

# Changes in CT manifestations of patients with mild to moderate coronavirus disease 2019 in a Fangcang Shelter Hospital

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## Research Article

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# Abstract

**Objectives:** To provide a reference for CT imaging changes for patients discharged from a Fangcang shelter hospital, a large-scale, temporary hospital for the centralized treatment of patients with mild to moderate Coronavirus disease 2019 (COVID-19) to provide essential functions (isolation, triage, basic medical care, frequent monitoring and rapid referral, essential living and social engagement) to them..

**Methods:** Patients with mild to moderate COVID-19 admitted to the Wuchang Fangcang Shelter Hospital who had undergone pre-discharge and previous CT scans were included. Changes in the CT imaging features were defined as progression, no change, improvement or recovery. Basic patient information was obtained, and imaging signs were compared between the two CT scans.

**Results:** A total of 83 patients were included. The median age was 53 years old. The course of disease was  $28.3 \pm 10.7$  days. CT imaging changes indicated progression, no change, improvement, and recovery in 3, 12, 66, and 2 patients, respectively. Between the two CT scans, the imaging signs showed a significant reduction in consolidation, a significant increase in fibrosis, and a reduction or / and thinning of ground-glass opacities. None of the patients showed signs of deterioration on follow-up and thus did not need to return to the hospital for treatment.

**Conclusion:** In the COVID-19 Fangcang shelter hospital, given the shortage of medical staff and lack of medical resources, CT imaging diagnostic methods can be used to accurately discharge patients who had met the discharge criteria for isolation and observation from the Fangcang Shelter Hospital.

## Key Points

- CT imaging diagnostic methods can be used to accurately discharge patients who had met the discharge criteria from the Fangcang Shelter Hospital.
- The manifestations of the COVID-19 are diverse and change rapidly.
- The variations of CT images are mainly reflected in the changes of consolidation and fibrosis

## Introduction

From December 2019 to February 3, 2020, the total number of patients with coronavirus disease 2019 (COVID-19) infections was 17,205, and the number of suspected cases was 21,558 in China[1]. To curb the rapid spread of COVID-19, Fangcang Shelter Hospitals were urgently constructed to accommodate most mild to moderate COVID-19 patients in China[2]. The COVID-19 spread more severely in Wuhan, the capital city of Hubei Province. On February 4, 2020, the National Emergency Medical Rescue Team rushed to Wuhan and participated in the treatment of mild to moderate COVID-19 patients in the Wuchang Fangcang Shelter Hospital (WFSH), which was converted from the Wuchang Hongshan Stadium in just 29 hours. WFSH was the first Fangcang Shelter Hospital been built in China and the last one to be closed since Feb 5<sup>th</sup> to March 10<sup>th</sup>. Its function is to provide medical care, disease monitoring,

food, shelter and social activities, while isolating mild to moderate COVID-19 patients from their families and communities. The Fangcang Shelter Hospital did not set up an intensive care unit (ICU), and patients with aggravated conditions need to be discovered in time and transferred to COVID-19 designated hospitals for more systematic and comprehensive examination, treatment and care[3]. If COVID-19 outbreaks cannot be controlled as quickly as possible, countries such as the United Kingdom, Italy and Iran may need to establish temporary hospitals as well[4-6].

The CT examination in the Fangcang Shelter Hospital was not only used to judge the nature and extent of pulmonary lesions, but also to manage and triage the mild and moderate patients with large scale admission in combination with the patient's nucleic acid detection results for SARS-CoV-2, body temperature, symptoms and course of disease, etc. Patients with aggravated CT changes should be transferred to a designated hospital for treatment regardless of whether other indicators were stable. Patients with little change in CT need to extend the length of hospitalization. Patients whose CT showed significantly improvement and also met other discharge criteria can be discharged to the isolation point for isolation and observation, and then they can return to society and family.

Currently published imaging studies were mainly carried out in designated hospitals of COVID-2019 and focused on disease diagnosis [7-12], but no valuable literature on CT imaging in the discharge judgment of patients in the Fangcang Shelter Hospitals has been seen. CT imaging has been used as an important diagnostic indicator in the admission and discharge of mild to moderate COVID-19 patients in Fangcang Shelter Hospitals[13]. Mild type refers to mild clinical symptoms and no pneumonia on imaging. Moderate type refers to fever, respiratory tract symptoms, and pneumonia on imaging. Discharge criteria include pulmonary imaging that shows significant absorption of inflammation[1]. We analysed the evolution of the CT findings of mild to moderate COVID-19 patients in the Wuchang Fangcang Shelter Hospital, providing a reference for the CT-based diagnosis of mild to moderate COVID-19 patients worldwide.

## Materials And Methods

This study was approved by the institutional review boards of the relevant centers (Approval Number. LYF2020060). The requirement for informed patient consent was waived by the ethics committee for this retrospective study.

### Patients

A relocatable CT cabin was completed on February 21, 2020. As of March 10, 2020, our medical team admitted a total of 394 patients with confirmed mild to moderate COVID-2019, of whom 290 patients were discharged from the Fangcang Shelter Hospital for medical isolation (hereinafter referred to as discharge), and 104 patients were transferred to designated hospitals for further treatment. The admission criteria were as follows: 1) mild to moderate patients; 2) positive nucleic acid test for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2); 3) capability of live independently and age  $\leq$  65 years old; 4) without serious organ (e.g. heart, liver, lung, kidney and brain etc.) dysfunction; 5) no

psychiatric history; 6) resting oxygen saturation (SaO<sub>2</sub>) > 93%, respiratory rate ≤ 24 times/min. The study included the patients who met the discharge criteria and had undergone pre-discharge and previous CT scans. The discharge criteria were derived from the "Fangcang Shelter Hospital Work Manual (3rd edition)" developed by the National Health Commission of China and had to be met for the patient to be discharged: 1) normal body temperature for more than 3 days; 2) respiratory symptoms significantly relieved; 3) pulmonary imaging showing significant absorption of inflammation; 4) negative SARS-CoV-2 nucleic acid tests for two consecutive respiratory specimens (sampling interval ≥ 24 h)[1].

## **Imaging Technique**

All included patients were scanned using a United Imaging uCT-550 80-slice VCT. The CT acquisition parameters were as follows: 100-120 kVp; 50-350 mAs; pitch 0.75–1.5; and collimation 0.625–5 mm. All imaging data were reconstructed with a thickness of 1 mm. The CT scans were obtained at full inspiration while each included patient was in the supine position.

## **Imaging Interpretation**

During the first 15 days, the radiology department of Wuchang Fangcang Shelter Hospital relied solely on the X-ray machine of the National Emergency Medical Rescue Team to carry out chest X-rays in a lying position for COVID-19 patients. During this period, the work of the radiology department was mainly completed by two radiographers and a radiologist. The two radiographers took the chest radiograph of the patients in turn during the day, and the radiologist read the radiograph that night, and then analyzed and issued a preliminary radiograph report. The chest radiograph in question will be held for the next morning after the chest imaging multidisciplinary team (MDT) discussion, and then the formal report will be released. On February 20, 2020, the government built a relocatable CT cabin for the Fangcang Shelter Hospital (Supplementary Figure 1 and Supplementary Figure 2). The CT examination of patients was started on February 21st. The CT examination operation process is shown in Figure 1. All chest CT images were reviewed blindly and independently by one radiologist, one pulmonologist, and one anaesthesiologist (They all have more than 10 years of clinical experience). For all patients, the CT scan was evaluated to determine the presence of the following characteristics [8]: ground-glass opacities (GGOs), consolidation, and fibrosis. We defined the changes in the CT images as progression, no change, improvement, or recovery.

## **Statistical Analysis**

The data were input into Epi Data software (version 3.2), and statistical analyses were performed using SPSS software (version 18.0). Since the imaging sign data from the two CT scans were all quantitative and the number of samples was greater than 40, the  $\chi^2$  test was used to compare the frequencies of the test indicators from the two CT scans. All analyses were considered significant at P < 0.05.

# **Results**

A total of 83 patients were included after evaluation (Table 1). There were 36 males and 47 females. The median age was 53 years old. The course of the disease was  $28.3 \pm 10.7$  days. Three (3.6%) patients showed progression in their CT changes, 12 (14.5%) patients showed no changes (10 patients never exhibited signs of pneumonia on CT imaging, and 2 patients always exhibited some signs of fibrosis, with no significant changes across the two CT scans), 66 (79.5%) patients showed improvement, and 2 (2.4%) patients showed recovery. Figures 2, 3, 4 and 5 show the CT imaging changes corresponding to progression, no change, improvement, and recovery in patients with COVID-2019. The changes in the imaging signs were primarily with respect to the presentation of GGOs and fibroses (Table 2). At follow-up in 7 and 14 days after hospital discharge, none of these 83 patients aggravated after been discharged from Fangcang Shelter Hospital.

## Discussion

On February 3<sup>rd</sup>, 2020, the conversion of Wuchang Fangcang Shelter Hospital from Wuchang Hongshan Stadium was started, and it was completed in only 29 hours. It was directly transformed from a stadium hall and was divided into three areas: A, B, and C. Each area was divided into a different number of subareas could accommodate 10-30 closely packed beds[1]. The large-scale use of the Fangcang Shelter Hospital is iconic in the history of Chinese medical rescue. Only the mild to moderate COVID-19 patients were admitted to the Fangcang Shelter Hospital. For the more serious patients, they would be temporarily transferred to the designated hospital for further treatment after a short period of stay in Fangcang Shelter Hospital. According to the WHO report, by 11 April 2020, a total of 1,610,909 patients with COVID-19 have been confirmed in 177 countries, and the number is still increasing[14]. According to relevant experience in China, the establishment of Fangcang Shelter Hospitals can effectively control the source of infection, cut off the transmission route, protect those susceptible people, reduce the overload of medical staff in regular hospitals, and more rationally use limited medical resources for the treatment of severe and critical illnesses patient. At the same time, the patients in the Fangcang Shelter Hospital received daily monitoring similar to those in regular hospitals during hospitalization, which helped to detect those patients who were aggravated and need timely medical treatment and respiratory support treatment. Thus could reduce the number of patients who died without timely treatment.

CT imaging results are very important for the determining whether a patient with COVID-19 can be discharged[15], so it is necessary to gather medical staff that can make an accurate and rapid diagnosis from CT imaging. Due to the emergency construction of the Fangcang Shelter Hospital and the temporary deployment of medical staff, the medical equipment is limited. In particular, CT equipment is expensive, and the construction of machine rooms, including transportation and loading, requires considerable manpower, material resources and time. On February 21, 2020, the construction of a relocatable CT cabin was completed, which provided powerful technical support for the diagnosis of COVID-19. This effort represents one of the fastest construction projects in China.

According to the basic patient information (Table 1), the median age was 53 years; the majority of the patients were 40-70 years old, and all patients had a course of disease longer than 13 days. This may be

related to the gradual recovery from COVID-19 after 14 days [11]. The interval between the two CT scans was different for each patient, which may be related to the conditions of the Fangcang Shelter Hospital, such as the large number of patients and the limited number of doctors and medical equipment.

As shown in Table 1, 66 (79.5%) patients showed improvement and 2 (2.4%) patients showed recovery according to the CT imaging changes. The imaging features of these patients indicated that the lesions were significantly better pre-discharge compared to those of the previous CT, thus meeting the discharge criteria (Figure 4 and Figure 5). There were 12 patients that showed no changes in the CT images (Figure 3). Of these, 10 patients had normal previous and pre-discharge CT images, and the other 2 patients only showed a few GGOs and fibrosis: both patients met the discharge criteria. The course of disease in both of these patients was longer than 35 days, indicating that as the course of disease progressed, the lesions were absorbed more completely. According to the results of the analysis, the CT imaging changes are mainly reflected in the changes in the presentation of consolidation and fibrosis. Although there are always ground glass opacities on the CT images, they were essentially thinner on the pre-discharge CT images.

There were also 3 patients that showed progression, and the interval between the two CT scans was more than 14 days, which may be related to the evolution of the disease course[16]. Figure 2 shows CT images from a 64-year-old woman diagnosed with COVID-19. On January 28, 2020, the CT images showed no obvious abnormalities in the bilateral lungs. Because of the need for the prevention and control of infectious diseases, we did not take the pre-admission CT film out of the Fangcang Shelter Hospital to the doctor's office and reading room in the clean area. Therefore, we use the special mobile phone of the Fangcang Shelter Hospital to take the patient's CT film and then use the WeChat app to send it to the mobile phone and computer outside the Fangcang Shelter Hospital. Although the image quality is not good, it also satisfies the comparison between the new and old films. This is a creative solution for our radiology department to deal with this COVID-19 epidemic while working in the Fangcang Shelter Hospital, and it is worthy of reference and reference for Fangcang Shelter Hospitals in other countries. On February 25, chest CT showed new small flake GGO in the posterior basal segment of the right lower lobe with linear opacities at the edges, indicating that absorption improvement had occurred over this period. In this patient, the interval between the two CT scans was 27 days; we have not detected imaging signs of deterioration or later improvement of absorption that may have occurred in this period. As with the other 80 patients, we conducted a complete follow-up after the three progression patients were discharged from the Fangcang Shelter Hospital. The final results showed that the conditions in all three patients had further improved, and none of them were hospitalized again for treatment.

The study has some limitations. First, some of the CT films of the COVID-19 patients had been obtained prior to admission to the Fangcang Shelter Hospital. Since the previous CT films had been contaminated by 2019-nCoV themselves, the original CT film could not be obtained for comparison. Instead, simple photos were taken by mobile phone in the Fangcang Shelter Hospital and sent to the reading area outside the hospital for comparison. Second, due to the conditions in the Fangcang Shelter Hospital, the interval between the two CT scans was different for each patient, with some patients having much larger intervals

than others. This was mainly because the clinical symptoms or nucleic acid tests of these patients did not meet the discharge criteria, and the pre-discharge CT scan was not started until the criteria were met. Finally, the medical staff was only temporarily deployed, with a team of three doctors of different specialties reviewing CT films and deciding whether the patient could be discharged. The advantages and disadvantages of this kind of medical staff formation need to be further explored.

In short, due to the shortage of medical staff, the lack of medical resources, and the difficulty in obtaining CT equipment within a short time, COVID-19 patients meeting discharge criteria should be released from Fangcang Shelter Hospitals as soon as possible. Regardless of whether the CT image of the patient shows no change, improvement, recovery or even progression of the disease, as long as the patient is within the absorption improvement period and meets the other discharge criteria, he or she can be discharged.

## Abbreviations

COVID-19 Common coronavirus disease 2019

GGO Ground-glass opacities

ICU Intensive care unit

WFSH Wuchang Fangcang Shelter Hospital

SARS-CoV-2 severe acute respiratory syndrome coronavirus 2

## Electronic Supplementary Material

supplementary material 1

## Declarations

**Financial Disclosures:** The authors received no specific funding for this work.

**Competing Interests:** The authors of this manuscript declared that there were no competing interests.

**Approvals and Permissions:** This study was approved by the institutional review boards of the relevant centers (Approval Number. LYF2020060). The requirement for informed patient consent was waived by the ethics committee for this retrospective study.

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## Tables

**Table 1 Basic information and results in our cohort**

Basic Characteristics	All Patients (n=83)	Progression (n=3)	No Change (n=12)	Improvement (n=66)	Recovery (n=2)
Sex					
Male	36(43.3)	2(66.7)	5(41.7)	29(43.9)	
Female	47(56.7)	1(33.3)	7(58.3)	37(56.1)	2(100.0)
Age, years					
Median	53.0				
Range	11-82				
≤20	4(4.8)		2(16.7)	2(3.0)	
21-30	5(6.0)		2(16.7)	3(4.5)	
31-40	7(8.4)		3(25.0)	4(6.1)	
41-50	18(21.7)	1(33.3)	1(8.3)	14(21.2)	2(100.0)
51-60	29(34.9)	1(33.3)	2(16.7)	26(9.1)	
61-70	18(21.7)	1(33.3)	2(16.7)	15(22.7)	
>70	2(2.4)			2(3.0)	
Course of disease*					
Mean±SD	28.3±10.7				
14-21	24(28.9)	1(33.3)	7(58.3)	16(24.2)	
22-28	25(30.1)	2(66.7)	1(8.3)	22(33.3)	
29-35	14(16.9)		1(8.3)	13(19.7)	
>35	20(24.1)		3(25.0)	15(22.7)	2(100.0)
CT interval, days					
≤7	12(14.5)		1(8.3)	11(16.7)	
8-14	37(44.6)		11(91.7)	24(36.4)	2(100.0)
15-21	19(22.9)	2(66.7)		17(25.8)	
≥22	15(18.1)	1(33.3)		14(21.2)	

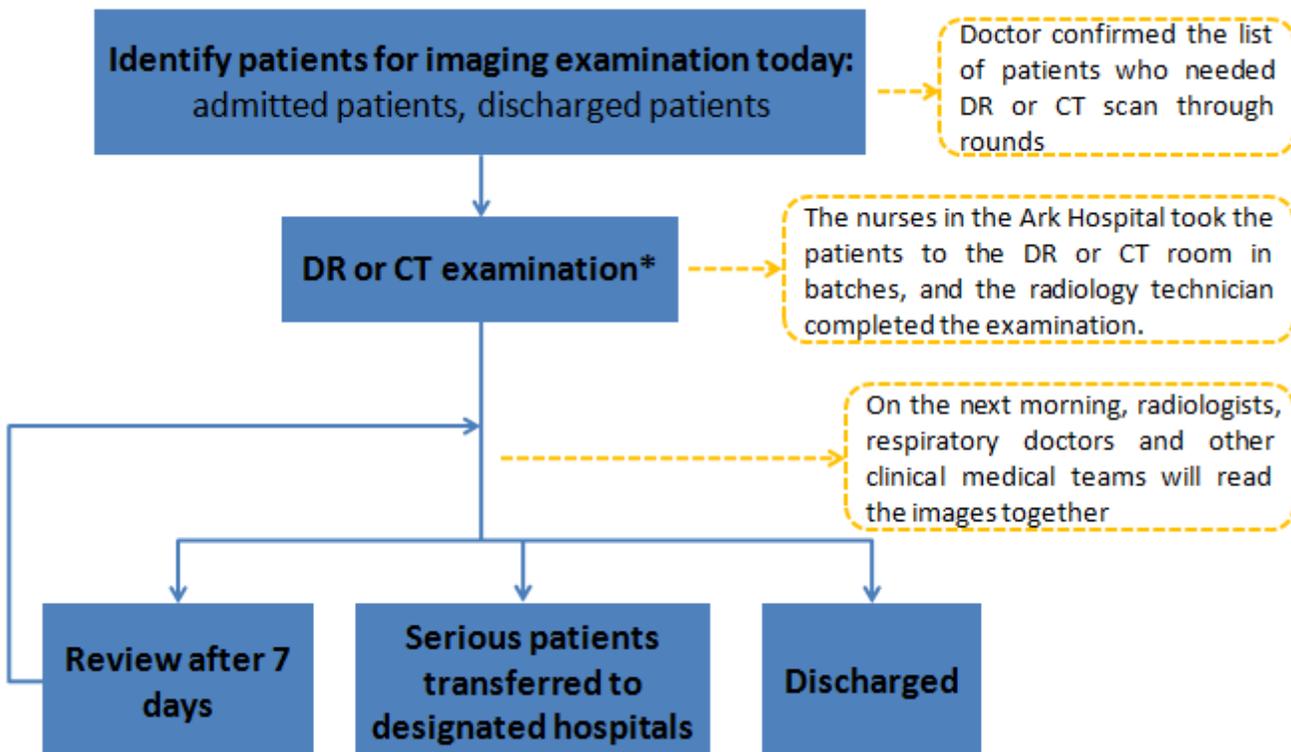
\* Course of disease = Date of CT scan before discharge - Disease onset time

**Table 2 Imaging signs from the two CT scans**

Image findings	Previous CT	Pre-discharge CT	<i>P</i>
All patients(83)			
Normal	11	12	0.835
Consolidation	31	5	0.000
GGO	60	66	0.593
Fibrosis	29	47	0.039
Progression (3)			
Normal	1	0	
Consolidation	1	0	
GGO	1	3	
Fibrosis	0	1	
No Change (12)			
Normal	10	10	
Consolidation	0	0	
GGO	2	2	
Fibrosis	2	2	
Improvement (66)			
Normal	0	0	
Consolidation	30	5	0.000
GGO	55	61	0.577
Fibrosis	26	44	0.031
Recovery (2)			
Normal	0	2	
Consolidation	0	0	
GGO	2	0	
Fibrosis	1	0	

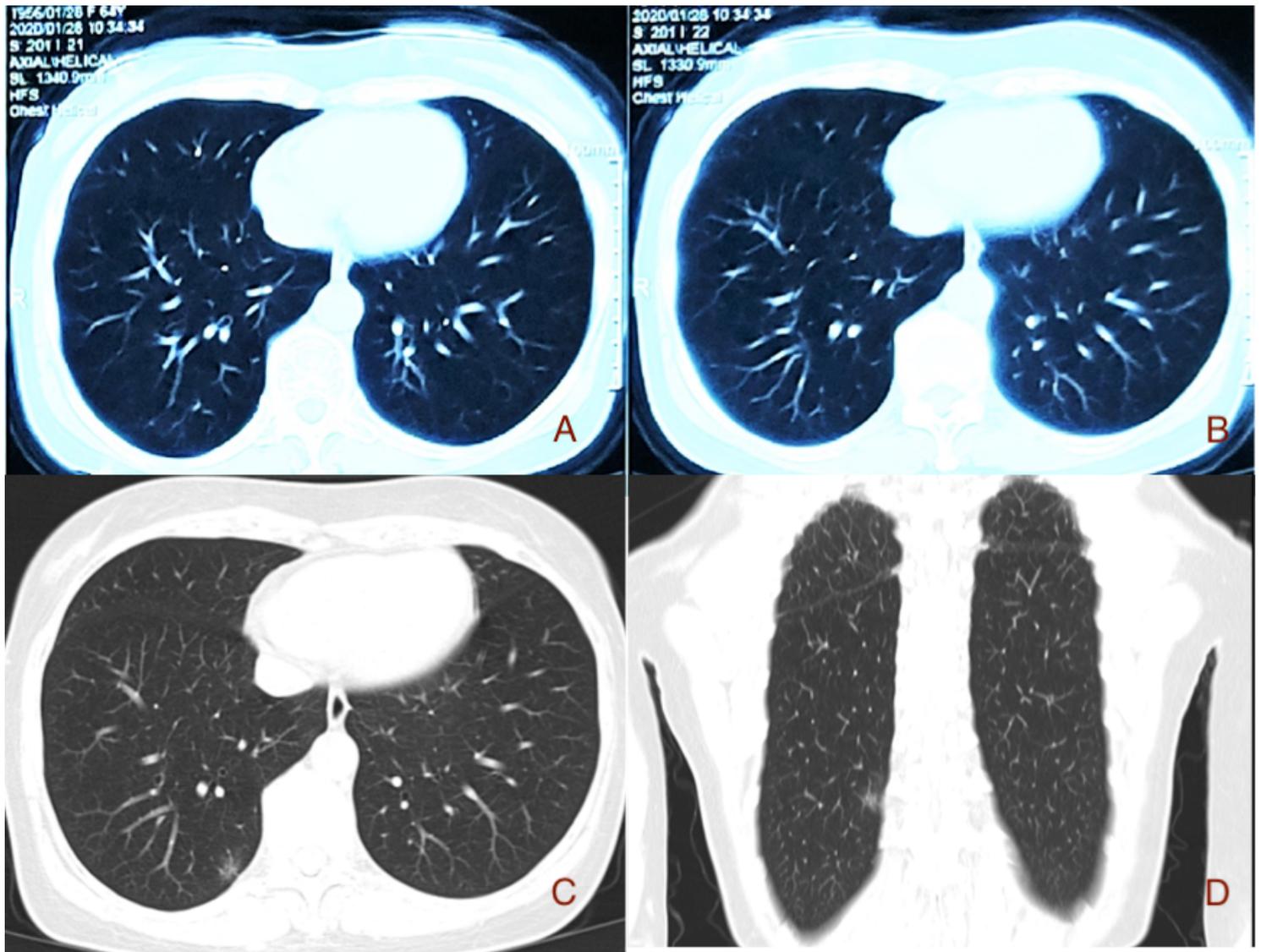
GGO: Ground-glass opacity

## Figures



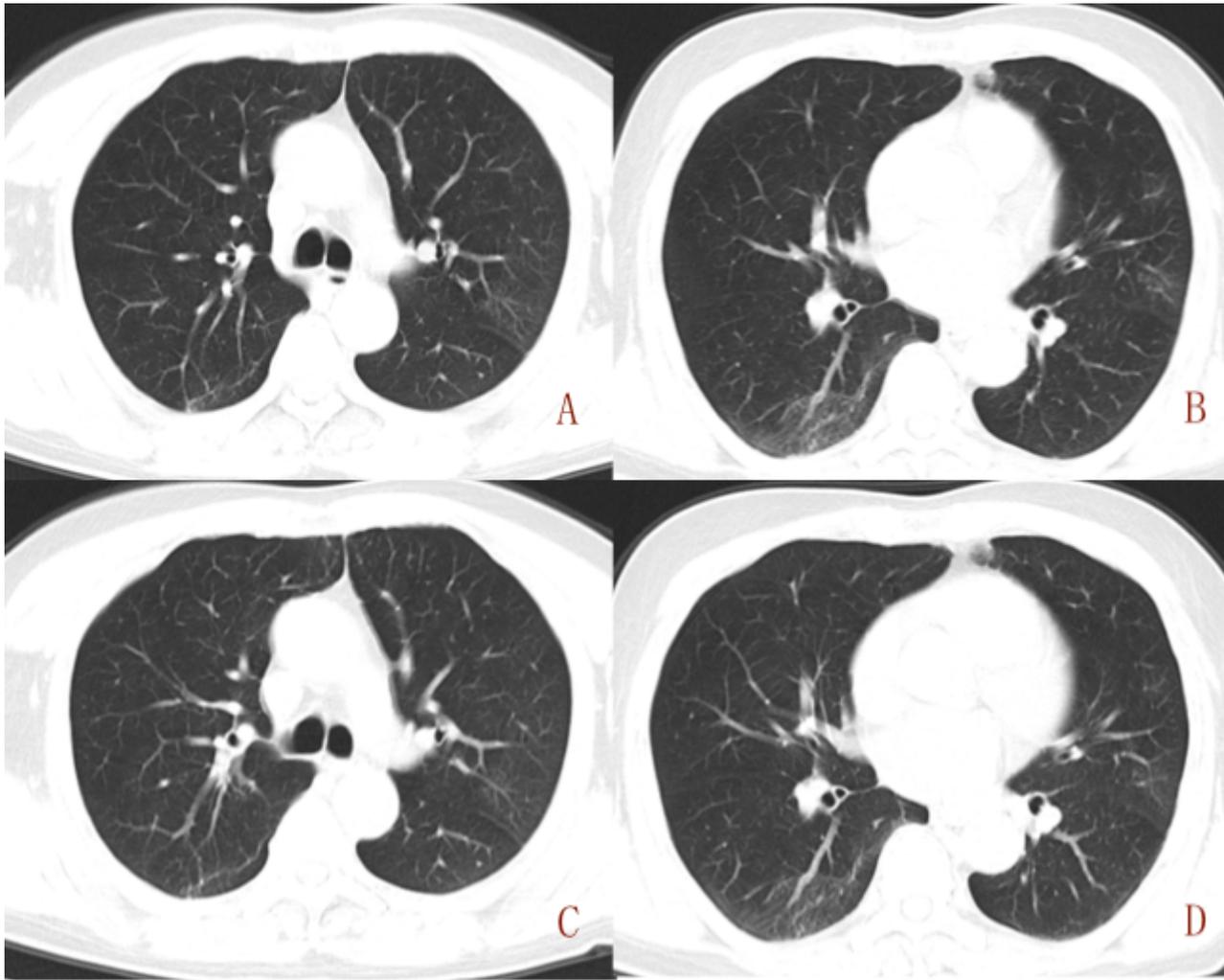
**Figure 1**

The CT examination operation process. \*Before February 21, 2020, the patient underwent on-board DR examination. After February 21, the patient started a CT examination.



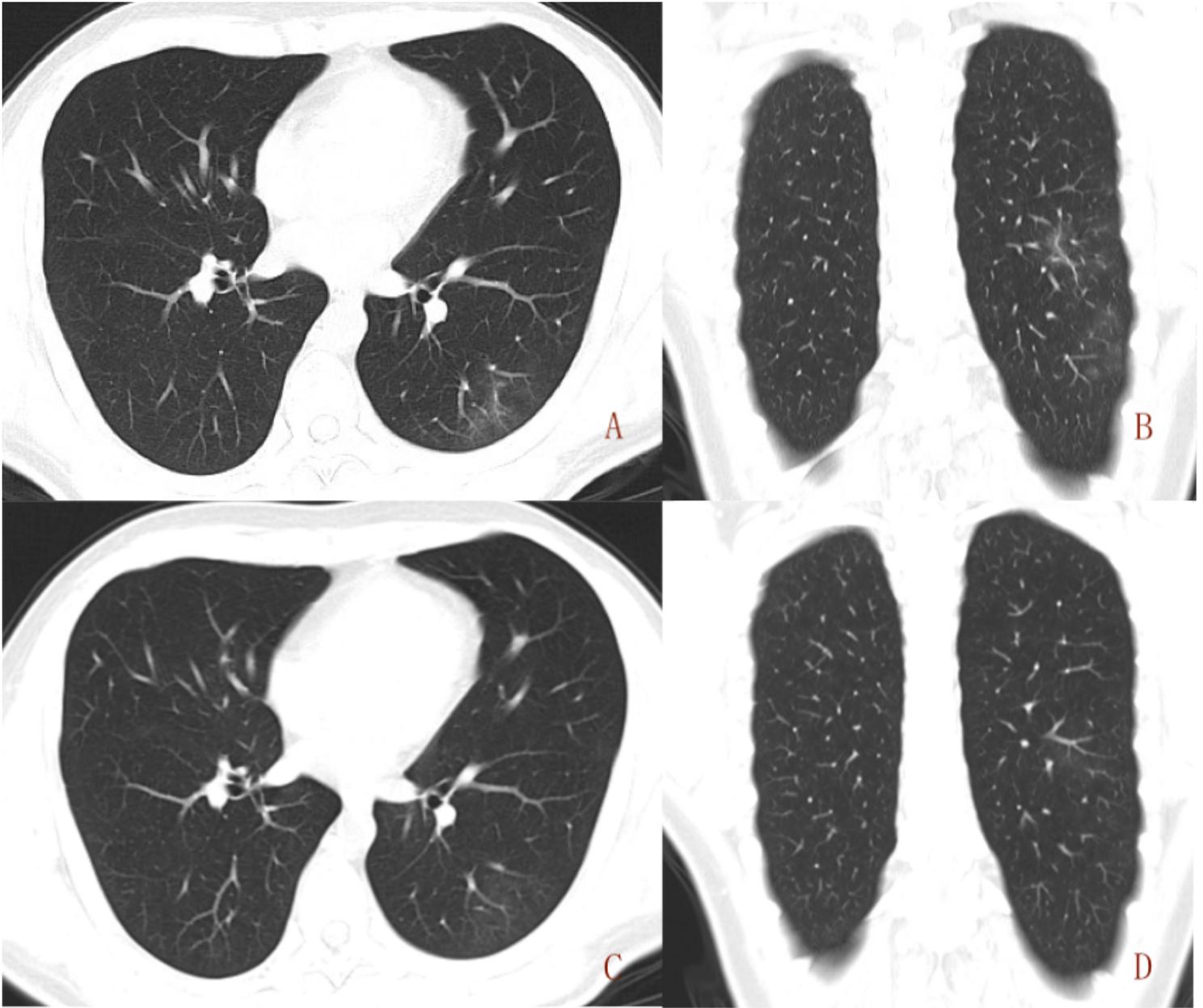
**Figure 2**

CT imaging changes showing progression. A 64-year-old woman was diagnosed with COVID-19. (A-B) On January 28, 2020, axial CT showed no obvious abnormalities in the bilateral lungs. On February 10, the patient was admitted to the Fangcang Shelter Hospital. On February 25, chest CT showed new small flake ground-glass opacities in the posterior basal segment of the right lower lobe with linear opacities at the edges (C-D).



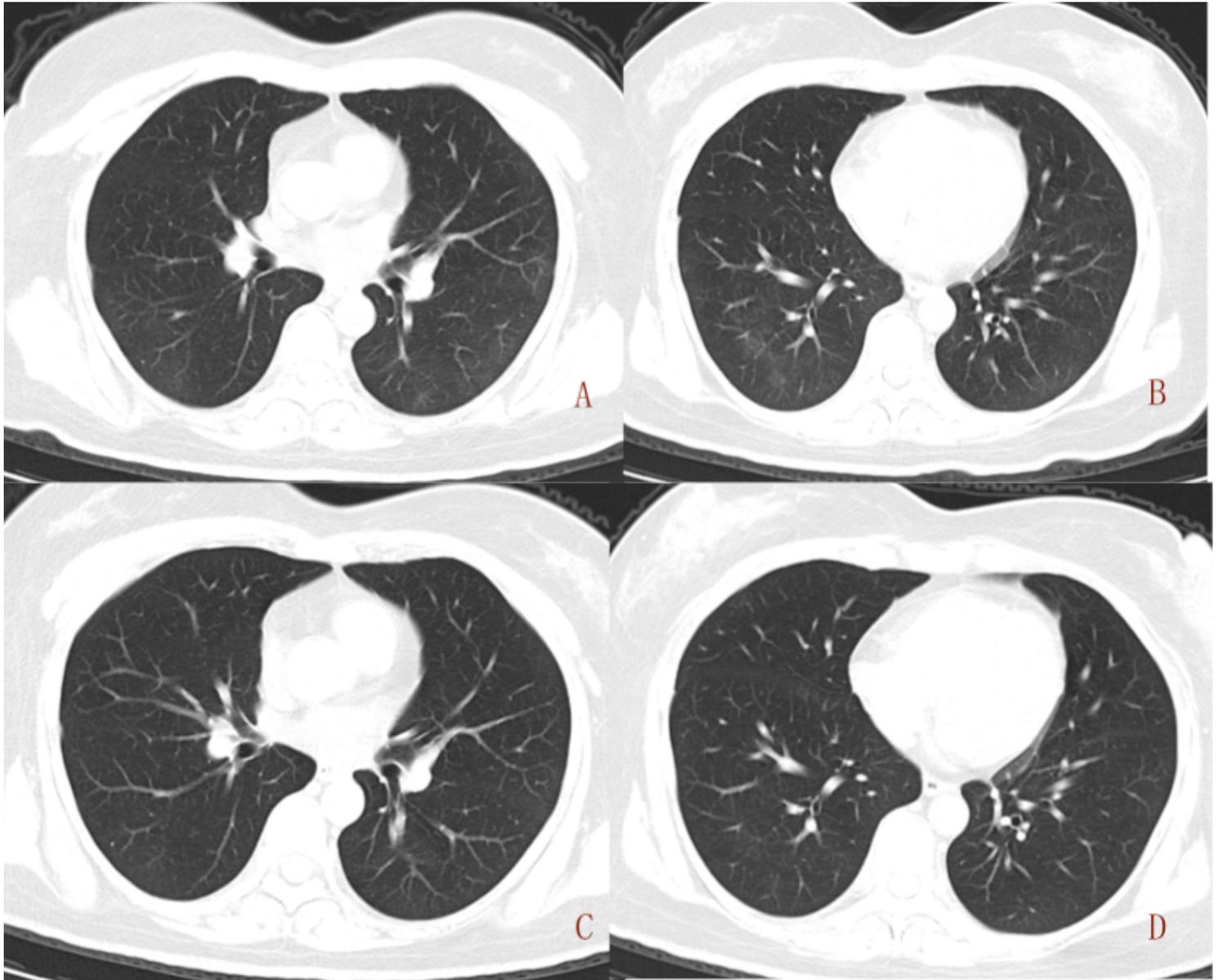
**Figure 3**

CT imaging changes showing no change. A 61-year-old man was diagnosed with COVID-19. On February 7, 2020, the patient was admitted to the Fangcang Shelter Hospital. (A-B) On February 25, axial CT showed multiple linear opacities and ground-glass opacities in the posterior segment of the left superior lobe, the lingular segment, the posterior segment of the right upper lobe, and the dorsal segment of the right lower lobe. (C-D) On March 8, chest CT showed no significant changes compared with the previous CT.



**Figure 4**

CT imaging changes showing improvement. A 30-year-old man was diagnosed with COVID-19. On February 15, 2020, the patient was admitted to the Fangcang Shelter Hospital. (A-B) On February 21, chest CT in axial and coronal planes showed ground-glass and linear opacities in the dorsal and posterior basal segments of the right lower lobe. (C-D) On March 6, chest CT showed significant absorption compared with the previous CT.



**Figure 5**

CT imaging changes showed recovery. A 42-year-old woman was diagnosed with COVID-19. On February 9, 2020, she was admitted to the Fangcang Shelter Hospital. (A-B) On February 21, axial CT showed scattered multiple ground-glass opacities in the bilateral lungs. (C-D) On March 6, chest CT showed that the lesions had been completely absorbed.

## Supplementary Files

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- [SupplementaryMaterial1.docx](#)