



The Prevalence and Incidence of Different Lung Parenchymal Changes on CT Chest Caused By COVID Pneumonia through Follow Up Course

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ABSTRACT

Background: COVID-19 pneumonia episodes had been present in Wuhan, China, since December 2019. It looks like ground glass lesions, consolidation patches, and sometimes alveolar exudates with interlobular involvement. Chest CT can show these signs before (RT-PCR) and is considered a gold standard for affirming COVID-19 recently. **Purpose:** We aimed to evaluate the relevance and value of chest CT in diagnosing and following up with the disease. **Materials and Methods:** A cross-sectional, retrospective study in the radiology department at Badr University Hospitals. 60 individuals were included in the 6-month study, which lasted from September 2021 to March 2022. Initial imaging was taken with follow-up imaging after 6 weeks in most cases. A third CT was due to the disease severity, and two of them had an earlier. Multi-detector CT chest obtained with 1 mm thick without an inter-slice gap. **Results:** There were 45% men and 55% females. For CT abnormalities there were 90% of cases showed GGO, 63.3% with vascular enlargement, 26.5% for traction bronchiectasis, and the lowest percentages were for sub-pleural lines (3.3%). There were a statistically significant decrease in GGO cases with (p-value= 0.03) and an increase in the sub-pleural line with a p-value of 0.01 on follow-up. A significant increase in the percentage of completely free CT patients in CTSS grades was seen on follow-up with (p-value =0.04). **Conclusion:** CT chest can help in following up with the patients and predicting the course of the disease according to the visualized signs of lung parenchyma.

KEYWORD: SARS-CoV-2, COVID-19, CT chest, RT-PCR, GGO, TSS, CXR.

Introduction

Since December 2019, Wuhan, China, experienced unexplained attacks of pneumonia. In China, as a response, rapid and severe action was implemented to manage and control this pandemic situation, and numerous etiological sorts of research were conducted (1).

The novel coronavirus (2019nCoV) was declared a public health emergency by the World Health Organization (WHO) in early 2020. On February 11, 2020, it became official to use the term (COVID-19). The Severe Acute Respiratory Syndrome Coronavirus 2 (SARSCoV2) classification was established by the International Committee on Taxonomy. As 2020, a total of 77041 cases of SARS-CoV-2 infection have been documented in the People's Republic of China (1). On 2020, (COVID-19) caused more than 425000 verified fatalities and approximately 8 million confirmed cases worldwide (2).

Instead of the primary diagnostic tool (*RT-PCR*), several laboratory and imaging investigations have been recommended for the early detection of COVID infection. These investigations include CBC, CRP, PT, PTT, ESR, pro-calcitonin, and ferritin. Imaging investigations like X-rays and (*CT*) also have high diagnostic criteria. Even though PCR is still the preferred investigation to confirm COVID infection. One or more negative findings do not rule out (COVID-19), and the sensitivity of RT-PCR testing is only 89%, according to a pooled estimate (3,4).

COVID-19 is a virus that may live on surfaces for up to 10 mm after being released from a source as a small, virus-containing particle. The clinical manifestations can range from asymptomatic patients to symptomatic ones that started within one week presenting as fever, cough, nasal congestion, and sometimes fatigue. In severe cases, it progresses to severe dyspnea and serious pneumonia-like symptoms in almost 75% of patients, confirmed by computed tomography on admission (5).

Pneumonia is mainly present from one to two weeks from the infection. It causes lower oxygen saturation and is associated with visible changes seen mainly by chest Computerized tomography (*CT*). It looks like ground glass lesions, consolidation patches, and sometimes alveolar exudates with interlobular involvement. Chest *CT* can show these signs before positive real-time fluorescence polymerase chain reaction (*RT-PCR*) and is considered a gold standard for affirming *COVID-19* recently (5).

We aim to distinguish the significance and importance of the CT Chest in the diagnosis and follow-up of the course of the *COVID-19 infection, through the use of a CT chest for the detection of different parenchymal findings as a standard imaging tool in patients with positive PCR and chest symptoms.*

Patients and methods

We carried out a cross-sectional, retrospective study in the radiology department at Badr University Hospital. 60 individuals were included in the 6-month study, which lasted from September 2021 to March 2022.

The patients were recruited from isolation, *COVID* triage, and *ICU* for initial imaging with follow-up imaging after 6 weeks in most of the cases. Only 6 patients required a third *CT* due to the disease severity, two of them had an earlier *CT* after 4 weeks and the last four patients had a third *CT* after the 6-week follow-up.

The included patients who were diagnosed with at least one positive (*RT-PCR*) result for (*SARS-CoV*) were obtained by two oro-pharyngeal swabs; the first one immediately before or after admission and another one after a CT scan with lung abnormalities. We excluded patients with severe respiratory distress or who needed intubation, patients with a medical history of lung affection, patients with a history of chronic lung disease, or those with non-controlled diabetes or hypertension.

CT protocol:

Patients were scanned on CT scanners while lying on their backs with their arms up in a thorax-centered posture. Motion artifacts were kept to a minimum by timing the scanning to the conclusion of the inspiration phase. Scouting range: from the lower neck to the middle of the belly. The whole lung is scanned, from the very top to the very bottom.

The following settings were used to get a multi-detector CT image: The field of view is 300 mm, the slices are 1 mm thick with no interslice gap, the tube voltage is 120 kV, and the tube current is automatically modulated (100-350 mAs). For the coronal and sagittal reconstructions, the axial images will be utilized with a slice thickness of 1 mm. Lung window pictures (-700HU window level, 1500HU window width) are used to identify parenchymal alterations.

Analyzing images: Two radiologists, separated by 15 years of age, reviewed CT chests without access to the patient's medical history or test results.

Using a scoring methodology, we determined the patient's severity based on the presence of abnormalities on each CT scan, such as Ground glass appearance (GGO), focal consolidation, crazy paving, reversed halo, linear consolidation, pleural effusion, and others; the locations of these lesions (peripheral, central, diffuse); the number of affected lobes; and the degree of involvement in each lobe.

There are several factors that may be used to categorize the severity of lung disease, including the location and the area of pulmonary lesions, the existence of ground glass anomalies or consolidations, and the patient's response to treatment. The CT severity scoring system (SSS) was used to assign numerical values to the extent to which lung lobes had been affected by the alterations. A score of 0 showed no involvement, while a score of 5 indicated involvement of more than 75% of the lobe, the total score was given by the sum of each lobe score, then grading will be done accordingly (6).

To get a score, the CTs were segmented using the Total severity scoring (TSS) approach, with each lobe of each lung being scored independently. According to the percentage of the affected lobe, a CT score from 0 to 4 might be assigned. For example, a score of 0 indicates no participation, 1 indicates 1–25% participation, 2–25% participation, 3–51–75% participation, and 4–100% participation.

The overall CT score, which might be between 0 and 20, is calculated by adding the scores from each lobe, the cut-off value for mild cases of CT score is less than 8 (with 82.6% sensitivity

and 100% specificity) while for moderate cases is identified by a value of 8-15, and for severe cases the value of more than 15 (7).

Statistical analysis:

Data collected and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. According to the type of data qualitative represent as number and percentage , quantitative continues group represent by mean $\pm$ SD. Differences between quantitative independent multiple by ANOVA . P value was set at <0.05 for significant results & <0.001 for high significant result.

Results

Our sample population's mean age was (42.4 ± 12.4) years, with a range of ages from 21 to 70. There were 45% men and 55% females (**Table 1**). According to symptom severity, 8.3% of cases had mild symptoms, 70% had moderate, and 21.7% had severe symptoms (**Table 1**). For CT abnormalities there were 90% of cases showed GGO in CT, 63.3% with vascular enlargement, 26.5% for traction bronchiectasis, 23.3% for nodular lesion and crazy paving, 18.3% for reticulation, and the lowest percentages were for subpleural line and air bubble sign (3.3%) (**Table 2**).

Table (2) illustrated that the mean CTSS among the study group on admission time was (6.12 ± 5) ranging between (0 and 22) years with, 10% showing completely free CT, 68.3% having a mild degree, 11.7% with a moderate degree, and 10% with a severe degree. The defined CT pathology was 71.7% of GGO in CT, 65% of vascular enlargement, 38.3% for traction bronchiectasis, and 33.3% for a nodular lesion. The lowest percentage was for Pleural effusion (5%), with 1.7% of cases with an air bubble sign (**Table 3**).

On discharge, there was a statistically significant drop in the number of cases of GGO ($p = 0.03$) and an increase in the subpleural line ($p = 0.01$). However, with reference to other CT results (Table 2), there was no statistically significant change with a p -value > 0.05 . Table 4 shows that there was a statistically significant rise in the proportion of CT patients in the highest CTSS grades at discharge ($p0.04$), whereas there was no statistically significant change in the CT scoring system ($p < 0.05$). There was no statistically significant difference with a p -value >0.05 in the grade of symptoms between different outcomes (**Table 4**).

Table (1): Description of demographic characteristics and symptoms among the study group.

Variables	Number (n=60)	
Age	Mean $\pm$ SD	42.4 $\pm$ 12.4

	Range	21-70	
sex	Female	33	55%
	Male	27	45%
Frequency of symptoms	Mild	5	8.30%
	Moderate	42	70%
	Sever	13	21.70%

Table (2): Frequency of CT findings on admission and after discharge among the study group.

CT findings	Findings on admission		Findings on discharge		P-value	Significance
GGO	54	90%	43	71.70 %	0.03	S
Consolidation	10	16.70%	11	18.30 %	0.9	NS
Crazy paving	14	23.30%	15	25%	0.9	NS
Reticulation	11	18.30%	17	28.30 %	0.2	NS
Traction bronchiectasis	16	26.50%	23	38.30 %	0.2	NS
Nodule	14	23.30%	20	33.30 %	0.07	NS
Subplural line	2	3.30%	6	10%	0.01	S
Vascular enlargement	38	63.30%	39	65%	0.9	NS
Air bubble sign	2	3.30%	1	1.70 %	1	NS
Pleural effusion	3	5%	3	5%	1	NS

Table (3): Description of the CT score system on follow-up among the study group.

Variables	NO (n=60)
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CTSS		
Mean ±SD	5.18±5.6	
Range	0-20	
CT SS grades		
Completely free	26	28.3%
Mild (1-7)	17	43.3%
Moderate (8-12)	13	21.7%
Sever (16-25)	4	6.7%

Table (4): Comparisons of CTSS grades in follow-up among study groups.

Variables	On admission		On discharge		P-value	Sig.
	Mean	SD	Mean	SD		
CTSS	6.12	5	5.18	5.6	0.22	NS
CT SS grades	NO.	%	NO.	%	0.04	S
Completely free	6	10%	17	28.3%		
Mild (1-7)	41	68.3%	26	43.3%		
Moderate (8-12)	7	11.7%	13	21.7%		
Sever (16-25)	6	10%	4	6.7%		

Case Presentation

Case (1): A 51-year-old female patient with a positive RT-PCR test for COVID-19 virus, presented with moderate symptoms of fever, cough, and dyspnea with mild respiratory distress symptoms. PO₂ ranges from (90to 85). CT chest findings: 1st CT (Fig 1A): done after 1 week of symptoms, it showed some parenchymal lung affections as GGOs seen mainly basal at ULL, LRL, and LLL, crazy paving, and vascular enlargement. No consolidation, reticulation, traction bronchiectasis, nodules, or air bubble sign. By the scoring system, it took 8 means a moderate form of the disease. 2nd CT (Fig 1B): was done after 6 weeks after the first one, it showed minimal changes in the lung parenchyma, GGO is still seen in LUL, RLL, LLL, crazy paving, vascular enlargement, and fibro-atelectatic lung bands are noted. No consolidation, reticulation, traction bronchiectasis, or air bubble sign. On the scoring system, it took 6 which represent a mild form of the disease. As the change was minimal in the past CTs, The patient did another one after 3 months (Fig 34C), which showed a noticeable change with only bilateral basal GGOs and some nodules. On the scoring system, it took 3 (mild form).

Case (2): A 63 year old male patient with positive RT-PCR test for COVID 19 virus, he presented with high fever, dry cough, dyspnea, diarrhea vomiting and respiratory distress

(decreased PO2 up to 88). CT chest findings: 1st CT (Fig 2 A1&2): done after 1 week after the symptom started, it showed multiple parenchymal lung features, GGOs occupying bilateral lower lobes with crazy paving on right lung, traction bronchiectasis, vascular enlargement, and nodules. Also, bilateral pleural and pericardial minimal effusion. On the scoring system, it took 10 which represents a moderate form of the disease. 2nd CT (Fig 2 B1&2): done after 6 weeks from the first one, it showed increase in GGOs and pleural effusion. On the scoring system, it took 18 which represents severe form of the disease. Patient started to have a chest pain and tachypnea, pulmonary CT angiography was done (Fig 2C1&2) after 4 weeks from the last CT, revealed a small pulmonary embolism in the segmental branch with resorbption of pericardial effusion and decrease the amount pleural effusion more on left side.



Fig (1): 51 years female patient with positive PCR test for COVID-19 (A) axial view of 1st CT Chest showed bilateral basal GGO and some crazy paving (B) Axial view of 2nd CT done after 6 weeks showed bilateral basal GGO –less than picture A and less crazy paving. (C) Axial view of 3rd CT done after 3 months showed remnant of basal GGO, no crazy paving.

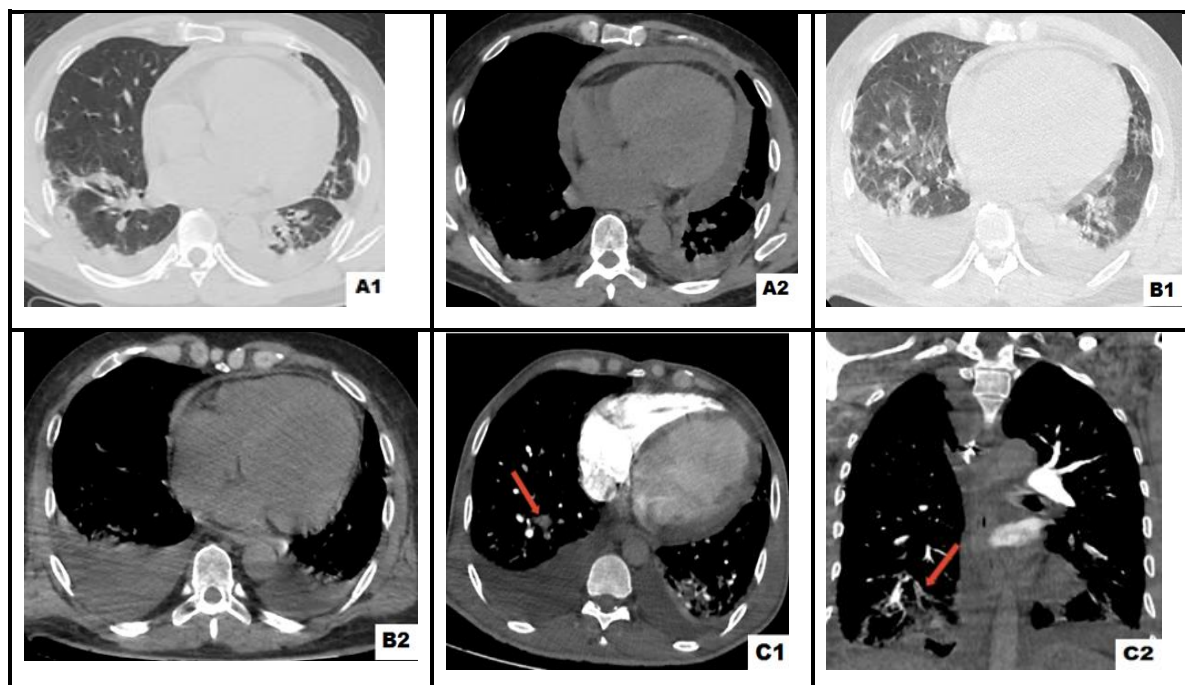


Fig (2): 63-years-old male patient with positive PCR test for COVID-19 virus, (A,B) Axial view of 1st CT showed bilateral GGO in upper and lower lobes with a vascular enlargement (C) pulmonary CT angiography.

Discussion

After the great outbreak in Wuhan/ China and the world witnessed a thousand daily diagnosed with the *COVID-19* virus. The radiological techniques had proven high sensitivity in early diagnosis of the *COVID* virus, especially *Chest (CT)* which is considered to be a golden standard and a diagnostic method for the evaluation of lung diseases. Although other methods were used for diagnosing the *COVID* infection, laboratory methods such as *PCR* test, *CBC*, prothrombin time, D-dimer, and imaging methods such as Chest X-ray, and despite the availability and the low radiation dose of the X-ray it doesn't consider a reliable method in diagnosing *COVID* patient due to high percentage of early false negative results as *CXR* shows the absence of early abnormalities and can't detect small lesions very well. As a result, high-resolution CT is one of the key instruments for screening, initial diagnosis, and determining the severity of a disease (8,9).

Our patients had at least two chest *CT* scans. 10% of the cases needed a third *CT*, some of them had it in between the initial and the follow-up *CTs* others had it after the follow-up *CT* according to the progression and *the* severity of the case. The initial chest *CT* was obtained at a mean of seven days following the start of symptoms and the follow-up *CT* was done after 6 weeks.

Patients' age ranged between 21 to 70 years with mean $\pm$ SD= 42.4 $\pm$ 12.4. 33 patients (55%), were males and 27 (45%), were females with male to female ratio of 1:0.82. There were different clinical manifestations at the time of admission, most of them had moderate to severe symptoms that required hospitalization, 42 patients (70%) showed moderate symptoms, and 13 patients (21.7%) showed severe symptoms, and finally, 5 patients (8.3%) showed mild symptoms. Our results agreed with Jedruik et al. (10), who stated that mild symptoms mostly didn't include lung parenchyma, no dyspnea or respiratory distress symptoms, only cases 100%) for vascular enlargement (6%) with pleural changes.

In follow-up *CT* findings, we divided the patients into two groups, an improved group, and deteriorated group, a first group seen in 39 patients (65%), 17 patients out of 39 (28.3%) showed negative *CT* findings, and the second group seen in 19 patients (35%) who got deteriorated with significant statistical changes according to different lung changes outcomes. However, the significant change seen in some radiological signs was ground glass opacity with (71.7% in follow-up *CTs*) compared to (90 % in initial *CTs*), and the less changed signs were vascular enlargement and pleural effusion with (65% and 5 % respectively in follow-up *CTs*) compared to (63.3 % and 5% respectively in the initial *CTs*), which may require more than six weeks for resolution.

The second most common signs seen in deteriorated patients were crazy paving and consolidation in a percentage of (25 % and 18.3% respectively) in the follow-up CTs compared to (23.3 % and 16.7% respectively) in the initial CTs.

Chest imaging is not a good independent technique for ruling out COVID-19 infection because of its low sensitivity and negative predictive value in the early post-symptom phase. Repeat CT scans should be performed on the high-risk group. This is in line with our results, since the first CT scan for six individuals took an average of seven days and revealed no anomalies in the lung parenchyma. In our study there was no statistically significant change in CT severity score with a p-value of 0.22, however a statistically significant increase in the percentage of completely *free CT* patients in CTSS grades on discharge with a p-value of 0.04 (11).

The limitations of this study were: the retrospective design of our study and challenging post-discharge thin-section CT follow-up observations of disease-related lung alterations for patients after 6 weeks due to discharge or dismissal following the death in serious cases. There were also insufficient lung tissue samples for a comparison of radiographic and histopathologic results.

Conclusion: CT chests not only can provide early detection of COVID which is critical mainly for the prevention of transmission and also for better treatment but also helped in following up with the patients and predicting the course of the disease according to the visualized signs of lung parenchyma.

Conflict of interest:

Authors declare that they don't have any conflict of interest.

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References:

1. Sun P, Lu X, Xu C, et al. Understanding of COVID-19 based on current evidence. *J Med Virol* 2020;92:548–551.
2. Hopkins J. corona virus Resource University Center. *School of Medicine*. Available from: <https://coronavirus.jhu.edu/>. 2020.
3. Kim H, Hong H, Yoon SH. Diagnostic performance of CT and reverse transcriptase polymerase chain reaction for coronavirus disease 2019: a meta-analysis. *Radiology* 2020;296:E145–E155.
4. WHO Coronavirus disease 2019 (COVID-19) Situation. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200315-sitrep-55-covid-19.pdf?sfvrsn=33daa5cb_8. 2020;55.
5. Guan W, Ni Z, Hu Y, et al. Clinical Characteristics of Coronavirus Disease 2019 in China.

- N Engl J Med 2020;382:1708–1720.
6. Pan F, Ye T, Sun P, et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiology.
 7. Wasilewski PG, Mruk B, Mazur S, et al. COVID-19 severity scoring systems in radiological imaging - a review. Polish J Radiol 2020;85:e361–e368.
 8. López-Cabrera JD, Orozco-Morales R, Portal-Díaz JA, et al. Current limitations to identify covid-19 using artificial intelligence with chest x-ray imaging (part ii). The shortcut learning problem. Health Technol (Berl) 2021;11:1331–1345.
 9. <http://en.nhc.gov.cn/>. The National Health Commission of the People's Republic of China.
 10. Jędrusik P, Gaciong Z, Sklinda K, et al. Diagnostic role of chest computed tomography in coronavirus disease 2019. Polish Arch Intern Med . Epub ahead of print 2020. DOI: 10.20452/pamw.15348.
 11. Bernheim A, Mei X, Huang M, et al. Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection. Radiology 2020;295:200463.