Temporal lung changes on thin-section CT in patients with COVID-19 pneumonia

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Abstract

We examined characteristics of chest CT during different time periods for patients with coronavirus disease 2019 (COVID-19) pneumonia in Huizhou, China. This study included 56 COVID-19 patients having abnormal CT acquired between January 22 and March 3, 2020. Scans of 56 patients were classified into 4 groups (Group 1-Group 4) based on the date on which scan was obtained at the 1st, 2nd, 3rd week and longer than 3 weeks after illness onset. Forty-five patients with follow-up scans were categorized into 4 groups according to extents that lesions reduced. GGO was prevalent in Groups 1-4 (58.1-82.6%). Consolidation was the more common in Group 2 (26.2%) and then declined in Group 3 and 4 (20.0%; 9.7%). The highest frequency of fibrous stripes occurred in Group 3 (46.7%) and then decreased to 35.5% in Group 4. CT scores were higher for Group 2 than others. Among 45 follow-up patients, 11 (24.4%) of them recovered with lesions reducing ≥75% and had shorter hospital durations compared with others. There were temporal patterns of lung abnormalities in COVID-19 patients, with the highest extent of lesion involvement occurring in the 2nd week. Isolation and review are required for COVID-19 patients who have been discharged from hospital.

Introduction

Large outbreaks of coronavirus disease 2019 (COVID-19) occurred in China and other countries, such as United States, Italy and Spain [1,2,3]. As of March 30, 2020, there have been 82,447 confirmed cases of COVID-19 and in total of 3,310 deaths in China, which far exceeded the burden of severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) [2,3]. Meanwhile, a total of 610,835 confirmed cases and 29,796 deaths have been reported in other 202 countries [3].

COVID-19 pneumonia was caused by infections of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which was the seventh member of coronaviruses. A certain number of patients with COVID-19 initially presented with fever, cough and myalgia or fatigue, and about half of the patients developed dyspnea [1]. As the knowledge of COVID-19 pneumonia has been accumulated, professional consensus, guidelines, and criteria have been established steadily to facilitate the diagnosis and treatment of COVID-19 pneumonia [4]. The COVID-19 epidemic is currently under control in China with the great efforts of Chinese government, health-care workers and others. However, the number of new infections is increasing dramatically in other countries.

For screening COVID-19 patients, the information on epidemiology history, clinical symptoms, laboratory findings and chest imaging were often recorded. At present, the gold standard for diagnosis of COVID-19 is the result of real-time polymerase chain reaction (PCR), which is performed on specimens taken from throat swabs, sputum, lower respiratory tract or blood [5]. However, the nucleic acid test is time consuming and has a high false negative rate at the early stage of infections [6]. Lack of cellular material and improper extraction of nucleic acid partially results in the high false negative rate [7]. As a supplement, chest CT examination is an important and effective tool for screening, diagnosing, and evaluating the disease severity of COVID-19 [5,6]. Seldom did previous studies report lung changes on chest CT at multiple times.

Huizhou is a city located in the south of China. The confirmed cases of COVID-19 pneumonia were mainly imported from other places with severe epidemic. The assessment of the imaging abnormalities on thin-section CT scans of patients with COVID-19 pneumonia performed during different time periods after illness onset can inform diagnosis and treatment for other locations at the early stage of COVID-19 outbreak. In this article, we examined various characteristics of thin-section CT scans obtained during different time periods after illness onset for patients with COVID-19 pneumonia reported in Huizhou, China.

Results

Clinical Characteristics

The demographic and clinical characteristics of subjects are presented in Table 1. Among the 56 included patients, 26 (46.4%) were males, with a median age of 51 years (range: 1-84 years). We found that 47/56 (83.9%) patients were residents of or had travelled to Hubei Province, while the remaining 9/56 (16.1%) patients reported that they had closely contacted with confirmed or suspected patients with COVID-19. The most prevalent clinical manifestations were fever (66.1%) and cough (53.6%), meanwhile 8 patients were asymptomatic on admission. A total of 9/56 (16.1%)

patients had at least 1 underlying disease. The most common abnormalities of laboratory examination were depressed white blood cell (44.6%) and lymphocyte count (42.9%). Only 3/56 (5.3%) included patients were severe cases with COVID-19 pneumonia. All patients had been discharged from hospital, with a median duration of hospitalization of 16.0 (IQR: 12.0–20.0) days.

Pulmonary CT Evaluation

During the course of our study, 141 chest CT scans were performed in the 56 patients. The most common CT abnormalities included GGO (73.0%), fibrous stripes (39.0%), interlobular septal thickening (31.2%) and consolidation (19.9%), while the atelectasis, pleural or pericardial effusion and thoracic lymphadenopathy were rarely observed (Table 2). As high as 90.8% of the abnormal CT involvement were distributed in bilateral lung and 124/141 (87.9%) scans suggested more than 2 lobes involved. Pure peripheral, pure peribronchovascular and diffuse distributions were presented in 67/141 (47.5%), 18/141 (12.8%) and 24/141 (17.0%) CT scans, respectively, while mixed peripheral and peribronchovascular distribution was observed in 32/141 (22.7%) CT scans. The median total CT score was 5.0 (IQR: 3.0–10.0), with a slight preference in bilateral lower lobes in terms of higher median scores (lower lobes: 2.0; others: 1.0) (Figure 1).

Among the 141 CT scans, 23 (16.3%), 42 (29.8%), 45 (31.9%) and 31 (22.0%) were performed at the 1^{st}, 2^{nd}, 3^{rd} week and longer than 3 weeks after illness onset (Groups 1-4).

Total CT scores were on average higher for scans performed in the 2^{nd} week after illness onset than for other groups (Figure 2). The imaging features varied across groups whose CT scans were performed at multiple times after illness onset (Table 2 and Figure 3). GGO predominated in Groups 1-4, observed in more than half of the scans and it dropped to 58.1% in Group 4. The highest percentages for and consolidation (26.2%) were observed in scans which were acquired at the 2^{nd} week after illness onset and the percentages declined in Group 3 and then in Group 4. The percentage for fibrous stripes in Group 1 was the lowest and it increased in Group 2, peaked in Group 3 (46.7%) before it decreased slightly in Group 4 at 35.5% which followed the percentage of GGO. Most of the CT abnormalities were less common to some extent in the scans which were obtained at longer than 3 weeks after illness onset, however, crazy-paving pattern was more frequently detected in scans performed during this time period (19.4%). The frequencies of interlobular septal thickening remained stable across groups. Halo sign, reversed halo sign, atelectasis, pleural effusion, pericardial effusion and thoracic lymphadenopathy were relatively rarely presented in the scans.

Follow-up Chest CT

In our study, 45 patients had at least 2 CT scans at different follow-up times, among which 21 (46.7%), 13 (28.9%), 6 (13.3%) and 5 (11.1%) patients had 2-5 scans, with median time intervals between 2 CT examinations of 6.0, 7.0, 4.5 and 5.8 days, respectively. Among these patients, 11/45 (24.4%), 17/45 (37.8%), 11/45 (24.4%), 6/45 (13.3%) of them were those whose lesions reduced ≥75%, 50-75%, 25-75% and <25% (i.e. Group A-Group D), respectively. No patient became worsen. Patients in Group C and D were on average older than those in Group A and B (median age: Group A: 41.0; Group B: 50.0; Group C: 63.0; Group D: 64.5 years). The duration of hospitalization for patients in Group A were shorter than in other groups (median duration of hospitalization: Group A: 15.0; Group B: 17.0; Group C: 18.0; Group D: 19.0 days). Median total CT scores acquired on admission increased from 2.0 for those in Group A to 12.5 for those in Group D (Table 3).

Discussion

The present study examined imaging abnormalities on thin-section CT scans performed during different time periods after illness onset for patients with COVID-19 pneumonia reported in Huizhou, China. We found that GGO, bilateral multiple lobular, peripheral with or without peribronchovascular distribution, with preference in lower lobes were the most common CT findings in COVID-19 pneumonia, which were similar to those reported previously for patients with COVID-19 pneumonia, SARS and MERS [8-11]. It was not surprising to observe the similar imaging features in patients with COVID-19 pneumonia, SARS and MERS, since all of them were family members of coronaviruses.

In our study, it was found that the most common clinical manifestations of patients with COVID-19 pneumonia were fever and cough, consistent with findings reported previously for COVID-19 pneumonia [12] and other lower respiratory tract infections [9]. It was worth noting that 8 patients were asymptomatic at the early stage of SARS-CoV-2 infections but had abnormal CT manifestations, indicating that clinical symptoms may be inconsistent with radiological findings to some extent. In addition, nucleic acid test had a high false negative rate. Therefore, performing CT scans could be beneficial for screening patients with COVID-19 at the early stage.

GGO was the most predominant pattern presented in chest CT scans of patients with COVID-19 pneumonia. It was a common abnormality for viral pneumonias, but not specific to COVID-19 [13]. GGO could be caused by various of factors, such as partial collapse of alveoli, interstitial thickening (due to fluid, cells, and/or fibrosis), partial filling of airspaces, and increased capillary blood volume, or a combination of these, with the common factor being the partial displacement of air [14]. Pulmonary oedema and hyaline membrane formation were pathological features of COVID-19 patients [15], which may explain the occurrence of GGO in pathology. In most of previous studies, peripheral distribution of lung abnormalities was the dominant distribution pattern [9,16]. However, distribution along bronchovascular bundle was also common in the CT scans of our subjects, which suggested that lung abnormalities spread from periphery to central region.

We observed that the extent of lung abnormalities in patients with COVID-19 pneumonia at the 2nd week after illness onset were the most serious than those performed at other time points. The findings were in accordance with 3 earlier studies [4,9,17]. During the 1st week, the main abnormalities presented on CT scans were GGO, interlobular septal thickening and fibrous stripes, which suggested the lung parenchymal and interstitial injury at the relatively early stage. During the 2nd week, the frequency of consolidation was the highest among those recorded during different time periods. The more common occurrence of consolidation may indicate disease progression [18]. However, the prevalence of consolidation was higher reported in a previous study (42-91%), which assessed the CT findings of patients in Wuhan, China [4]. A possible reason for the disparity was that COVID-19 patients in Wuhan were in general more severe than in Huizhou due to the lack of health-care resources. We found that total CT scores reduced gradually from the 3rd week, implying the decreasing extent of lung abnormalities. In this period, GGO and consolidation declined in frequency apparently. Fibrous stripes and interlobular septal thickening became the most common manifestations with GGO. Lung fibrosis, which were described to be parenchymal bands, traction bronchiectasis and irregular interfaces, usually reflected the outcomes in the evolution of illness [8]. This finding indicated that fibrosis may be a main pattern in the following development of illness in COVID-19 patients. Further studies are required to confirm the hypothesis.

Serial CT scans in our study provided a precious opportunity to monitor lung changes in COVID-19 patients at different disease stages. We found that patients whose lesions reduced ≥75% had a relatively shorter median hospitalization duration, lower total CT scores of their 1st scans and younger median age compared with other groups. These findings suggested that patients with better outcomes in radiological manifestations had a shorter hospitalization duration and the disease burden maybe reduced accordingly. In addition, the age and extent of lung abnormalities on admission could affect the evolution of lesions in lung. To our knowledge, there is no previous study reporting the differences in hospitalization duration, age and lung abnormalities on admission among patients with different image changes. Many reasons may account for the 100% discharge rate in our hospital, including reasonable and effective drug therapy. Of note that all the patients in our hospital united traditional Chinese medicine and western medicine for treatment. Further studies can be conducted to determine whether the traditional Chinese medicine promoted the prognosis of this illness.

There were several limitations in our study. First, we had a relatively small number of patients evaluated in this study due to the limited number of patients identified in Huizhou. Second, 46.7% of the included patients with COVID-19 pneumonia had only 2 CT scans. Although most of the patients had discharged from hospital after 2 CT scans were acquired, more CT scans could help for evaluating whether the residual lesions were absorbed in the future. Third, the relationship between imaging and histopathological findings was not assessed, since lung biopsy specimens were not available in our study. Finally, the time intervals between 2 CT scan acquisitions varied across patients since we could not require all of the patients to have systematically evaluations at certain times. Multiple CT scans are recommended to be performed for patients for whom the diagnosis is uncertain or further evaluation of lung abnormalities is required.

In conclusion, the predominant imaging features of COVID-19 pneumonia were GGO, bilateral multiple lobular, peripheral with or without peribronchovascular distribution, with preference in lower lobes. There were temporal patterns of lung abnormalities, with the highest extent of involvement in the 2nd week. Isolation and review are required for COVID-19 patients who have been discharged from hospital.

Methods

The study was approved by the Research Ethics Committee of the Central People's Hospital of Huizhou, and in accordance with guidelines outlined in the Declaration of Helsinki. Informed consent was waived for this study. We collected and analyzed data of these patients anonymously.

Patients

All of the patients with COVID-19 pneumonia in Huizhou city between January 22, 2020 and March 5, 2020 were under treatment in the Central People's Hospital of Huizhou. The patients were diagnosed with COVID-19 according to the World Health Organization (WHO) interim guidance [19]. A total of 62 consecutive patients in the hospital were enrolled in this retrospective study. Among the 62 patients, 3 patients did not have chest CT scans, while another 3 patients did not have abnormal chest CT imaging. We excluded the 6 patients and the remaining 56 patients were included. All patients enrolled have been discharged from hospital according to the discharge criteria formulated by National Health Commission [20,21].

Data on gender, age, clinical symptoms, laboratory findings, exposure history (resident of or having travelled to Hubei Province; having closely contacted with confirmed or suspected COVID-19 patients), comorbidities, the date of illness onset and the date of performing CT examination were collected for all patients by carefully reviewing their medical records. Disease duration was defined as the time interval between the date of symptom onset or on which the specimen of asymptomatic case was detecting positive for SARS-CoV-2 and the date of CT acquisition.

CT Protocol

Chest CT scans were obtained on a commercial 16-detector CT scanner (Philips MX16, Philips Medical

Systems, the Netherlands). To reduce motion artifacts, the patients were required to hold breath during scanning. All of the patients were performed a spiral scan for the following parameters: 2-mm section thickness, 1-mm gap, 24-mmcollimation, 360-mm field of view, 512-mm matrix, 120 KV, automatic tube current modulation. From the raw data, CT images were reconstructed with a lung algorithm for parenchymal analysis.

Imaging Analysis

All images were reviewed by 2 experienced chest radiologists who had worked more than 5 years in this field blindly to the clinical information. They reviewed the images independently and reached a decision in consensus. The following image characteristics were recorded [14]: (1) ground-glass opacities (GGO, defined as hazy increased opacity of lung without obscuration of the underlying vessels and airway walls), (2) consolidation (defined as homogeneous increase of lung parenchyma with obscuration of the underlying vessels and airway walls), (3) crazy-paving pattern (defined as GGO with superimposed thickened interlobular and intralobular lines), (4) interlobular septal thickening, (5) halo sign (defined as a nodule or mass surrounded by GGO), (6) reversed halo sign (defined as focal rounded area of GGO surrounded by a more or less complete ring of consolidation), (7) fibrous stripes, (8) air bronchogram, (9) atelectasis, (10) subpleural curvilinear line, (11) pleural or pericardial effusion, (12) thoracic lymphadenopathy (defined as lymphnode with short axis diameter ≥1cm). To estimate the extent of lung involvement of all these abnormalities, we used a semi-quantitative score to assign each of 5 lung lobes. Each lung was assigned a score from 0 to 4 (0: no involvement; 1: 1-25% involvement; 2: 26-49% involvement; 3: 50-75% involvement; 4: >75% involvement) [8]. The CT scores of 5 lung lobes were summed up as the total CT score which measured the overall lung involvement, ranging from 0 (no involvement) to 20 (maximum involvement).

The distribution of lung abnormalities was also recorded: (1) peripheral (involving mainly the outer one-third of the lung), (2) peribronchovascular (abnormalities along the path way of bronchovascular bundle), (3) diffuse (continuous involvement without respect to lung segments), (4) both peripheral and peribronchovascular. Radiological manifestations and distribution of some glossaries were presented in Figure 4.

Subsequently, we classified the CT scans of 56 patients into 4 groups based on the date on which the CT scan was obtained at the 1st, 2nd, 3rd week and longer than 3 weeks after symptom onset. If a patient was asymptomatic, we categorized the scans of the patient according to the date on which the specimen of patient was detecting positive for SARS-CoV-2 instead of the date of symptom onset. Patients with follow-up chest CT scans further revealed the time course of major lung abnormalities in patients. According to the extent of reduction of abnormities presented in CT imagines, we categorized the 45 patients which had at least 2 follow-up CT scans into 4 groups: Group A, patients whose lesions reduced ≥75%; Group B, those whose lesions reduced 50-75%; Group C, those whose lesions reduced 25-50%; Group D, those whose lesions reduced <25%).

Statistical Analysis

Clinical characteristics and laboratory findings of the 56 include patients were reported. In addition, imaging features of CT scans acquired at the 1st, 2nd, 3rd week and longer than 3 weeks after symptom onset were evaluated. Further, we compared hospitalization durations, age and total CT scores among patients with at least 2 CT scans which were divided into 4 groups based on the extents that lesions reduced. We summarized continuous variables as medians and interquartile ranges (IQRs) or ranges as appropriate, while categorical variables were expressed as counts and percentages. All statistical analyses were performed using R software version 3.6.2 (R Foundation for Statistical Computing).

Declarations

Data Availability

The datasets generated during and/or analysed during the current study are not publicly available due to the data sharing policy of the Central People’s Hospital of Huizhou, but are available from the corresponding author on reasonable request.

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Author Contributions

ZZ, RT, BL, LL and OCQ designed the study. ZZ and RT drafted the manuscript; RT, HS, HD collected the imaging and clinical data; KC, XY, WY, and SK revised it critically for important intellectual content. RT and LL conducted statistical analysis. All authors have read and approved the manuscript.

Competing interests

The author(s) declare no competing interests.

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Tables

Table 1. Clinical characteristics and main laboratory findings of patients with coronavirus disease 2019 (COVID-19) pneumonia.

Variable	All patients (n=56)
Median age (IQR) – years	51.0 (37.0–63.0)
Male sex – no./total no. (%)	26/56 (46.4)
Exposure history within 14 days – no./total no. (%)	
Residents of or having travelled to Hubei Province	47/56 (83.9)
Having closely contacted with confirmed or suspected COVID-19 patients	9/56 (16.1)
Clinical symptoms – no./total no. (%)	48/56 (85.7)
Fever	37/56 (66.1)
Dyspnoea	12/56 (21.4)
Cough	30/56 (53.6)
Fatigue	11/56 (19.6)
Myalgia or arthralgia	12/56 (21.4)
Comorbidities – no./total no. (%)	9/56 (16.1)
Hypertension	7/56 (12.5)
Diabetes	3/56 (5.4)
Coronary heart disease	0/56 (0.0)
Chronic obstructive pulmonary disease	1/56 (1.8)
Others	9/56 (16.1)
Clinical classification–no./total no. (%)	
Usual cases	53/56 (94.6)
Severe cases	3/56 (5.4)
Laboratory findings	
White cell count	
Median (IQR) – $x10^9$/L	4.1 (3.2–5.4)
Distribution –no./total no. (%)	
<4 x 10^9/L	3/56 (5.3)
>10 x 10^9/L	25/56 (44.6)
Percentage of neutrophile granulocyte	
Median (IQR) – %	63.4 (55.5–71.0)
Distribution – no./total no. (%)	
<40%	6/56 (10.7)
>70%	16/56 (28.6)
Lymphocyte count	
Median (IQR) – x 10^9/L	1.1 (0.7–1.4)
Distribution – no./total no. (%)	
<0.9 x 10^9/L	24/56 (42.9)
>5.2 x 10^9/L	0/56 (0.0)
Median duration of hospitalization (IQR) – days	16.0 (12.0–20.0)

Notes: Continuous data were summarized as median with interquartile range (IQR) in brackets. Categorical variables were presented as counts with percentages in brackets.

Table 2. Features of thin-section CT scans of patients with coronavirus disease 2019 (COVID-19) pneumonia.

Variable	All scans (n=141)	Group 1 (n=23)	G
Median time from illness onset to CT examination (IQR) – days	15.0 (10.0–21.0)	6.0 (3.0–6.5)	1
Lung lobes involved – no./total no. (%)			
Single lobe	17/141 (12.1)	6/23 (26.1)	5
Multiple lobes	124/141 (87.9)	17/23 (73.9)	3
Lung involvement – no./total no. (%)			
Left	7/141 (5.0)	1/23 (4.3)	2
Right	6/141 (4.3)	3/23 (13.0)	3
Left & right	128/141 (90.8)	19/23 (82.6)	3
Distribution – no./total no. (%)			
Pure peripheral	67/141 (47.5)	13/23 (56.5)	1
Pure peribronchovascular	18/141 (12.8)	3/23 (13.0)	8
Peripheral & peribronchovascular	32/141 (22.7)	6/23 (26.1)	1
Diffuse	24/141 (17.0)	1/23 (4.3)	7
Imaging features – no./total no. (%)			
Ground-glass opacities	103/141 (73.0)	19/23 (82.6)	3
Halo sign	11/141 (7.8)	5/23 (21.7)	4
Reversed halo sign	9/141 (6.4)	2/23 (8.7)	3
Interlobular septal thickening	44/141 (31.2)	6/23 (26.1)	1
Crazy-paving pattern	21/141 (14.9)	3/23 (13.0)	5
Air bronchogram	22/141 (15.6)	5/23 (21.7)	7
Consolidation	28/141 (19.9)	5/23 (21.7)	1
Subpleural curvilinear line	24/141 (17.0)	3/23 (13.0)	8
Fibrous stripes	55/141 (39.0)	5/23 (21.7)	1
Atelectasis	2/141 (1.4)	1/23 (4.3)	1/
Pleural effusion	2/141 (1.4)	1/23 (4.3)	1/
Pericardial effusion	4/141 (2.8)	0/23 (0.0)	0/
Thoracic lymphadenopathy	3/141 (2.1)	0/23 (0.0)	1/

Notes: We classified the scans into 4 groups (Group 1-4) based on the date on which the CT scan was obtained at the 1st, 2nd, 3rd week and long than 3 weeks after illness onset. Continuous data were summarized as median with interquartile range (IQR) in brackets. Categorical variables were presented as counts with percentages in brackets.

Table 3. Duration of hospitalization, age and CT scores on admission of 45 follow-up patients with coronavirus disease 2019 (COVID-19) pneumonia.

Variable	All patients (n=45)	Group A (n=11)	G
Median duration of hospitalization (IQR) – days	17.0 (14.0– 20.0)	15.0 (13.0– 18.5)	1
Median age (IQR) – years	51.0 (40.0– 63.0)	41.0 (37.0– 50.0)	5
Median total CT scores on admission (IQR) – points	6.0 (3.0– 10.0)	2.0 (1.0–4.0)	4

Notes: We categorized the 45 patients who had at least 2 follow-up scans into 4 groups: Group A, patients whose lesions reduced ≥75%; Group B, those whose lesions reduced 50-75%; Group C, those whose lesions reduced 25-50%; Group D, those whose lesions reduced <25%. Continuous data were summarized as median with interquartile range (IQR) in brackets.

Figures

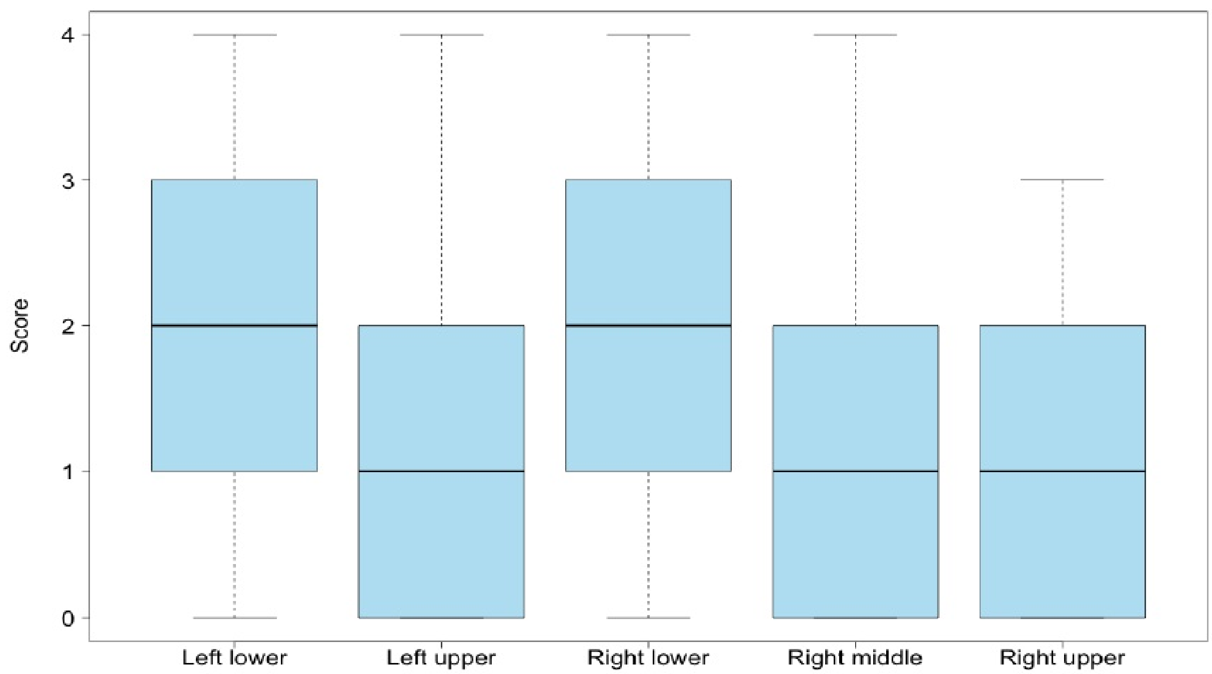

Figure 1

Boxplots of CT scores. Thick lines in boxes indicate medians of scores. Lower and upper bounds of boxes represent the 1st (Q1) and 3rd quartiles (Q3) of scores. IQR=Q3-Q1. Thin lines located outside boxes are the minimum and maximum CT scores.

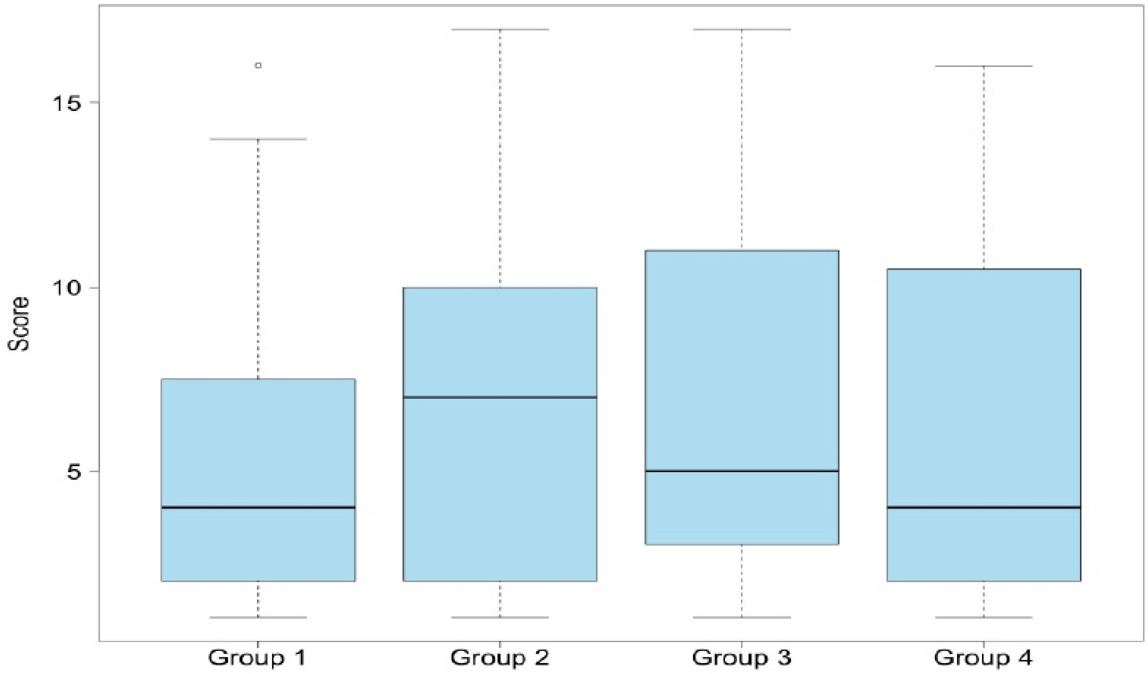

Figure 2

Boxplots of total CT scores for different groups. We classified the CT scans into 4 groups (Group 1-4) based on the date on which the CT scan was obtained at the 1st, 2nd, 3rd week and long than 3 weeks after illness onset. Thick lines in boxes indicate medians of scores. Lower and upper bounds of boxes represent the 1st (Q1) and 3rd quartiles (Q3) of scores. IQR=Q3-Q1. Thin lines located outside boxes are the minimum CT scores and the smaller of the maximum CT scores and Q3+1.5×IQR. Circles were used to indicate values outside the ranges between Q1-1.5×IQR and Q3+1.5×IQR.

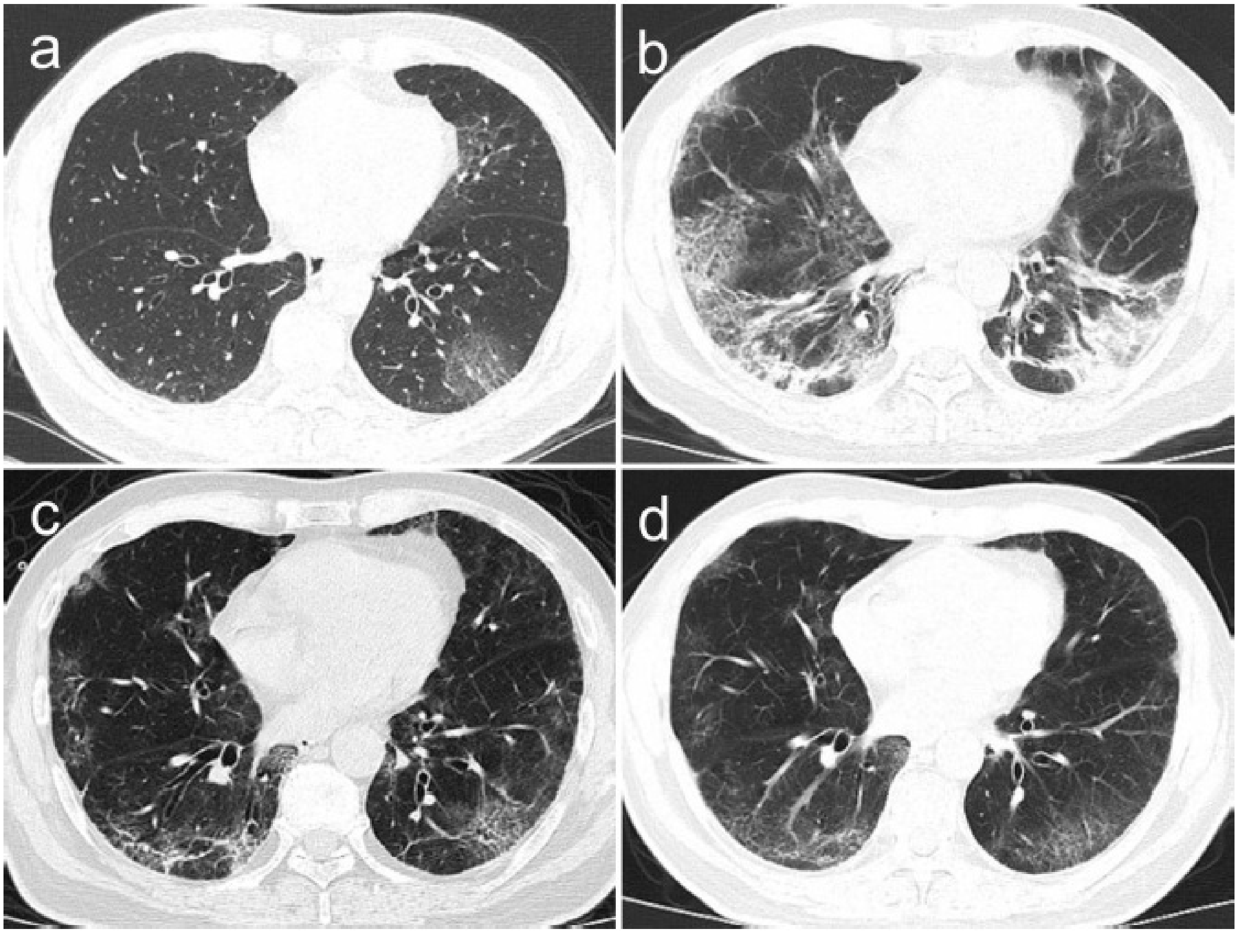

Figure 3

Transverse CT images in a 56-year-old man with COVID-19 pneumonia presented with cough and fever for 4 days. (a) Scans obtained on day 4 after illness onset showed peripheral patchy ground-glass opacities in the left lower lobe; (b) After 7 days, the followed-up scan showed lesions progression obviously and consolidation with air bronchogram, ground-glass opacities and crazy paving pattern were observed in the bilateral lungs. (c) After 10 days, previous lesions were absorbed obviously and ground-glass opacities, irregular fibrous stripes and Interlobular septal thickening were observed in the bilateral lungs. (d) After 14 days, further absorption of the lesions. The patients were discharged from hospital 3 days after the final scan was acquired.

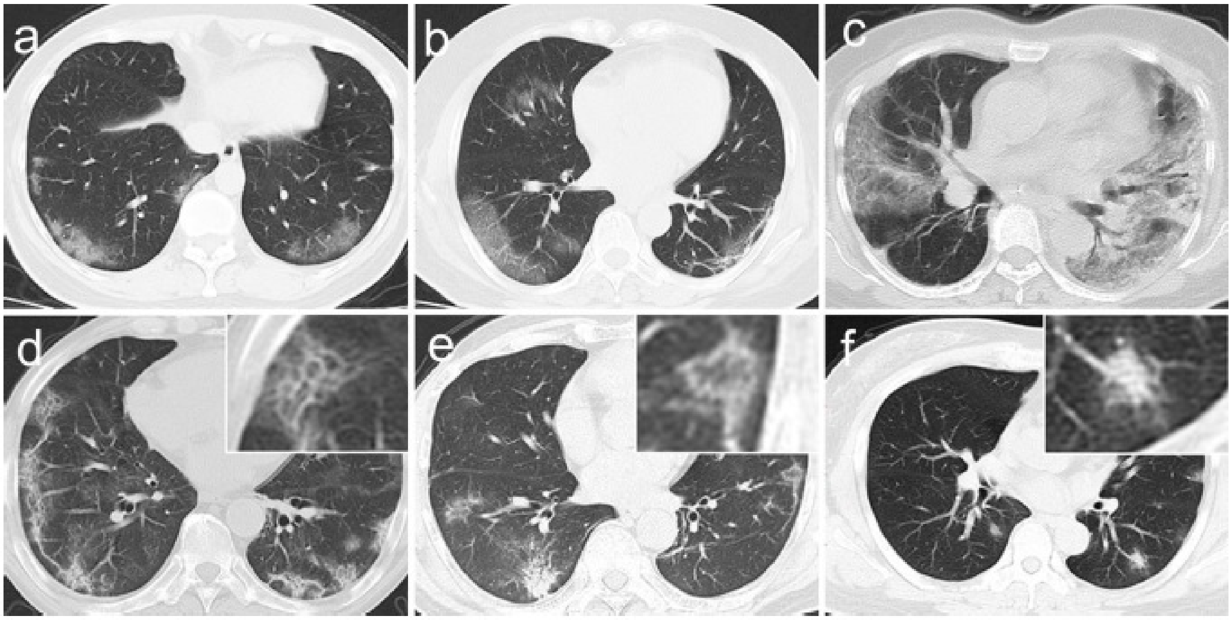

Figure 4

Chest CT findings of COVID-19 pneumonia on transaxial images. (a) bilateral and peripheral ground-glass opacities in the lower lobe; (b) Ground-glass opacities along peripheral and peribronchovascular distribution in right lower and middle lung, subpleural curvilinear line in left lower lung; (c) Consolidation with air bronchogram in left lung; (d) Crazy paving pattern along peripheral distribution in right lung; (e) Reversed halo sign in the left lower lung; (f) Halo sign in the left lower lung.