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Study on the Dynamic Changes in Chest CT Findings of COVID-19 Rehabilitated Patients

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Abstract

Objective: *To study the dynamic changes in CT findings in COVID-19 (coronavirus disease-19, COVID-19) rehabilitated patients.*
Methods: *A total of 148 chest CT images of 37 patients with COVID-19 were collected. In the first 21 days of the course of disease, 7 stages were performed every 3 days, and the eighth stage was performed after 21 days.*
Results: *In the first chest CT examination, 19 cases were ground glass opacity, and 18 cases were high-density shadows with consolidation. The lesion shape was flaky and patchy in 33 cases. The percentage of consolidation, air bronchogram, fiber cord, interlobular septal thickening, subpleural line and pleural thickening were the highest on days 4-6, 7-9, 7-9, 10-12, 19-21 and 19-21, respectively. The highest percentage of disease progression was 80.00% on days 4-6, and then the percentage of disease progression gradually decreased with the extension of the onset time. The percentage of patients with improvement gradually increased from days 4-6, reaching 83.33% on days 16-18 and 100.00% on day 21. The percentage of lesion range enlargement and density increase was the highest on days 4-6, both of which were 60.00%, Then the percentage of both decreased gradually. The percentage of patients with lesion range reduction and density absorption dilution increased gradually with the onset time. There was no obvious regularity in the number of lesions.*
Conclusion: *Patients with COVID-19 have regular changes in their lung conditions.*

Keywords: *Novel coronavirus, Pneumonia, Viral, Tomography, X-ray computed*

Abbreviations: *COVID-19: Coronavirus Disease-19; CT: Computed Tomographic; SARS: Severe Acute Respiratory Syndrome; MERS: Middle East Respiratory Syndrome*

Introduction

COVID-19 (coronavirus disease-19, COVID-19) was caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Since the outbreak of COVID-19, more than three million people have been infected, and more than 200 thousand patients have died in many countries around the world. Although SARS-CoV-2, SARS-CoV and MERS-CoV are coronaviruses, they are very different [1]. It has been reported that SARS-CoV-2 can be transmitted from person to person through droplets, contact and other means and is highly infectious [2,3], and asymptomatic SARS-CoV-2 virus-infected people are also infectious [4]. At present, there are many reports on the CT manifestations of COVID-19, but there are few studies on the dynamic changes in the CT findings of rehabilitated patients. Therefore, this study intends to summarize the dynamic changes in the CT findings of rehabilitated patients with COVID-19 and their relationship with the clinical prognosis to provide a basis for clinicians to master the patient's condition in a timely manner and make a reasonable treatment plan.

Materials and Methods

General information

Clinical and chest CT data of 37 patients with COVID-19 confirmed by the SARS- CoV-2 virus nucleic acid test in our hospital from January to March 2020 were collected. There were 20 males and 17 females, with an average age of 43.59 ± 12.27 years. The primary symptoms of the patients were fever, sore throat, fatigue, cough, muscular soreness, chest tightness and diarrhea (Table 1). Laboratory examination showed normal or decreased leukocytes and normal or decreased absolute number of lymphocytes. This study was approved by our hospital Institutional Review Board, and the requirement for informed consent was waived.

	All patients (n = 37)
Average length of stay	17.92 ± 6.74
Gender	
Male	20 (54.05%)
Female	17 (45.95%)
Age	
Average	43.59 ± 12.27
Symptom	
Fever	29 (78.38%)
Sore throat	3 (8.11%)
Fatigue	17 (45.95%)
Cough	15 (40.54%)
Muscular soreness	6 (16.22%)
Diarrhea	4 (10.81%)
Chest tightness	10 (27.03%)

Table 1. Statistical table of general information of 37 COVID-19 patients [n (%)].

CT Protocol

GE LightSpeed VCT and Bright Speed CT scanners were used. The patient was asked to lie in a supine position, and after the deep inspiratory breath-holding condition, a chest plain scan was performed. The scan ranges from the tip of the lung to the bottom of the lung. Scanning parameters: tube voltage 120 kV, fixed tube current 250 mA, rotation speed 120 r/min, pitch 1.375 mm, matrix 512×512, field of view 360 mm×360 mm, scanning layer thickness 5 mm, reconstruction layer thickness 1.25 mm.

Image Analysis

Two radiologists who have worked for more than 8 years independently reviewed the image and reached consensus through consultation when there were differences of opinion. The number of affected pulmonary lobes and the location, shape and signs of the lesion (interlobular septal thickening, subpleural line, fibrous cord, air bronchogram, pleural thickening) were observed.

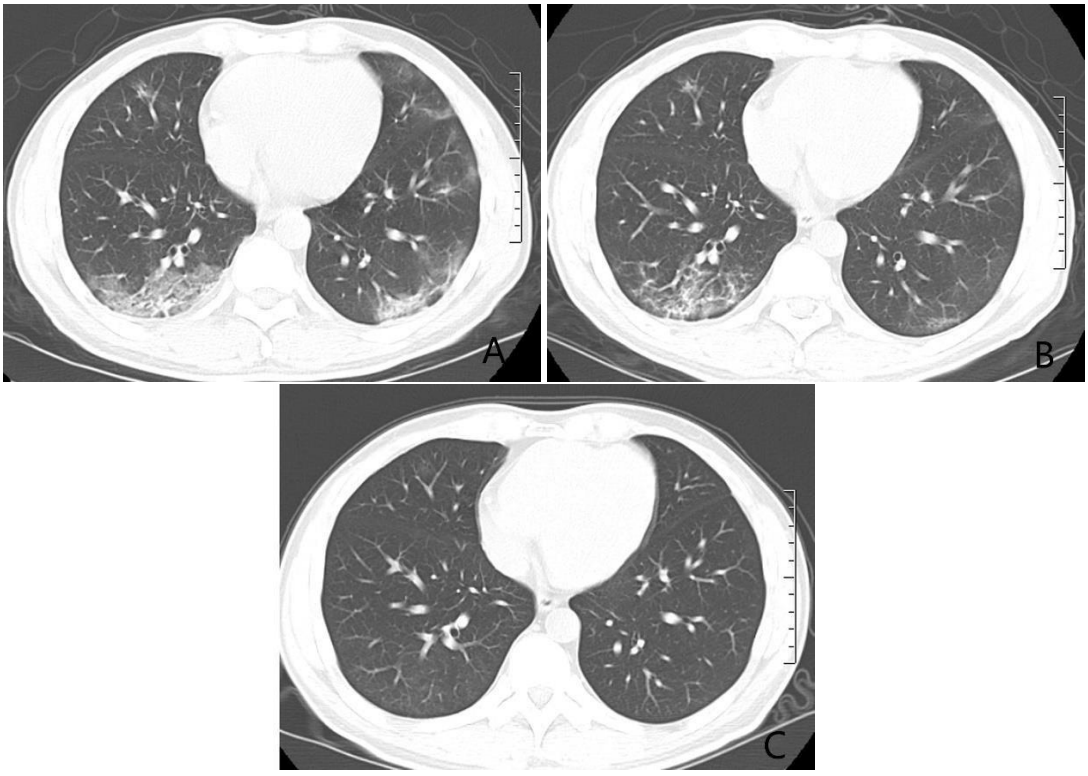

Figure 1. A: COVID-19 patient, male, 43years old, CT images on the 11th day of onset. Multiple patchy ground glass opacity in both lungs, with thickening of interlobular septum, consolidation and fibrous cord shadow. **B:** The same patient with figure A, re-examination CT images on the 19th day of onset. The lesion density absorption became weaker, the scope was narrowed, and the number of lesions decreased. **C:** The same patient with figure A, re-examination CT images on the 52nd day of onset. The lesions absorbed obviously, a little residual ground glass opacity seen in the lung.

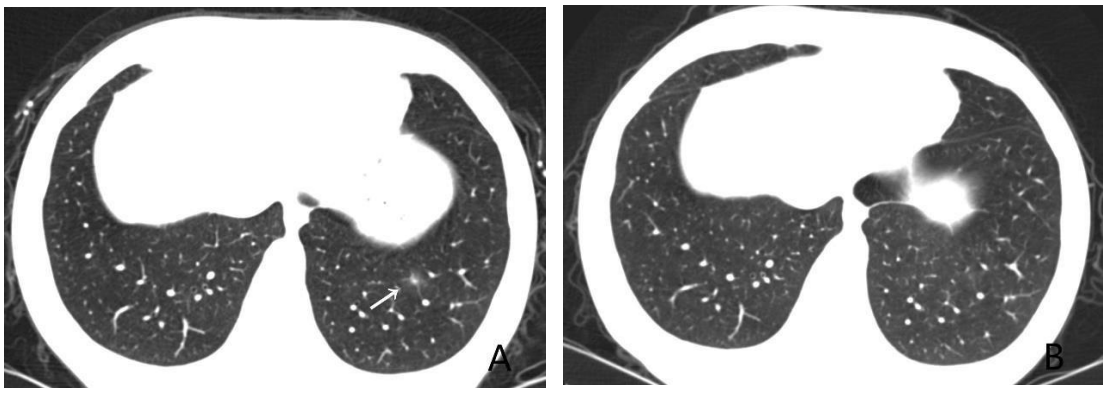

Figure 2. A: COVID-19 patient, male, 51years old, CT images on the 17th day of onset. Single ground glass nodules in the left lower lung (arrow). **B:** The same patient with figure A, CT images on the 31th day of onset. The left lower lung disease was completely absorbed.

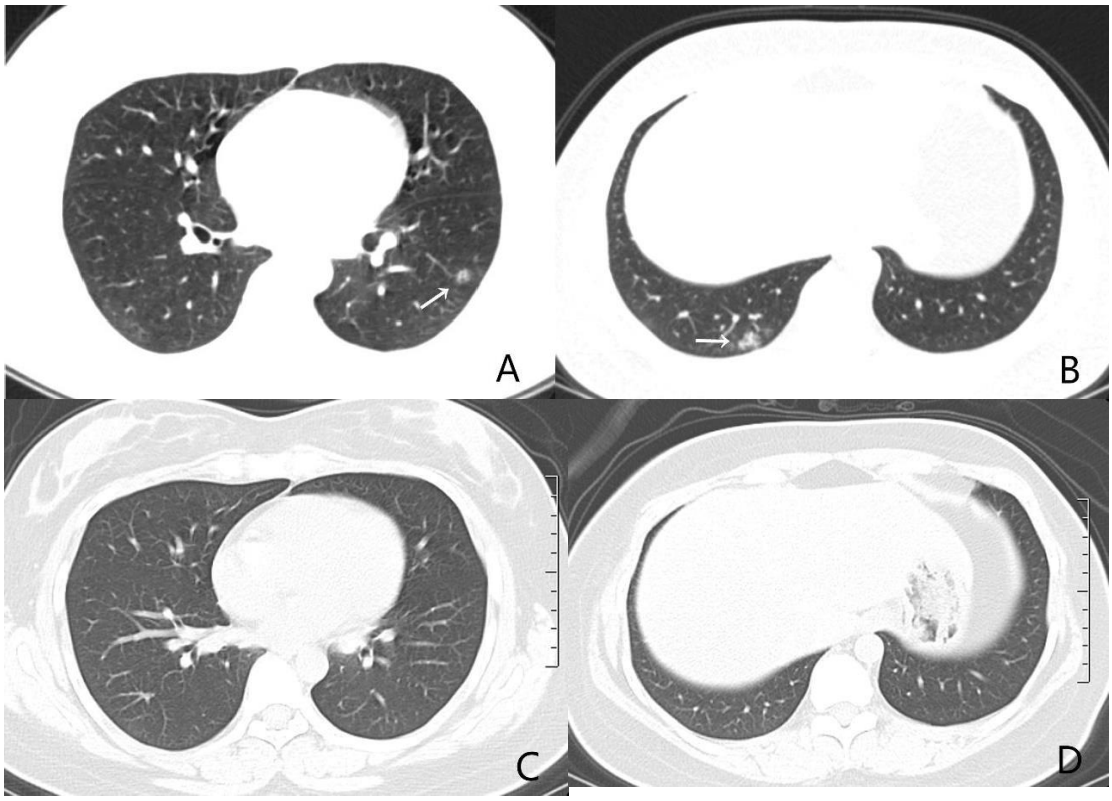

Figure 3. A: COVID-19 patient, female, 25years old, CT images on the 2nd day of onset. Nodular ground glass opacity in left lower lungs (arrow). **B:** The same patient with figure A. Nodular ground glass opacity in right lower lungs (arrow), and the lesions were more serious than those in figure 2. **C:** The same patient with figure A, CT images on the 16th day of onset. The lesions of left lower lungs were completely absorbed. **D:** The same patient with figure A, CT images on the 16th day of onset. The lesions of right lower lungs were completely absorbed, with less time than patient shown in Figure 2.

Total lobe involvement	119	
Average	3.22	
Range	1-5	
Standard deviation	1.62	
Five lobes were involved	14	37.84%
Right upper	18	48.65%
Right middle	23	62.16%
Right lower	28	75.68%
Left upper	25	67.57%
Left lower	24	64.86%
Both lower lungs are involved	22	59.46%
The subpleural exenterium is prominent	31	83.78%
Both lung involvement	27	72.97

Table 2: The location and distribution of lesions in first CT in 37 patients with COVID-19 [n (%)]

Onset time/day	Consolidation n(%)	Air bronchogram n(%)	Fiber cord n(%)
1-3 (n = 9)	7 (77.78)	1 (11.11)	2 (22.22)
4-6 (n = 13)	12 (92.31)	4 (30.77)	7 (53.85)
7-9 (n = 17)	15 (88.24)	9 (52.94)	13 (76.47)
10-12 (n = 17)	14 (82.35)	5 (29.41)	9 (52.94)
13-15 (n = 15)	11 (64.71)	4 (26.67)	7 (46.67)
16-18 (n = 24)	13 (76.47)	3 (12.50)	9 (37.5)
19-21 (n = 11)	5 (29.41)	2 (18.18)	7 (63.64)
> 21 (n = 42)	10 (23.81)	4 (9.52)	18 (42.86)
Total (n = 148)	87 (58.78)	32 (28.03)	72 (54.12)

Onset time/day	Septal thickening n(%)	Pleural subline n(%)	pleural thickening n(%)
1-3 (n = 9)	3 (17.65)	0 (0)	0 (0)
4-6 (n = 13)	5 (38.46)	2 (15.38)	4 (30.77)
7-9 (n = 17)	12 (70.59)	5 (29.41)	6 (35.29)
10-12 (n = 17)	14 (82.35)	6 (35.29)	6 (35.29)
13-15 (n = 15)	7 (46.67)	2 (13.33)	5 (33.33)
16-18 (n = 24)	15 (62.50)	5 (20.83)	9 (37.50)
19-21 (n = 11)	5 (45.45)	6 (54.55)	5 (45.45)
> 21 (n = 42)	11 (26.19)	5 (11.90)	9 (21.43)
Total (n = 148)	72 (54.12)	31 (26.03)	44 (35.06)

Table 3. CT signs of 37 patients with COVID-19 [n (%)].

Onset time/day	Improvement	Progressed n(%)	Increased density n(%)	Density of absorption n(%)	No change in density n(%)
1-3(n = 0)	/	/	/	/	/
4-6（n = 5）	1（20.00）	4（80.00）	3（60.00）	1（20.00）	1（20.00）
7-9（n = 6）	3（50.00）	3（50.00）	2（33.33）	3（50.00）	1（16.67）
10-12（n = 10）	6（60.00）	4（40.00）	2（20.00）	7（70.00）	1（10.00）
13-15（n = 13）	8（61.54）	5（38.46）	2（15.38）	10（76.92）	1（7.69）
16-18（n = 24）	20（83.33）	4（16.67）	3（12.50）	19（79.17）	2（8.33）
19-21（n = 11）	10（90.91）	1（9.09）	1（9.09）	9（81.82）	1（9.09）
＞21（n = 42）	42（100.00）	0（0.00）	0（0.00）	41（97.62）	3（7.14）

Onset time/day	Lesion reduction n(%)	Lesion enlarge n(%)	No change in size n(%)	Decrease in number n(%)	Increase in number n(%)	No change in number n(%)
1-3（n = 0）	/	/	/	/	/	/
4-6（n = 5）	1（20.00）	3（60.00）	1（20.00）	1（20.00）	3（60.00）	1（20.00）
7-9（n = 6）	2（33.33）	3（50.00）	1（16.67）	1（16.67）	1（16.67）	4（66.67）
10-12（n = 10）	4（40.00）	3（30.00）	3（30.00）	2（20.00）	4（40.00）	4（40.00）
13-15（n = 13）	7（53.85）	5（38.46）	1（7.69）	1（7.69）	4（30.77）	8（61.54）
16-18（n = 24）	18（75.00）	4（16.67）	2（8.33）	9（37.50）	4（16.67）	11（45.83）
19-21（n = 11）	8（72.73）	1（9.09）	2（18.18）	3（27.27）	0（0.00）	8（72.73）
＞21（n = 42）	39（92.86）	0（0.00）	3（7.14）	29（69.05）	0（0.00）	13（30.95）

Table 4. Characteristics of CT image changes in patients with COVID-19 reexamination.

Discussion

Chest CT findings of COVID-19

The literature [5-8] reported that COVID-19 CT showed multiple flaky and patchy ground glass density shadows in the subpleural spaces of both lungs, which easily involved multiple pulmonary lobes or pulmonary segments. The vasculature was clearly visible, and some lesions had partial or complete consolidation. Some studies [9] have pointed out that for patients with a history of exposure or travel to the epidemic area, bilateral multiple ground glass shadows or consolidation appear on chest CT, which is highly suggestive of the diagnosis of COVID-19. In our study, the first CT examinationof 72.07% (27/37) showed bilateral distribution of lesions, 83.78% (31/37) showed significant subpleural spaces, 89.19% (33/37) showed flaky and patchy appearance, 51.35% (17/19) showed ground glass density

shadow, and 89.19% (33/37) showed consolidation, which was consistent with the above study results.

CT signs of COVID-19 patients changed with the onset time

In the early stage of the disease, due to the dilatation and congestion of the interstitial capillary in the alveolar septum, the alveolar cavity produces exudate frequently, and pulmonary interstitial edema is presented by CT as ground glass opacity. Subsequently, the lesion progresses, the alveolar cavity produces more exudate and gradually fills the alveolar cavity, and consolidation is observed [10,11]. Xu, et al. [12] showed that consolidation indicates the progression of the disease, and it is more common in severe and critical patients than in common patients. In this study, 77.78% (7/9) of the patients showed consolidation on the first 1-3 days of onset, and the highest percentage was 92.31% (12/13) on days 4-6. After 7 days, the percentage of consolidation was reduced, and only 23.81 (10/42) patients had consolidation after 21 days. At 7-9 days, 88.24% (15/17) of the patients had consolidation. At this time, "air bronchogram" and fiber cord shadow were also common, representing 52.94% (9/17) and 76.47% (13/17), respectively. As viruses in the same virus family have similar pathogenesis [5], SARS-CoV-2 has similar CT manifestations to SARS and MERS infection, which are mainly lung interstitial lesions, lobular septal thickening and subpleural lines. In this study, the percentages of interlobular septal thickening and subpleural thickening were the highest at 10-12 days and 19-21 days, respectively, which were 82.35% and 54.55%, respectively. With the extension of the onset time, the lesion was gradually absorbed, and fiber bands can be left in the lung [12]. Therefore, the appearance of fiber bands suggests the improvement of lesion absorption. In this study, 63.64% (7/11) of the patients presented with fiber-cord shadows on days 19-21, and 42.86% (18/21) of the patients still had fiber-cord shadows after 21 days. In this study, pleural thickening was not observed 1-3 days after the onset of the disease, and the percentage difference in other stages was not significant, ranging from 30.77% to 45.45%, indicating that the percentage of pleural thickening had no obvious temporal regularity.

Changes in the images of patients with COVID-19 during follow-up compared with the previous time

In patients with COVID-19, the pulmonary lesions gradually worsened in the early stage of onset, presenting as increased density, increased range and increased number. After 2-3 weeks, the lesions gradually absorbed, decreased in range and decreased in density [13,14]. Pan, et al. [14] found that 85.7% of patients with COVID-19 had a peak pulmonary lesion severity on the 10th day of the course of disease and then gradually improved. Other studies [15] reported that some patients with severe lung disease progressed rapidly. In our study, 80.00% of patients had more advanced lesions in 4-6 days. The percentage of patients with increased density, increased range and increased number of lesions was higher than that of patients with decreased density, decreased range and decreased number (all 60.00% VS. 20.00%). The absorption of the lesion improved in 83.33% of the patients between 16 and 18 days after onset, and the percentage of the patients improved gradually with the extension of the onset time. In this study, the percentage of decreased absorption of lesion density gradually increased after 6 days, and the percentage of patients with decreased lesion density gradually increased after 9 days, indicating that the lesion began to be absorbed after 6 days. After 21 days, there was no increase in the density or enlargement of the lesions. The increase in the number of lesions was higher at 4-6 days, but there was no trend with the extension of the onset time.

The absorption status and differences in pulmonary lesions in different patients with COVID-19

Xu, et al. [12] showed that most of the lesions reexamined 4-10 days after treatment were better absorbed than before, and the scope of the lesions was reduced and the density was reduced. The right lung lesions could be absorbed 4 days after treatment in common patients. Lin, et al. [16] found that most patients with mild COVID-19 after treatment had complete absorption of intrapulmonary lesions, and some patients had residual fibrotic foci in the lung. In this study, among the 5 patients with complete absorption of lesions, the patients with complete absorption on day 16 were heavier than those with complete absorption on day 31, and the other 3 patients with complete absorption of lesions were also heavier on days 40, 44 and 54.

It's a retrospective study, the number of cases collected was small, some cases were lost to follow-up, and some cases were still in the follow-up process, which may have had an impact on the results.

Conclusions

In conclusion COVID-19 has typical chest CT findings, and the CT signs at different stages of the disease have certain characteristics. The disease changes rapidly, and the disease progresses in 4-6 days. The lesion can be absorbed and improved after 6 days. The time to complete absorption of the lesion varies among different patients. Timely chest CT reexamination to master the CT features and outcome characteristics of COVID-19 is helpful for clinicians to monitor changes in the condition and make timely adjustments to the treatment plan.

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