Chest CT and Clinical Follow-up of Discharged Patients with COVID-19 in Wenzhou City, Zhejiang, China

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Key Words: CT imaging; follow-up; SARS-CoV-2; COVID-19; recurrently positive

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Abstract

Rationale: Many clinical studies focused on the epidemiological and clinical characteristics of the inpatients with COVID-19. However, there are few reports about clinical follow-up about discharged patients.

Objectives: This paper aimed to describe the follow-up of patients with COVID-19 in Wenzhou city, Zhejiang, China.

Methods: We retrospectively reviewed 4-week follow-ups in patients with COVID-19, including CT chest scanning, blood test, and oropharyngeal swab test of SARS-CoV-2 RNA. The chest CT scan and blood test were performed on the last day before discharge, two weeks and four weeks after discharge. The oropharyngeal swab test was performed on both one week and two weeks after the discharge. Fifty-one common COVID-19 patients were enrolled in the study. All the CT and clinical data were collected between January, 23 and March, 28, 2020.

Results: Compared with the last CT scan before discharge, the abnormalities in lungs were gradually absorbed in the first and second follow-ups after discharge. The cases with focal ground-glass opacity (GGO) reduced from 17.7% to 9.8%. The cases with multiple GGO decreased from 80.4% to 23.5%. The cases with consolidation reduced from 49.0% to 2.0%. The cases with interlobular septal thickening reduced from 80.4% to 35.3%. The cases with subpleural lines reduced from 29.4% to 7.8%. The cases with irregular lines reduced from 41.2% to 15.7%. The lung lesions of 25.5% patients were fully absorbed in the first CT scans after discharge and the rate of lung recovery increased to 64.7% after the second follow-up. Nucleic acid tests turned recurrently positive in 17.6% discharged patients, in which only 33.3% patients

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complained clinical symptoms. There were no differences in the characteristics of the last CT before discharge between the patients with recurrently positive test and patients with negative test. The lung damages were fully absorbed in 55.6% discharged patients with recurrence of positive SARS-CoV-2 RNA.

Conclusions: The lung damage due to COVID-19 could be reversible for the common COVID-19 patients. A few cases showed recurring positive results of nucleic acid tests after discharge.

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Since December 2019, a cluster of patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have been identified in Wuhan, China [1,2]. The pneumonia caused with the virus was named with coronavirus disease 2019 (COVID-19) by WHO. The virus has led worldwide panic for its significant infectivity and virulence [3,4].

Many clinical studies focused on the epidemiological and clinical characteristics of the inpatients with COVID-19 , such as the onset symptoms and blood test results [1, 2]. However, there are few reports about clinical follow-up about discharged patients with COVID-19 [8]. According to the criteria of discharge released by the China National Health and Fitness Commission, the nucleic acid tests of SARS-CoV-2 RNA were repeated after discharged and the results of a few patients were positive [9,10]. Therefore, it is necessary to keep the follow-up visit of patients with COVID-19. In addition, followed chest CT of discharged patients could help better understand the effect to the lung caused by COVID-19.

In our hospital, chest computed tomography (CT) scan, blood examination and nucleic acid test of SARS-CoV-2 RNA were widely used in the follow-up evaluation of discharged patients infected with COVID-19. The purpose of this study was to describe the clinical follow-up of the patients who had discharged from our hospital for 4 weeks.

Methods

Patients

Our study was approved by the ethics committees of Ruian People's hospital and Ruian hospital

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of traditional Chinese medicine. The informed consent was waived. There were 51 patients infected with SARS-CoV-2 enrolled in this study. All the patients were in the common COVID-19 group (Table 1), who were treated in the Ruian People's Hospital. According to "Pneumonia diagnosis and treatment program for novel coronavirus infection (trial version 5)" issued by National Health Commission of the People's Republic of China (Table 1), common COVID-19 patients had fever, some respiratory infected symptoms, and pneumonia on radiographic images. The patients were discharged from Ruian People's Hospital after two negative nucleic acid tests, taken at least 24 hours apart, and the indications of clinical recovery according to the China National Health and Fitness Commission criteria (Supplementary Table 1).

Data Collection

The clinical data, including blood test, chest CT scan and oropharyngeal swab test, were retrospectively collected in our study. Blood examination included blood routine, alanine aminotransferase, aspartate transaminase, lactate dehydrogenase, blood urea nitrogen, creatinine. Clinical data was collected between January, 23 and March, 28, 2020. For all the patients infected with COVID-19, the blood examinations and CT scans were performed on the last day before discharge, around two weeks after the discharge, about four weeks after the discharge. In addition, oropharyngeal swab test was performed one and two weeks after the discharge. The frequency of follow-up tests and chest CT imaging were suggested by National Health Commission of the People's Republic of China.

The CT chest scan was performed using one of the multi-slice spiral scanners: uCT 528

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(United Imaging Healthcare, Shanghai, China), or Siemens SOMATOM Perspective CT Scanner (Siemens Medical Solution, Forchheim, Germany). The pixel spacing of CT image was 0.72 mm and 0.85 mm for uCT and Simens scanncer respectively. The slice thickness was 5 mm for both scanners. All chest scan acquisitions were performed in the spiral mode at a pitch of 1.125, tube voltage of 100 kVp, and adaptive tube current. The scan covered the entire chest and provided a detailed look from the thoracic inlet to the costophrenic angle. The oropharyngeal swab was tested using the Coronavirus Disease 2019 (ORF lab/N gene) nucleic acid detection kit (Shanghai BioGerm Medical Biotechnology Co., Ltd). The detection kit was officially approved by the National Medical Products Administration and received European Union CE certification. The detection limit of the kit was 968 copies/mL [11].

Data Analysis

All the CT scans were analyzed on a radiology PACS workstation (Greenlander version 6.0, Mindray Healthcare, Shenzhen, China). Two or more senior general radiologists with over 15 years of clinical experience reviewed and evaluated the CT imaging features, came to a consensus, and eventually reported the CT findings in the electronic information system. All CT findings were taken from the original clinical reports. The CT imaging features were evaluated, including focal ground glass opacities (GGO), multiple GGO (Figure 1(a-b)), diffused GGO, consolidation (Figure 1(c-d)), interlobular septal thickening (Figure 1(e)), subpleural lines (Figure 1(e)), irregular lines (Figure 1(e)), bronchiectasis (Figure 2), and reticular pattern (Figure 1(f)). In our study, focal GGO indicated that multiple or single ground glass attenuation was

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concentrated in one lung lobe. Multiple GGO meant that multiple ground glass attenuation was presented in at least two lung lobes. Diffuse GGO referred to large areas with increased density in both lungs on chest CTs. Consolidation was defined as higher density than GGO and blurred margins of pulmonary blood vessels and bronchial tubes. Reticular pattern was defined as a collection of innumerable small linear opacities.

Results

Clinical Characteristics

Fifty-one common patients with COVID-19 completed the clinical follow-up for four weeks. The clinical characteristics of these patients are presented in Table 2. The clinical characteristics of male and female patients are shown in Supplementary Table 3, 4 respectively.

Follow-up of Chest CT Scans

Three CT examinations were performed on 51 patients. The first CT scans were captured on the last day before discharge. The median interval between discharge and the first follow-up CT was 10 days with the range of 7~16 days. The median interval between the first and second follow-up CT was 31 days with the range of 20~37 days.

Compared with the last CT scan before discharge, the abnormalities in lungs gradually resolved in the first and second follow-ups after discharge (Table 3). The numbers mentioned in this section are the number of subjects with the specific finding, not the total number of such

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findings. The number of focal ground-glass opacity (GGO) reduced from 9 (17.7%) to 5 (9.8%) in the 1st follow-up CT after discharge, and remained 5 (9.8%) in the 2nd follow-up CT after discharge. The reduced GGO cases indicated that the GGO lesions were completely resolved in these cases. The number of multiple GGO decreased from 41 (80.4%) to 32 (62.8%), and then to 12 (23.5%). The number of diffused GGO remained 1 (2.0%) in the 1st follow-up CT after discharge, and reduce to 0 in the 2nd follow-up CT. The number of consolidations reduced from 25 (49.0%) to 4 (7.8%), and to 1 (2.0%). The number of interlobular septal thickening reduced from 41 (80.4%) to 25 (49.0%), and to 18 (35.3%). The number of subpleural lines reduced from 15 (29.4%) to 11 (21.6%), and to 4 (7.8%). The number of irregular lines reduced from 21 (41.2%) to 16 (31.4%), and to 8 (15.7%). The number of bronchiectasis reduced from 17 (33.3%) to 6 (11.8%), and to 2 (3.9%). The number of reticular pattern reduced from 2 (3.9%) to 1 (2.0%), and to zero. The lung lesions of 13 patients (25.5%) were fully absorbed in the first CT scans after discharge and the rate of lung recovery increased to 64.7% after the second follow-up CT (Figure 3). In the 1st follow-up CT, 84% (21/25) of consolidation cases were resolved, which was the quickest among the different types of lesions. Between the 1st and 2nd CT follow-ups, 75% (3/4) of consolidation cases got recovered, which was the quickest compared to other lesions (excluding diffused GGO and reticular pattern due to the small number). During the 4 week follow-up, the recovery of consolidation (96%, 24/25) was quicker than other type of lesions.

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Follow-up of Blood Test

The laboratory test of blood was performed on the same day as the follow-up CT. The patients were regrouped based on the recovery from lung damages into partially absorbed (Figure 4) and fully absorbed (Figure 3) groups. However, there was no significant difference between two groups in the two-week follow-up CT and in the four-week follow-up (Supplementary Table 4, 5).

Discharged Patients with Recurrence of Positive SARS-CoV-2 RNA

All 51 patients had two negative nucleic acid tests before discharge, taken at least 24 hours apart. However, oropharyngeal swab tests of SARS-CoV-2 RNA were performed for all these patients in one and two weeks after the discharge, respectively. Five patients recurred weakly positive in one week after the discharge. Two weeks after the discharge, 4 of them turned negative and one case remained weakly positive. However, oropharyngeal swab tests of SARS-CoV-2 RNA turned weakly positive recurrently in 4 other patients, whose nucleic acid tests were negative in the first week. In total, 9 of 51 patients (17.6%) were recurrently weakly positive. Among them, 3 cases complained of dry cough, 1 case complained of cough with sputum, and the other 6 patients showed no clinical symptoms. Out of the 9 patients, one was pregnant, one had diabetes, and another one had hypertension.

We compared the last CT before discharge of patients with recurrently positive nucleic acid tests to those of patients with negative tests (Table 4). There were no differences in the characteristics of CT between the two subgroups. The subsequent analysis of the blood tests

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before discharge between these two subgroups showed no significant differences either (Table 5). Considering the symptoms after 4 weeks post-discharge, there was no significant difference in clinical characteristics between the recurring positive and negative patients (Supplementary Table 6). In addition, there was no significant difference (p=0.25) in the length of hospital stay between the recurring positive and negative patients (Supplementary Table 7).

In the 1st follow-up CT after discharge, the lung lesions were fully absorbed in one case with recurrently positive test. The lung damages of 4 patients were fully absorbed in the 2nd follow-up CT. By the 2nd follow-up CT, the abnormalities in lung of 5 patients with recurrently positive nucleic acid test were fully absorbed, and the lung damages of 4 other patients were partly absorbed than before. Moreover, none of the patients further infected other people.

Discussion

COVID-19 has been raging in China for over 3 months. Until March 31, 2020, China has cured over 76,000 COVID-19 patients. However, SARS-CoV-2 outbreak is a global pandemic. The number of COVID-19 patients in America and Europe has been increasing rapidly. A follow-up observation of chest CT and clinical features could feedback the COVID-19 diagnosis and treatment. In our study, 51 common COVID-19 patients who met the discharge criteria (Supplementary Table 1) were evaluated during the four weeks after the discharge. These patients are returnees from Wuhan or close contacts to returnees. Local Disease Control Centers and hospitals conducted screening, diagnosis, and treatment in the early stage. The

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prevention and treatment work were relatively well done.

Compared with the CT features before the discharge, the lesions were significantly reduced, and the lesion density became decreased. Furthermore, the lung lesions of 64.7% discharged patients were fully absorbed after 4-week follow-up. It indicated that the damage to lung tissue by COVID-19 could be reversible for the common COVID-19 patients. It also suggested that the prognosis of non-severe patients (Table 1) is favorable, and the clinical intervention should be conducted in time to prevent common COVID-19 patients from worsening to sever patients.

We noticed that two and four weeks after the discharge the lung consolidations in the common COVID-19 patients got recovered more quickly than other types of lesions. As far as we know, the dynamic change of chest CT imaging in COVID-19 patient was as follows. In the early stage, chest CT of COVID-19 patients mainly manifest as GGO and interstitial changes. As the disease progresses, consolidations may occur in some patients. After the active treatment, the consolidations would be absorbed gradually, so the recovery of consolidations could be relatively faster than other type of lesions. The lung lesions were absorbed gradually in chest CT imaging.

Our follow-up observation showed that nucleic acid tests turned recurrently positive in 17.6% patients during two weeks after discharge. On the premise of normalized sampling operation, the false negatives of oropharyngeal swabs tests at the time of discharge are presumed to be the reason for later positive results of nucleic acid tests. Angiotensin-converting enzyme-2 (ACE-2) was identified as the cell entry receptor of SARS-CoV-2, which was

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highly expressed in the lungs rather than in the upper respiratory tract [12,13]. Therefore, we speculate that the viral load of SARS-CoV-2 in the lungs is more than it's in the upper respiratory tract. As the patient's condition improved, viral load, especially in the upper respiratory tract, decreased significantly. At this period, there could be a false negative result through the oropharyngeal or nasopharyngeal swab test. Thus, combining sputum, blood and other specimens may be more clinically meaningful for the comprehensive judgment of whether the patients have turned to virus-negative. Besides, a positive nucleic acid test result does not mean that the virus still survives. In 9 patients with recurrently positive nucleic acid, only one-third complained about clinical symptoms. By the 2nd follow-up CT, the abnormalities in lung of 5 patients were fully absorbed, and the lung damages of 4 other patients were partly absorbed than before. All the contacts of each patients were identified and traced until the 4th week after discharge. None of the discharged patients further infected other people. Viral culture is required to determine whether these patients are still contagious. However, a recent study has shown that SARS-CoV-2 could not be isolated eight days after the onset of symptoms, although high viral load could be detected in the throat swab and sputum culture samples of patients [14]. According to our patient cohort, there may be amount of viral nucleic acid fragments detected in the samples, which is not necessarily infectious. In addition, there were no differences in the characteristics of the last CT scan and blood test before discharge between the patients with recurrently positive test and patients with negative test. Therefore, we can not use these indicators to predict whether the results of SARS-CoV-2 RNA test would be recurrently positive.

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The limitation of our study is that only common COVID-19 patients were enrolled. The follow-up visit was too short. Long-time CT follow-up is required to determine whether the reticular patterns evolve into irreversible fibrosis. For the patients with positive nucleic acid results in the second week after discharge, no further follow-up nucleic acid test was performed.

In summary, the lung damage due to COVID-19 could be reversible for the common patients. A few cases showed recurring positive results of nucleic acid tests after discharge, probably related to the false negativity of the nucleic acid test at the time of discharge.

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Table 1. The clinical classification of pneumonitis diagnosis and treatment program for COVID-19 infection (trial version 5)

Mild	Clinical symptoms are mild and no pneumonia on radiographic image
Common	With fever, some respiratory infected symptoms; Pneumonia on radiographic images
Severe	Meet any of the following, a. Respiratory distress, RR≥30/min b. At rest, finger clip oxygen saturation ≤93% c. PaO_2/FiO_2 ≤300mmHg (1 mmHg = 0.133Kpa)
Critical	Meet any of the following, a. Respiratory failure, requiring mechanical ventilation b. Shock c. Other organ failures requires ICU monitoring

Note: the mild and common patients were regarded as non-severe group, and the severe and critical were regarded as severe group.

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Table 2. Clinical characteristics of patients

Age, years	46.6 ± 13.9 (14~70)
Male/Female	21 / 30
Smoking	3 (5.9%)
Comorbidity	8 (15.9%)
Diabetes	4 (7.8%)
Hypertension	7 (13.7%)
Coronary heart disease	1 (2%)
Pregnancy	1 (2%)
Symptoms after 4 weeks post-discharge	
cough	8 (15.7%)
sputum	2 (3.9%)
throat discomfort	3 (5.9%)

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Table 3. Comparison of chest CT scans before discharge, the first and second CT follow-ups after discharge

	Last CT scan before discharge	1st follow-up CT after discharge	2nd follow-up CT after discharge
GGO	9 (17.7%)	5 (9.8%)	5 (9.8%)
Multiple GGO	41 (80.4%)	32 (62.8%)	12 (23.5%)
Diffused GGO	1 (2.0%)	1 (2.0%)	0 (0%)
Consolidation	25 (49.0%)	4 (7.8%)	1 (2.0%)
Interlobular septal thickening	41 (80.4%)	25 (49.0%)	18 (35.3%)
Subpleural lines	15 (29.4%)	11 (21.6%)	4 (7.8%)
Irregular lines	21 (41.2%)	16 (31.4%)	8 (15.7%)
Bronchiectasis	17 (33.3%)	6 (11.8%)	2 (3.9%)
Reticular pattern	2 (3.9%)	1 (2.0%)	0 (0%)

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Table 4. Comparison of the last CT features before discharge between the recurring positive and negative patients.

	Recurring positive (n=9)	Negative (n=42)	p-value
Focal GGO	0 (0%)	8 (19.1%)	0.17
Multiple GGO	2 (22.2%)	32 (76.2%)	0.11
Diffused GGO	0 (0%)	1 (2.4%)	0.62
Consolidation	6 (66.7%)	20 (47.6%)	0.57
Interlobular septal thickening	8 (88.9%)	32 (76.2%)	0.78
Subpleural lines	3 (33.3%)	13 (30.1%)	0.92
Irregular lines	3 (33.3%)	19 (45.2%)	0.67
Bronchiectasis	6 (66.7%)	12 (28.6%)	0.17
Reticular pattern	0 (0%)	3 (7.1%)	0.39

Note: p-values are obtained from Chi-square test

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Table 5. Comparison of the last laboratory test before discharge between the recurring positive and negative patients

	Recurring positive (n=9)	Negative (n=42)	p-value
Leu ($\times 10^9$/L)	5.04±1.58	5.62±1.68	0.37
Lym ($\times 10^9$/L)	1.45±0.47	1.52±0.48	0.71
Neu ($\times 10^9$/L)	3.04±1.06	3.48±1.38	0.39
PLT ($\times 10^9$/L)	308.0±98.66	279.9±104.8	0.34
ALT (IU/L)	25.88±28.29	29.5±22.36	0.41
AST (IU/L)	23.75±15.69	25.07±12.85	0.28
LDH (u/dl)	212.2±71.22	215.1±62.22	0.93
BUN (mmol/L)	4.12±1.36	3.86±0.87	0.54
Cr (umol/L)	64.33±5.24	67.14±10.02	0.51
Na^+ (mmol/L)	139.4±1.77	138.4±2.47	0.30
K^+ (mmol/L)	3.92±0.34	3.69±0.37	0.11

Leu: Leucocyte; Lym: lymphocyte; Neu: neutrophil; PLT: Platelet; ALT: alanine aminotransferase; AST: aspartate transaminase; LDH: lactate dehydrogenase; BUN: Blood urea nitrogen; Cr: Creatinine. p-values are from Mann-Whitney U test.

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Figure Legends:

Figure 1. Chest CT features of COVID-19 patients. (a) Chest CT of a 48-year-old male patient. Multiple ground-glass opacities were shown in the lower lobes. (b) Chest CT after 3 days of treatment of a 34-year-old female patient. Multiple patchy GGOs were shown in the lower lobes. (c) Chest CT at admission of a 51-year-old male patient. Consolidation in the right middle lobe and air bronchogram signs were shown. (d) Chest CT after 8 days of treatment of a 36-year-old male patient. Mutiple consolidations were shown in both lungs. (e) The last chest CT before discharge of a 65-year-old male patient. Subpleural lines and interlobular septal thickening were shown in the right lung, and irregular lines was present in left lung. (f) Chest CT after 3 days of treatment of a 70-year-old male patient. Multiple reticular patterns were shown in the right lung, and small consolidations were shown in the left lung.

Figure 2. The chest CT scans from a 34-year-old female COVID-19 patient. (a~d) the chest CTs at admission; (e~h) the chest CTs four weeks after the discharge showed that multiple patchy GGO in the lower lobes, consolidations and bronchiectasis mostly got recovered.

Figure 3. The chest CT scans from a 35-year-old male COVID-19 patient. (a, e) the chest CTs at admission. Chest CT presented multiple consolidation in the upper and lower lobes, GGO in the peripheral lung, and small cavity in the lower lobe of left lung. (b, f) the last chest CT before

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discharge. The consolidations were absorbed mostly and transformed into small patchy GGO. (c, g) the chest CT two weeks after the discharge. The GGO was absorbed completely. (d, h) the chest CT four weeks after the discharge showed no recurrence.

Figure 4. The chest CT scans from a 48-year-old male COVID-19 patient. (a, e) the chest CTs at admission. Mutiple patchy GGO, consolidation and interlobular septal thickening were shown in the lower lobes. (b, f) the last chest CT before discharge. Most of subpleural consolidations were absorbed. Small patchy consolidation in the lower right lung was present. GGO transformed into irregular line and subpleural lines. The density of interlobular septal decreased. (c, g) the chest CT two weeks after the discharge. The consolidation in the right lower lobe transformed into GGO. The density of sub-pleural GGO in both lungs was gradually absorbed. (d, h) the chest CT four weeks after the discharge showed that the damages were partly absorbed. The consolidation in the left upper lobe transformed into GGO, and the subpleural GGO was further absorbed.

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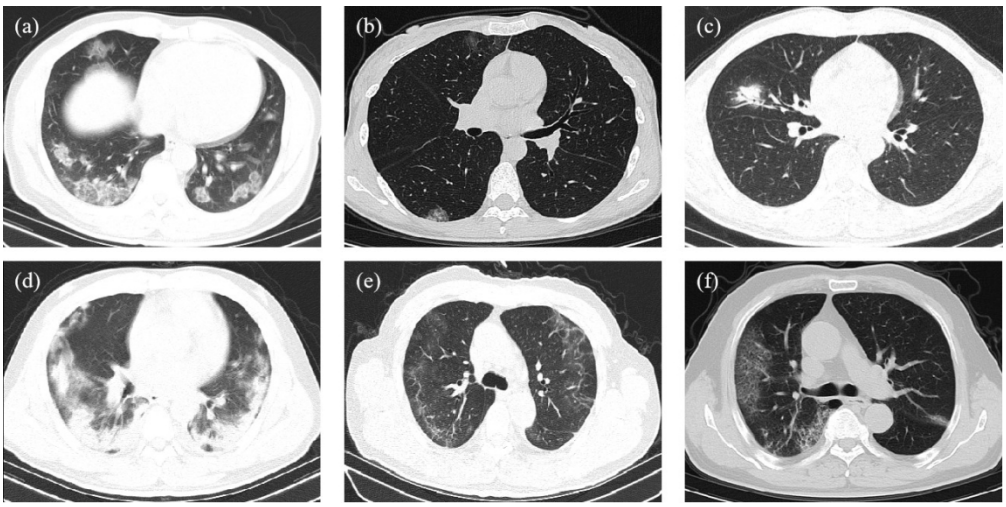

Figure 1. Chest CT features of COVID-19 patients. (a) Chest CT of a 48-year-old male patient. Multiple ground-glass opacities were shown in the lower lobes. (b) Chest CT after 3 days of treatment of a 34-year-old female patient. Multiple patchy GGOs were shown in the lower lobes. (c) Chest CT at admission of a 51-year-old male patient. Consolidation in the right middle lobe and air bronchogram signs were shown. (d) Chest CT after 8 days of treatment of a 36-year-old male patient. Mutiple consolidations were shown in both lungs. (e) The last chest CT before discharge of a 65-year-old male patient. Subpleural lines and interlobular septal thickening were shown in the right lung, and irregular lines was present in left lung. (f) Chest CT after 3 days of treatment of a 70-year-old male patient. Multiple reticular patterns were shown in the right lung, and small consolidations were shown in the left lung.

110x54mm (300 x 300 DPI)

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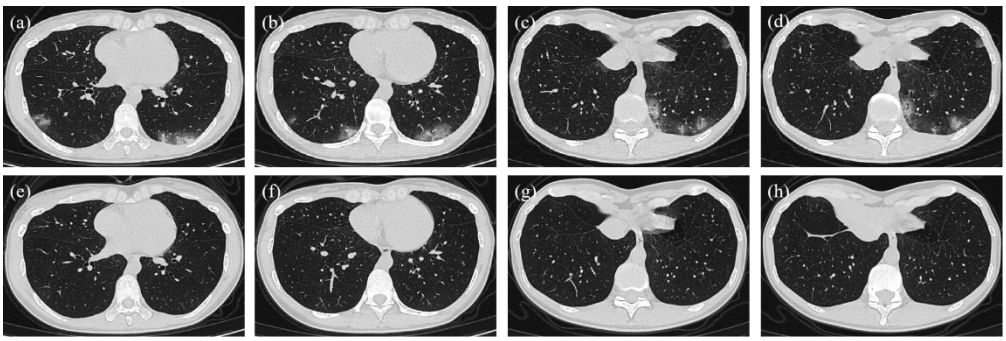

Figure 2. The chest CT scans from a 34-year-old female COVID-19 patient. (a~d) the chest CTs at admission; (e~h) the chest CTs four weeks after the discharge showed that multiple patchy GGO in the lower lobes, consolidations and bronchiectasis mostly got recovered.

186x61mm (300 x 300 DPI)

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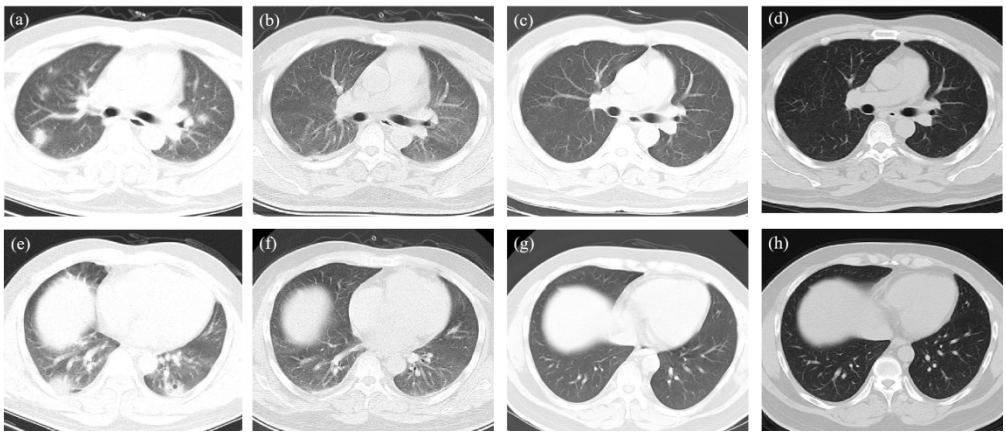

Figure 3. The chest CT scans from a 35-year-old male COVID-19 patient. (a, e) the chest CTs at admission. Chest CT presented multiple consolidation in the upper and lower lobes, GGO in the peripheral lung, and small cavity in the lower lobe of left lung. (b, f) the last chest CT before discharge. The consolidations were absorbed mostly and transformed into small patchy GGO. (c, g) the chest CT two weeks after the discharge. The GGO was absorbed completely. (d, h) the chest CT four weeks after the discharge showed no recurrence.

198x84mm (300 x 300 DPI)

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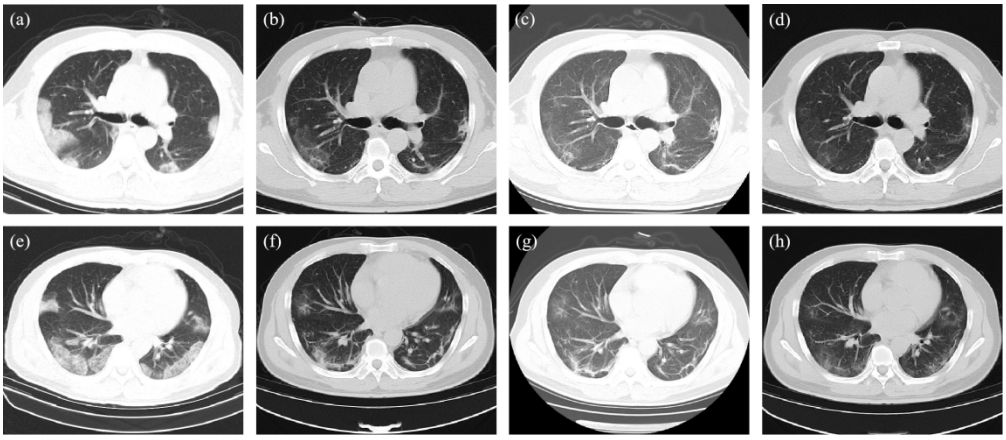

Figure 4. The chest CT scans from a 48-year-old male COVID-19 patient. (a, e) the chest CTs at admission. Mutiple patchy GGO, consolidation and interlobular septal thickening were shown in the lower lobes. (b, f) the last chest CT before discharge. Most of subpleural consolidations were absorbed. Small patchy consolidation in the lower right lung was present. GGO transformed into irregular line and subpleural lines. The density of interlobular septal decreased. (c, g) the chest CT two weeks after the discharge. The consolidation in the right lower lobe transformed into GGO. The density of sub-pleural GGO in both lungs was gradually absorbed. (d, h) the chest CT four weeks after the discharge showed that the damages were partly absorbed. The consolidation in the left upper lobe transformed into GGO, and the subpleural GGO was further absorbed.

190x82mm (300 x 300 DPI)

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Online Data Supplement

Chest CT and Clinical Follow-up of Discharged Patients with COVID-19 in Wenzhou City, Zhejiang, China

Chenbin Liu, Ling Ye, Ruike Xia, Xudong Zheng, Cuiyun Yuan, Zhenguo Wang, Ruiwu Lin, Deen Shi, Yuantong Gao, Junpu Yao, Qingfeng Sun, Xiaoyang Wang, Meiling Jin

Supplementary Table 1. The discharge criteria for COVID-19 confirmed patients

(i) Body temperature is back to normal for more than three days
(ii) Respiratory symptoms improved obviously
(iii) Pulmonary imaging shows obvious absorption
(iv) Two consecutive negative nucleic acid tests for respiratory specimens (sampling interval being at least 24 hours)

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Supplementary Table 2. Clinical characteristics of male patients

Age, years	46.9 ± 14.9 (21~70)
Male	21
Smoking	3 (14.3%)
Comorbidity	4 (19.1%)
Diabetes	3 (14.3%)
Hypertension	3 (14.3%)
Coronary heart disease	1 (4.8%)
Symptoms after 4 weeks post-discharge	
cough	3 (14.3%)
sputum	1 (4.8%)
throat discomfort	2 (9.5%)

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Supplementary Table 3. Clinical characteristics of female patients

Age, years	46.7 ± 13.6 (14~68)
Male	30
Smoking	0
Comorbidity	4 (13.3%)
Diabetes	1 (3.3%)
Hypertension	4 (13.7%)
Coronary heart disease	0 (2%)
Pregnancy	1 (3.3%)
Symptoms after 4 weeks post-discharge	
cough	5 (16.7%)
sputum	1 (3.3%)
throat discomfort	1 (3.3%)

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Supplementary Table 4. Comparison of the laboratory test at admission between partially and fully recovered groups in the 1st CT scan after discharge

	Partially absorbed (n=37)	Fully absorbed (n=12)	P-value
Leu ($\times 10^9$/L)	5.53±1.06	6.14±1.47	0.12
Lym ($\times 10^9$/L)	1.78±0.44	2.10±0.72	0.07
Neu ($\times 10^9$/L)	3.13±0.72	3.40±1.06	0.34
PLT ($\times 10^9$/L)	236.8±51.84	235.7±87.51	0.33
ALT (IU/L)	50.0±40.11	53.25±38.1	0.72
AST (IU/L)	33.19±23.34	29.25±12.81	0.94
LDH (u/dl)	175.8±43.88	157.5±17.09	0.15
BUN (mmol/L)	4.13±0.92	4.58±1.07	0.16
Cr (umol/L)	57.19±10.86	64.67±14.18	0.06

Leu: Leucocyte; Lym: lymphocyte; Neu: neutrophil; PLT: Platelet; ALT: alanine aminotransferase; AST: aspartate transaminase; LDH: lactate dehydrogenase; BUN: Blood urea nitrogen; Cr: Creatinine.

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Supplementary Table 5. Comparison of the laboratory test at admission between partially and fully recovered groups in the 2nd CT scan after discharge

	Partially absorbed (n=18)	Fully absorbed (n=30)	P-value
Leu ($\times 10^9$/L)	5.7±1.78	5.45±1.30	0.58
Lym ($\times 10^9$/L)	1.86±0.64	1.82±0.62	0.83
Neu ($\times 10^9$/L)	3.31±1.34	3.1±0.82	0.56
PLT ($\times 10^9$/L)	233.6±60.02	232.7±59.88	0.96
ALT (IU/L)	41.56±33.62	41.47±34.02	0.85
AST (IU/L)	31.94±20.27	28.0±15.18	0.49
LDH (u/dl)	206.8±49.8	201.2±29.9	0.67
BUN (mmol/L)	4.66±1.20	4.44±1.07	0.50
Cr (umol/L)	66.72±8.08	63.33±8.51	0.18

Leu: Leucocyte; Lym: lymphocyte; Neu: neutrophil; PLT: Platelet; ALT: alanine aminotransferase; AST: aspartate transaminase; LDH: lactate dehydrogenase; BUN: Blood urea nitrogen; Cr: Creatinine.

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Supplementary Table 6. Comparison of symptoms after 4 weeks post-discharge between the recurring positive and negative patients.

Symptoms after 4 weeks post-discharge	Recurring positive (n=9)	Negative (n=42)	p-value
cough	3 (33.3%)	5 (11.9%)	0.21
sputum	1 (11.1%)	1 (2.4%)	0.27
throat discomfort	0	3 (7.1%)	0.39

Note: p-values are obtained from Chi-square test

The symptoms (cough, sputum, and throat discomfort) were recorded after 4 weeks post-discharge, and the real-time reverse transcription-PCR tests were done after one and two weeks post-discharge. There was no significant difference in symptoms between the recurring positive and negative patients.

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Supplementary Table 7. Comparison of the length of hospital stay between the recurring positive and negative patients.

	Recurring positive (n=9)	Negative (n=42)	p-value
Length of hospital stay	14.56±5.67	12.83±4.58	0.25

Note: p-values are obtained from Wilcoxon rank sum test

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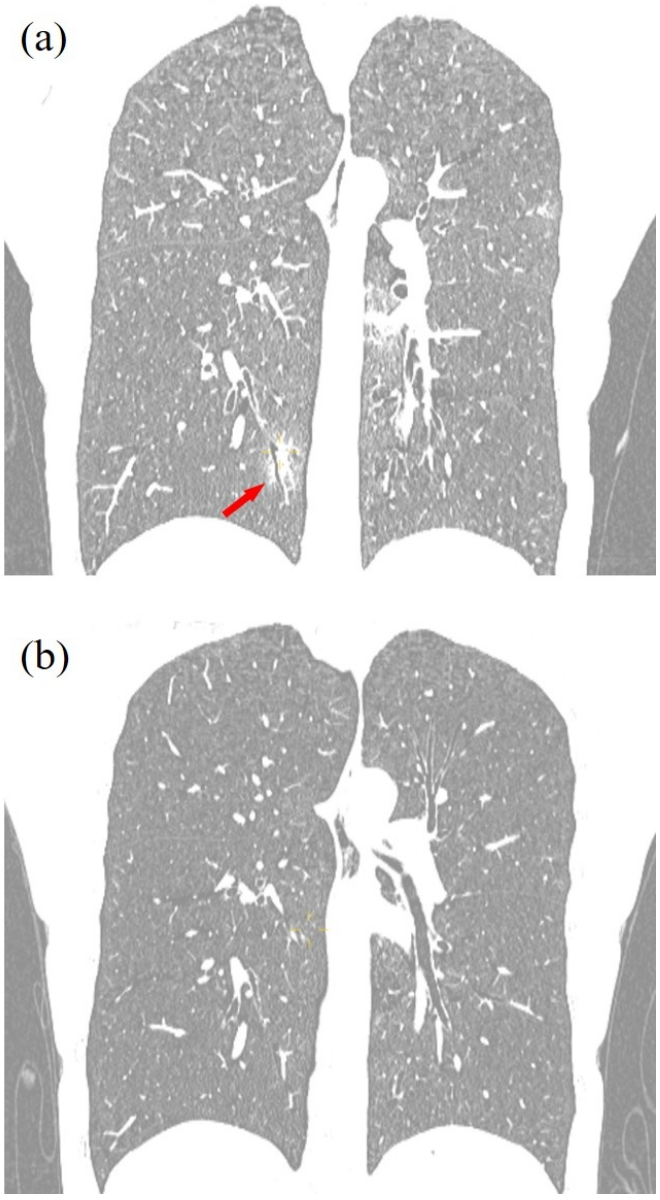

Supplemental Figure 1. The chest CT scans from a 41-year-old male COVID-19 patient. (a) the last chest CT before discharge. Bronchiectasis was shown in consolidation (red arrow). (b) the chest CT four weeks after the discharge. Both bronchiectasis and consolidation got recovered.

54x98mm (300 x 300 DPI)

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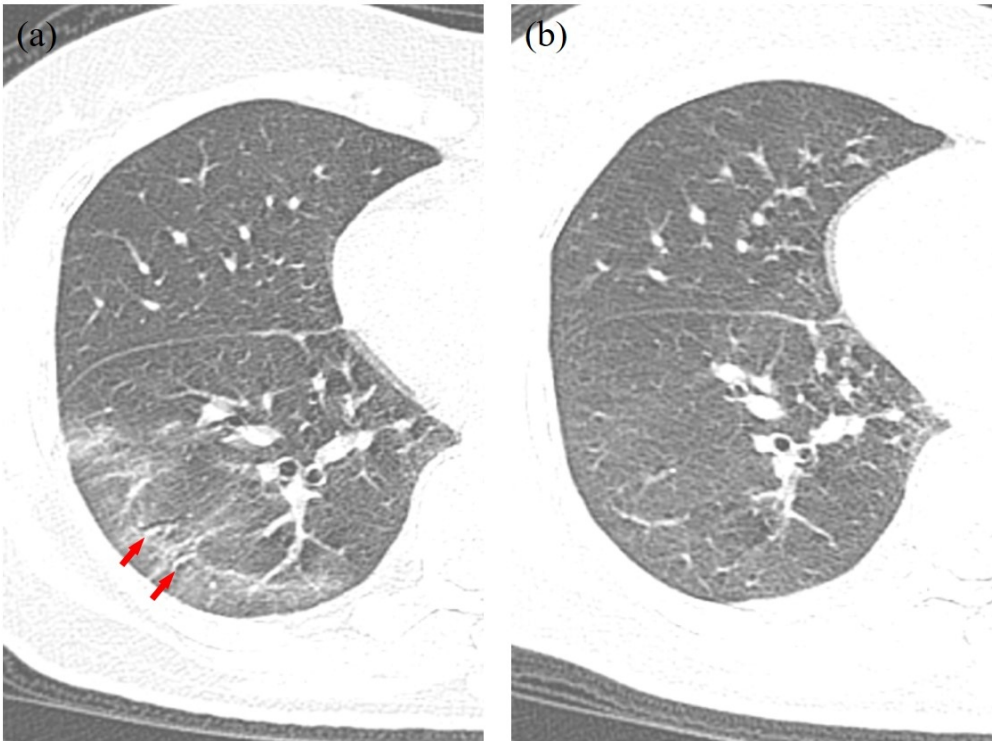

Supplemental Figure 2. The chest CT scans from a 60-year-old male COVID-19 patient. (a) the last chest CT before discharge. Bronchiectasis was shown in GGO (red arrows). (b) the chest CT four weeks after the discharge. Both bronchiectasis and GGO got recovered.

94x70mm (300 x 300 DPI)

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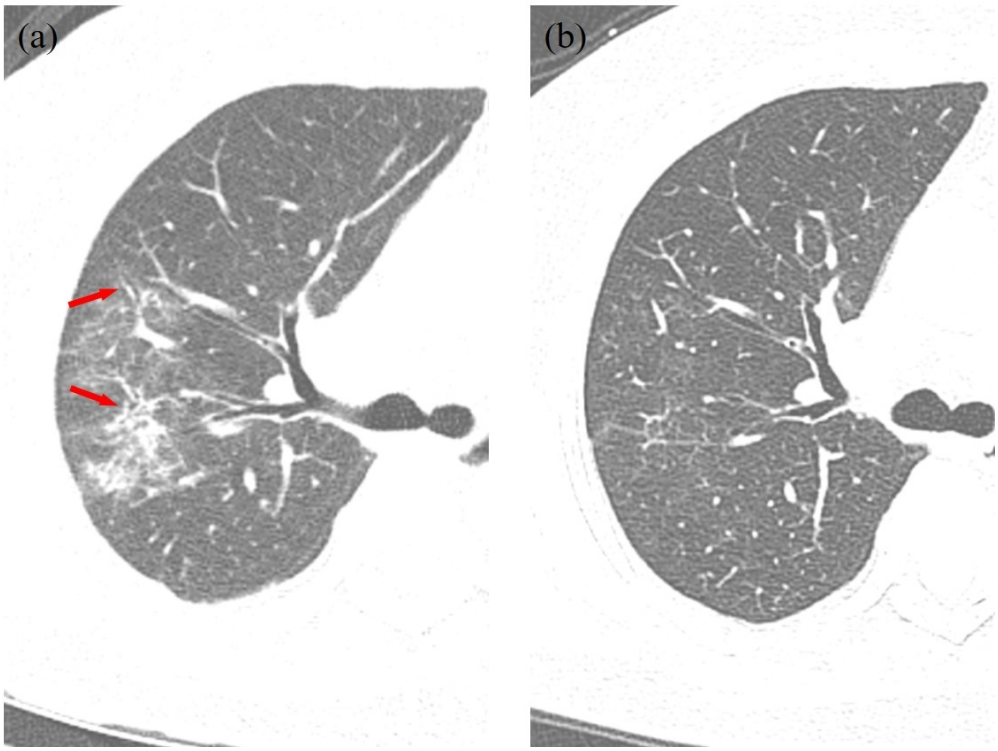

Supplemental Figure 3. The chest CT scans from a 68-year-old female COVID-19 patient. (a) the last chest CT before discharge. Bronchiectasis was shown (red arrows). (b) the chest CT four weeks after the discharge. The bronchiectasis got recovered.

95x71mm (300 x 300 DPI)

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