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ORIGINAL ARTICLE

Chronic Pulmonary Sequels on CT Scans of Patients with COVID-19

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Abstract: *Background: Lung tissue changes following COVID-19 may persist for a long time after discharge and recovery, but not enough information is available about these chronic pulmonary sequels. We addressed to evaluation of chronic pulmonary sequels on CT scans of patients with COVID-19. Methods: This cross-sectional study was conducted on 94 patients with COVID-19 who were evaluated by CT scan at the time of discharge and also underwent continuous evaluation by CT scan of the lungs for at least three months. Through reviewing the hospital archive files, patients' backgrounds and three-month follow-up information were collected. Results: Chronic pulmonary involvement during the follow-up of patients was found in 83%. Peripheral and diffuse involvements were revealed in 79.8% and 3.2% respectively. Also, single-lobar and multi-lobar involvements were found in 69.1%% and 13.8% respectively. In terms of abnormal lung findings on CT scan, ground-glass opacity was found in 20.2%, Crazy-paving pattern in 2.1%, reticulation in 3.2%, parenchymal band in 12.8%, consolidation in 1.1% and bronchiectasis in 3.2%. The mean CT score was also 4.21 ± 3.45. The appearance of findings in CT patients was strongly influenced by the patients 'age, body mass index, underlying comorbidities, and also, the severity of initial COVID-19. Conclusion: Within at least three months of disease recovery in hospitalized patients with COVID-19, evidence of pulmonary involvement in 83% in the form of chronic pulmonary sequels can be expected. The most common findings related to pulmonary involvement included GOO in 20.2% and parenchymal band in 12.8% of cases.*

Keywords: *Chronic pulmonary sequels, CT scan, Covid-19*

INTRODUCTION

Although several effective vaccines with high immunity have been developed to prevent the spread of COVID-19, preventing its transmission is now believed to be the only way to combat the disease. In recent months, much effort has been published to explain the epidemiology, clinical manifestations, and clinical features and imaging of COVID-19 [1-4]. In this regard, the occurrence of fever and dry cough are the first and most common symptoms of the disease [5]. However, these symptoms are similar to those of other infections, such as the flu A and B, making it difficult to diagnose. Also, laboratory evaluation in patients is often time-consuming and its diagnostic kit may not be available for homogeneity. On the other hand, laboratory tests are sometimes associated with high levels of false negatives. In this regard, imaging plays a key role in the diagnosis and management of COVID-19-induced pneumonia. CT scan is the first diagnostic modality in patients with suspected disease and also a desirable protocol in following the effect and treatment process in these patients [6]. Especially in patients with a negative RT-PCR result, CT scan evaluation can be very useful [7,8]. Various studies have evaluated and described radiographic changes in the acute phase of COVID-19 disease and have correlated these changes with the severity of clinical manifestations [9-11]. Recent studies have also shown that about 94% of hospitalized patients still experience pulmonary parenchymal changes at discharge [12, 13]. In addition, some have shown that pulmonary opacities persisted in 53% of patients with mild COVID-19 without developing negative and complicating scaffolds for up to three weeks after discharge and clinical recovery [14]. Therefore, it seems that lung tissue changes, even the occurrence of pulmonary fibrosis, may persist for a long time after discharge and recovery of patients [15-17]. But not enough information is available about these chronic pulmonary sequels. What we addressed in the present study was the evaluation of chronic pulmonary sequels on CT scan of patients with Covid-19.

MATERIALS AND METHODS

This cross-sectional study was conducted on patients with COVID-19 who were admitted to our medical center during 2020 and 2021 and were evaluated by CT scan at the time of discharge and also underwent continuous evaluation by CT scan of the lungs for at least three months after treatment and recovery. Initially, through reviewing the hospital archive files, patients' background information including sex, age, history of underlying diseases, body mass index (BMI), and clinical characteristics of patients were collected. Also, in the initial CT scan of patients (during hospitalization) and also at the time of follow-up of patients (at least three months after discharge) and by an experienced radiologist, a complete interpretation of pulmonary involvement patterns was provided in terms of form and extent of involvement and CT score and classified according to the underlying characteristics of the patients. The severity of COVID-19 was stratified into four types mild, moderate, severe, and critical on the basis of patients' symptoms, laboratory results, and imaging findings at admission as previously described [18]. Pulmonary involvement was also assessed based on the type of lesion (peripheral or diffuse), the pattern of lobar involvement (single-lobar or multi-lobar), and the type of pulmonary lesions. To determine the CT score, each of the five lung lobes was visually scored on a scale of 0 to 5, with 0 indicating no involvement and 5 indicating more than 75% involvement. The total CT score was determined as the sum of lung involvement, ranging from 0 (no involvement) to 25 (maximum involvement) [19].

For statistical analysis, results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by frequency (percentage) for categorical variables. Continuous variables were compared using the t-test or Mann-Whitney test whenever the data did not appear to have normal distribution or when the assumption of equal variances was violated across the study groups. The categorical variables were compared using the Chi-Square test or Fisher's exact test if required. P values of ≤ 0.05 were considered statistically significant. For the statistical analysis, the statistical software SPSS version 23.0 for Windows (IBM, Armonk, New York) was used. Interventional studies involving animals or humans, and other studies that require ethical approval, must list the authority that provided approval and the corresponding ethical approval code.

RESULTS

A total of 94 patients were evaluated and followed up for at least three months after discharge. The average age of patients was 53.02±4.86 years ranged 40 to 62 years and 59.6% were male. The mean BMI was also 25.41±1.91 kg/m^2 and 5.3% were obese. Regarding comorbidity, 22.3% were hypertensive, 13.8% were diabetics, and 6.4% had a history of ischemic heart disease. With respect to disease severity, 4.3% were classified as mild, 86.2% as moderate, 6.4% as severe, and 3.2% as critical.

First, there was no evidence of pulmonary involvement in CT scans in 17.0% and therefore the frequency of chronic pulmonary involvement during the follow-up of patients was 83%. In terms of how the lesions were spread, 79.8% of the involvement was peripheral, and only 3.2% was diffuse. Also, single-lobar and multi-lobar involvements were revealed in 69.1%% and 13.8% respectively. In terms of abnormal lung findings on CT scan, GOO was found in 20.2%, Crazy-paving pattern in 2.1%, reticulation in 3.2%, parenchymal band in 12.8%, consolidation in 1.1% and bronchiectasis in 3.2%. The mean CT score was also 4.21 ± 3.45.

As shown in Table 1, the patterns of chronic pulmonary sequels in patients suffering from COVID-19 were independent of patients' gender. However, the pattern and distribution of pulmonary involvements were different in the younger and the elderly, and the diffuse and multi-lobar patterns were more found in older adults. Also, abnormal lung lesions were more prevalent in older patients. Totally, the mean CT score was significantly higher in older adults than in the younger. Similar patterns were revealed in obese as compared to non-obese patients and thus obesity was found to be another factor predicting more severity of chronic sequels on CT. As shown in Table 1, the presence of comorbidities was in line with more severe pulmonary expansion of abnormal lesions. Also, as indicated in Table 2, we showed diffuse and multi-lobar lesions as well as a higher rate of pulmonary lesions in those with more severe initial COVID-19 disease. There was also a significant association between CT score and disease severity (Figure 1).

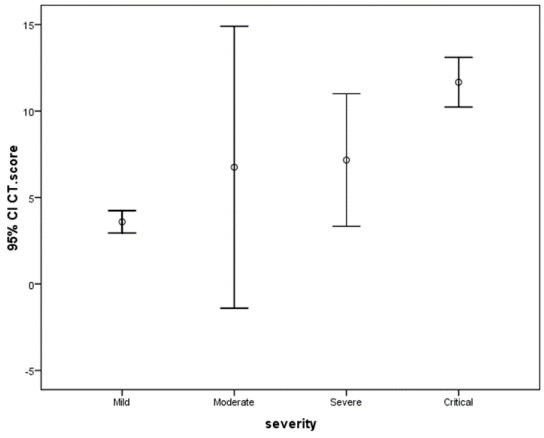

Figure 1: The correlation between CT score and severity of primary Covid-19

Table 1: Status and pattern of pulmonary involvement according to underlying factors

Item	Gender		Age		Obesity		Morbidity	
	Male	Female	≤50	>50	Obese	Non-obese	Present	Absent
Distribution								
Peripheral	76.8	84.2	63.4	92.5*	50.0	81.1*	78.3	80.3*
Diffuse	3.6	2.6	0.0	5.7	50.0	1.1	13.0	0.0
Pattern								
Single-lobar	64.3	16.1	53.7	81.1*	50.0	70.0*	52.2	74.6*
Multi-lobar	76.3	10.5	9.8	17.0	50.0	12.2	39.1	5.6
GOO	17.9	23.7	17.1	22.6	50.0	18.9*	43.5	12.7*
Crazy-paving	3.6	0.0	0.0	3.8	25.0	1.1*	8.7	0.0*
Reticulation	3.6	2.6	0.0	5.7	50.0	1.1*	13.0	0.0*
Parenchymal band	14.3	10.5	9.8	15.1	0.0	13.3	26.1	8.5*
Consolidation	1.8	0.0	0.0	1.9	0.0	1.1	4.3	0.0
Bronchiectasis	3.6	2.6	0.0	5.7	0.0	3.3	13.0	0.0*
Mean CT score	4.62±3.49	3.61±3.33	3.37±3.47	4.78±3.32*	7.25±4.92	4.08±3.34*	5.83±3.97	3.69±3.11*

Table 2: Status and pattern of pulmonary involvement according to disease severity

Item	Mild	Moderate	Severe	Critical	P value
Distribution					0.001
Peripheral	100	80.2	100	0	
Diffuse	0	0	0	100	
Pattern					0.001
Single-lobar	77.8	25.0	16.7	0	0.001
Multi-lobar	2.5	75.0	83.3	100	0.001
GOO	9.9	75.0	83.3	100	0.001
Crazy-paving	0	0	0	66.7	0.001
Reticulation	0	0	0	100	0.001
Parenchymal band	50.0	7.4	50.0	33.3	0.201
Consolidation	0	0	0	33.3	0.001
Bronchiectasis	0	1.2	16.7	33.3	0.004
Mean CT score	3.59±2.92	6.75±5.12	7.17±3.65	11.67±0.57	0.001

DISCUSSION

In the acute phase of Covid-19, different patterns of pulmonary involvement are examined in depth and the severity and extent of the disease are classified accordingly. But the question remains, how long will these involvements last after recovery from the disease, and in other words, will there still be evidence of lung involvement due to the disease months after the symptoms have improved? Obviously, the presence of these abnormal findings in the form of chronic scoliosis in CT scans of patients, weeks and months after discharge from the hospital can indicate the continuation of clinical manifestation of the disease and sometimes even exacerbation of these symptoms. What we did in the present study was the evaluation of chronic pulmonary edema on CT scans of patients with COVID-19 and related underlying factors. First, the study showed that for at least three months after treatment and recovery from COVID-19 disease, evidence of pulmonary involvement would still be expected in 83% of patients even after improvement in clinical symptoms. The most common findings of CT as chronic disease sequels included GOO patterns in 20.2% and parenchymal band in 12.8%. Other findings included reticulation in 3.2%, bronchiectasis in 3.2%, Crazy-paving pattern in 2.1%, and consolidation in 1.1% of patients. Therefore, even after about three months of the disease and the relative recovery, the occurrence of some evidence in CT patients with COVID-19, especially GOO, is still predictable. Additionally, in terms of the pattern of involvements, the lesions are mainly in the form of peripheral, and in most cases, they will be single-lobar involvements rather than multi-lobar or diffuse ones. As a second finding, we found that the appearance of these

findings in CT patients during the months following recovery from COVID-19 was strongly influenced by the patients 'age, BMI, underlying comorbidities (such as hypertension, diabetes, and history of ischemic heart disease) and also, the severity of initial Covid-19. In other words, the incidence of chronic pulmonary sequels in CT is more predictable in the months following recovery from COVID-19 at older ages, in obese individuals with underlying comorbidities, and in individuals with severe underlying COVID-19.

Various studies have reported the persistence of chronic pulmonary lesions in the weeks and months after discharge from the hospital, although due to differences in patients' underlying characteristics, different follow-up periods, and different intensities of underlying COVID-19 disease, CT scans were quite different during patient follow-up. In a study by Caruso et al and at 6-month follow-up, 72% of patients showed fibrosis-like changes and 42% of patients showed evidence of GOO [20]. In a study by Han et al., fibrotic-like changes were observed in 35% of cases, while 65% of cases either had completely clean lungs or had grand glass opacity or increased interstitial thickness. Age over 50, heart rate above 100 at admission, length of hospital stay over 17 days, respiratory distress syndrome, non-invasive mechanical ventilation, and CT scan score above 18 as factors associated with fibrotic-like changes over six months after discharge [21]. In another study by Dehan Liu et al during the first to third weeks, the GOO opacity and pulmonary fibrosis remained constant [22]. In a study by Safont et al., during a 180-day follow-up with a CT scan, 66% had chronic pulmonary lesions. Among this evidence, 68.3% had GOO and 38.4% had parenchymal bands [23]. In the study by Blanco et al., 19 patients with COVID-19 were evaluated by CT scan during a six-month follow-up period, in which only 48% had a normal CT scan [24]. Also, in the study of Hossein et al., 42.3% had pulmonary sequels in CT scan follow-up. The most common residual patterns in CT scans included GOO at 54.5% followed by grand glass mix at 31.8% and parenchymal bands at 13.7% [25]. Therefore, a wide range of findings related to COVID-19 can be seen in the weeks and months after recovery, sometimes without symptoms and sometimes with signs and symptoms associated with COVID-19. It seems that follow-up of these patients and simultaneous and continuous evaluation of lung CT scan findings along with clinical manifestations in patients will be necessary even after partial recovery and hospital discharge.

CONCLUSIONS

As a final conclusion, within at least three months of disease recovery in hospitalized patients with COVID-19, evidence of pulmonary involvement in 83% in the form of chronic pulmonary sequels can be expected. The most common findings related to pulmonary involvement included GOO in 20.2% and parenchymal band in 12.8% of cases. The presence of chronic pulmonary lesions in COVID-19 patients is strongly influenced by old age, obesity, the presence of underlying comorbidities as well and the severity of early COVID-19 disease.

Conflicts of interest and sources of funding

The authors declare no conflict of interest.

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None.

Authors' contribution

Design and concepts: TFL, SK, MH, KO; Data gathering and analysis: TFL, SK, MH, KO; Preparing the manuscript: TFL, SK, MH, KO.

Ethics approval and consent to participate

The ethical committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran confirmed the proposal of this study with IR.SBMU.MSP.REC.1400.253 code.

Patient consent for publication

Informed consent was obtained from all subjects involved in the study.

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