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Research Article

Pulmonary CT findings in Patients Recovered from COVID-19 Pneumonia

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ABSTRACT

***Background*:** The COVID-19 infection is a more recent pandemic disease all over the world and studying the pulmonary findings on survivors of this disease has lately commenced.
Objective: We aimed to estimate the cumulative percentage of whole radiological resolution after 3 months from recovery and to define the residual chest CT findings and exploring the relevant affecting factors.
***Subjects and Methods*:** Patients who had been previously diagnosed with COVID-19 pneumonia confirmed by RT-PCR test and had radiological evidence of pulmonary involvement by Chest CT during the acute illness were included in the present study. The radiological data of chest CT scan of all patients were collected and analyzed after recovery (confirmed by negative RT- PCR) three months after their initial diagnosis of having COVID 19 pneumonia.
***Results*:** A total of 40 patients who had a second CT scans were assessed; there were 27 (67.5%) male and 13 (32.5%) female, with a mean age of 40.3 years old. The collective percentage of whole radiological resolution was 65% (26 patients). Patients >40 years old showed a significantly lower cumulative percentage of complete radiological resolution than patients ≤40 years old at the 3 months follow-up. The predominant patterns of abnormalities observed at discharge were ground-glass opacity (GGO), fibrous stripe and reticular opacities.
***Conclusion*:** Lung findings in COVID-19 pneumonia patients can be resolved completely during medium-term follow up with no sequelae. The older age and co-morbidities are the main significant risk factors for residual radiological findings of COVID-19 disease.

Introduction

The COVID-19 infection is a more recent pandemic disease all over the world and studying or monitoring the data on survivors of this disease has recently begun (1). The CT findings usually detected in patients with COVID-19 pneumonia are representer of acute interstitial lung injury and subsequent parenchymal changes caused by the cytokine storm activated by the incorporation of the virus into the pneumocytes (2,3). While reverse transcription-polymerase chain reaction (RT-PCR) is the essential laboratory test to confirm the diagnosis of COVID-19, non-contrast chest CT may represent a valuable tool in assessing this patient population (4). The histological changes in the lungs of COVID-19 patients as evaluated by post-mortem studies revealed the occurrence of pulmonary edema, alveolar cellular exudates and hyaline membranes (5). These

changes are probable base for the common recorded CT findings, such as ground-glass opacities (GGO) and focal consolidation (6,7). The parenchymal lesions were commonly distributed as bilateral, multilobar, and peripheral, with common involvement of the posterior areas of the lungs (8,9). With a lower prevalence, other chest CT findings have been reported such as interlobular septal thickening, bronchiectasis, "crazy paving," and halo sign (10,11). Mediastinal lymphadenopathy, pleural effusions, and pulmonary nodules have been rarely observed (12).

The initial data imply that lung changes do not resolve in all COVID-19 recovered patients and may progress into lung fibrosis (13). In the last two years, some published studies have evaluated the changes in lung findings in a short-term follow-up, usually after four weeks from recovery (14-17).

To identify patients at risk of long-term COVID-19-induced lung compromise, comprehending the intermediate-term lung changes on CT may provide a starting point for picking patients for prospect trials concerning antifibrotic treatment.

This study aimed to analyze the CT imaging findings in patients recovered from COVID 19 pneumonia and to estimate the cumulative percentage of complete radiological resolution.

Subjects and Methods

This descriptive observational case series study was conducted at the radiology department in Al-Yarmook Teaching Hospital, Baghdad, Iraq from August 2020 to April 2021. This study was conducted under the Declaration of Helsinki and was approved by our hospital's ethics and scientific research committees. We gained informed consent from all the patients involved in the study, and we safeguarded their personal health information .

Initially, a total of 70 patients previously diagnosed with COVID-19 were selected. Of these, 27 patients refuse to have a second CT examination, one patient with previous TB and pulmonary fibrosis and two patients with heart failure were excluded from the study. Then, 40 patients underwent a second chest CT study, (27) man and (13) women were included in this study with age ranging from (20) to (63) years. The basic information included gender, age, co-morbidities and history of smoking or occupational exposure were obtained

Any patient who had been previously diagnosed with COVID-19 pneumonia confirmed by RT-PCR test and had radiological evidence of pulmonary involvement by Chest CT during the acute illness were included by this study. The radiological characteristics of all patients were collected and analyzed after recovery (confirmed by negative RT- PCR) by chest CT scan three months after their initial diagnosis of having COVID 19 pneumonia .

Patients with preexisting interstitial lung disease or heart failure were excluded from the study to avoid the overlapping of the radiological pictures. Additionally, those with normal chest CT during the acute stage of disease were not involved by our study.

Thin-section CT examination was achieved on a multi-detector CT machine (Philips Ingenuity Core128, Philips Medical Systems, Best, the Netherlands; SOMATOM Definition AS, Siemens Healthineers,Germany) with a single inspiratory phase. The patient lay supine with head in advance and hands up. CT images were then acquired during a single breath-hold. The tube voltage was set as 120 kVp with automatic tube current modulation.with WL (-600) and WW (1600). CT images were reconstructed from the raw data with a sizable matrix of 512×512 as transverse images (1.5 mm thickness and 1.5 mm increment) with pulmonary B70F kernel and a mediastinal B30f kernel (Siemens Healthineers, Germany) or hybrid iterative reconstruction (iDose level 5, Philips Medical Systems, the Netherlands). No contrast media was administered. All images were transmitted to the post processing workstation to be reconstructed by high-resolution algorithms and conventional algorithms.

The CT images were evaluated by two experts' radiologists (five years of experience for each). The major CT findings were described by using internationally standard nomenclature defined by the Fleischner Society glossary (18) using terms including ground-glass opacity (GGO), sub pleural fibrous band, thickening of adjacent pleura or reticular shadows. Ground glass opacity is defined as is hazy increased attenuation of the lung, with preservation of bronchial and vascular margins. Sub pleural band is defined as a linear opacity up to 5 cm long with 1–3 mm thickness that typically spreads to the visceral pleura. This band reflects pleuroparenchymal fibrotic change and is frequently linked with alteration of the lung architecture. A reticular pattern is a gathering of immeasurable minor rectilinear opacities that yield an appearance similar to a net (synonym: reticulation). This finding usually represents interstitial lung disease. Intralobular lines, Interlobular septal thickening, or the cyst walls of honeycombing are the elements of a reticular pattern at thin- section CT. The distribution of lung abnormal findings was reported as chiefly subpleural (involving the peripheral one third of the lung), random (without predilection for central or subpleural regions), or diffuse (generalized involvement without respect to lung segments).

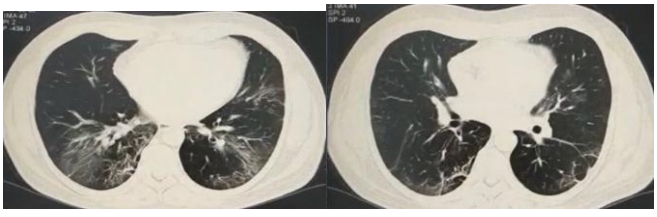
Statistical analysis:

Collected data were introduced into an excel sheet (Microsoft excel sheet 16) and loaded into Statistical Package for Social Sciences (SPSS), SPSS® for Windows, Version 24.0 (IBM Corp, Armonk, NY). Results of analysis were arranged in categorical variables and in scales variables (means & standard deviation). Fishers' exact test was used for categorical variables. To compare between two means, an independent sample t-test was used. The P value of 0.05 or less was regarded as significant.

Results

This study included 40 patients who recovered from COVID-19 pneumonia with a mean age of 40.3±10.2 years; 55.5% were less than 40 years of age, and 44.5% of them were 40 years of age and more. Male patients were more than females with a male to female ratio of 1.35:1.

The smoking was present among 20% of COVID-19 patients, while 80% of them were not smokers. The co-morbidities were absent in 70% of COVID-19 patients, while the present co-morbidities were hypertension (50%), hypertension and diabetes mellitus (25%), diabetes mellitus (16.7%) and ischemic heart disease (8.3%). The CT scan revealed that 26 patient (65%) of them had complete radiological resolution, while 14 (35%) of them had residual radiological findings as in Figure 1.



A B

Figure 1 (A & B): Axial chest CT images of adult patient 3 months after recovery from initial infection with Covid-19, showing fibrous stripes with reticular parenchyma opacification and ground glass appearance seen in the lower lobes of both lungs. Both images have the same window level of − 600 and window width of 1600

The residual radiological findings, patterns, and distribution were summarized in Table 1.

Table 1: Residual pulmonary CT findings of patients included in this study

Variable	n (%)
Residual CT findings	
GGO	13/14 (92.9%)
Fibrous stripes	13/14 (92.9%)
Parenchyma reticular opacification	10/14 (71.4%)
Pleural thickening	8/14 (57.1%)
Pleural effusion	1/14 (7.1%)
Traction bronchiectasis	2/14 (14.3%)
Distribution of findings	
Unilateral	3/14 (21.4%)
Bilateral	11/14 (78.6%)
Patterns of findings	
Predominantly subplueral	8/14 (57.2%)
Random	3/14 (21.4%)
Diffuse	3/14 (21.4%)

GGO; ground glass opacity

A significant association was observed between the increased age of COVID-19 patients and residual radiological findings (p=0.03). The mean age of patients with residual radiological findings was significantly higher than patients with complete resolution (p=0.03). We observed no significant differences between COVID-19 patients with full radiological resolution and COVID-19 patients with residual radiological findings regarding their gender (p=0.4), as in Table 2

Table 3 shows no significant differences between residual CT scan findings of COVID-19 patients between unilateral and bilateral distribution (p=0.3).

We observed no significant differences between residual CT scan findings of COVID-19 patients between different patterns distribution (p=0.4) as in Table 4.

Discussion

The COVID-19 infection is a more recent pandemic disease all over the world and studying or monitoring the data on survivors of this disease has newly started. However, most of data available at present emphases on the short-term sequelae of this disease and data on medium-term radiological findings are uncommon (19).

Table 2: Distribution of patients' demographic characteristics according to radiological findings

Variable	Complete resolution		Residual findings		P value
	No.	%	No.	%	
Age					0.03* Sig.
<40 years	18	69.2	5	35.7	
≥40 years	8	30.8	9	64.3	
Mean±SD (years)	36.2±10.8		45±11.3		0.03** Sig.
Gender					0.4* non sig.
Male	19	73.1	8	57.1	
Female	7	26.9	6	42.9	

*Fishers exact test, **Independent sample t-test. SD; standard deviation

Table 3: Distribution of residual CT scan findings; Unilateral versus bilateral

CT findings	Unilateral	Bilateral	
GGO	2	11	
Fibrous stripes	3	10	
Parenchyma reticular opacification	0	10	
Pleural thickening	2	6	0.3*
Pleural effusion	0	1	
Traction bronchiectasis	1	1	

*Fishers exact test. GGO; ground glass opacity

Table 4: Distribution of residual CT scan findings according to their patterns

CT finding	Subpleural	Random	Diffuse	P value
GGO	7	5	1	
Fibrous stripes	9	1	3	
Parenchyma reticular opacification	5	3	2	0.4*

*Fishers exact test, GGO; ground glass opacity

Current study showed that 65% of COVID-19 patients had complete radiological resolution, while 35% of them had residual radiological findings. These findings are close to results of Tabatabae et al (20) study in Iran on 52 patients with COVID-19 pneumonia with at least two chest CT scans and interval duration of 3 months which revealed that 57.5% of patients had complete radiological resolution and 42.3% of patients had residual radiological findings. However, our study findings are inconsistent with results of Han et al (21) prospective study on 114 patients with severe COVID-19 pneumonia which found that after six months of recovery, the CT scan showed that 35% of patients showed fibrotic like changes, while 65% of them showed either complete radiological resolution (38%) or residual ground-glass opacification or interstitial thickening (27%). This inconsistency might be attributed to many factors such as virulence variances of COVID-19 infection between different populations, differences in healing periods and discrepancies in

radiological technologies and interpretation of CT scan findings in addition to difference in study durations. Liu et al (22) stated that the lung abnormalities of COVID-19 disease could disappear completely through short time duration leaving no residuals and optimum time required for identification of early complete radiological resolution was mainly two weeks after patient's discharge.

Present study showed that residual radiological findings of COVID-19 patients detected by CT scan were GGO, fibrous stripes, parenchyma reticular opacification, pleural thickening, traction bronchiectasis and pleural effusion. These findings are consistent with results of Brogna et al (23) study in Italy which found that the main residual radiological findings by CT scan were ground glass obacities (GGO), fibrous stripes and parenchyma reticular opacification.

The radiological characteristics of chest as detected by CT scan are usually differ according to time of CT scan, the stage of COVID-19 disease at time of follow-up, the age of patients, immune status, co-morbidities and type of management provided for patients. Ding et al (24) study found significant changes in radiological findings with time and the prevalence of GGOs, consolidations, crazy-paving patterns and linear opacities decreased with time. Pan et al (25) study found that in high cases of COVID-19 pneumonia, the residual CT scan findings like GGOs and consolidations might be absorbed within period of 26 days after discharge. However, another Chinese study conducted by Li et al (26) found that after two weeks follow up of patients with COVID-19 pneumonia, 27% of the patients had residual CT scan findings commonly GGOs parenchyma reticular opacification and pleural thickening.

The current study showed that 78.6% of residual findings were bilateral, while 21.4% of them were unilateral in distribution. Our study also found that CT scan residual finding patterns were predominantly subplueral (57.2%), random (21.4%) and diffuse (21.4%). These findings are similar to results of Wang et al (27) study in China which documented that the common residual CT scan findings detected among COVID-19 patients were bilateral and subplueral in pattern. The present study found that mean age of patients with residual radiological findings was significantly higher than mean age of patients with complete resolution (p=0.02). This finding is consistent with results of Parry et al (17) study in India on 81 COVID-19 patients revealed that increased age, obesity, higher co-morbidities, low oxygenation, increase duration of hospital stay, admission to intensive care unit, increased WBC count, increased CT severity score and low steroid intake were the main risk factors for residual radiological findings detected by CT scan for COVID-19 patients. Santesmasses et al (28) study in USA reported that the COVID-19 disease is an emergent disease of aging and the age or the age-related disorders are the main risk factors for this disease. However, Ho et al (29) population-based cohort study in UK found that higher death rates of COVID-19 disease among older age population is related to other older age diseases and healthier older age population at low risk of COVID-19 disease mortality.

In current study, there was a significant association between positive co-morbidities of COVID-19 patients and residual radiological findings (p=0.02). This finding is similar to reports of George et al (30) study in UK which stated that co-morbidities accompanying COVID-19 infection such hypertension and diabetes mellitus are the main significant risk factors of residual radiological findings detected by CT scan after follow up.

Our study has few limitations. Firstly, this study involved small number of patients, as many patients refuse to undergo a second CT examination, and the short duration of the study. Secondly, we could not estimate the effects of different treatment regimens to the patients as well as the disease severity during the acute illness and its consequent effects.

Conclusion

The rate of residual radiological findings of COVID-19 disease detected by computerized tomography is within acceptable range. The common residual radiological characteristics of COVID-19 disease detected by computerized tomography are ground glass opacities, fibrous stripes, parenchyma reticular opacification and pleural thickening. The bilateral distribution is the common anatomical residual distribution and the subpleural pattern is more prevalent residual pattern. The age and co-morbidities are the main significant risk factors for residual radiological findings of COVID-19 disease.

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Conflict of Interest

No conflict of interest

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