggest an alternate diagnosis in reverse transcription polymerase chain reaction negative patients. In conclusion we can say that radiological correlation helps in better understanding of clinical course of COVID-19 pneumonia and provides a better insight towards the pathophysiology and clinical manifestations along with its prognostic implications.

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