Quality Improvement Study

Medicine®

OPEN

Disease state prediction for 2019 novel coronavirus (COVID-19) pneumonia using CT manifestations and body temperature dynamic analysis

A SQUIRE-compliant study

Pan Liang, MD, Rui Wang, MD, Xiu-chun Ren, MD, Wen-peng Huang, MD, Jian-bo Gao, MD*

Abstract

2019 Novel Coronavirus (COVID-19) is a new acute infectious disease of respiratory system, posed a great threat to human health because of its strong infectivity and rapid progress. This study aimed to assess the severity of COVID-19 Pneumonia by analyzing the change of CT manifestations and body temperature.

This retrospective review included 22 patients with COVID-19 pneumonia. The imaging manifestations and clinical features were observed and evaluated.

Most of the infected patients were men (13/22, 59%). Fever (>38°C) (17/22, 77%) and cough (6/22, 27%) were the main symptoms. Leukocytes count decreased in 23% of patients and lymphocyte decreased in 41%. Twenty-one patients with pneumonia had abnormal findings on chest CT. The special CT manifestations were observed at the first CT examination when the lesions progressed, including a single ground glass nodule with uneven density, multiple ground glass opacities distributed in subpleural, and the ground glass opacities confined in superior lobe. The special CT manifestations were observed at the first CT examination when the lesions resolved, including ground glass opacities with homogeneous density. The lesion involved in the bilateral lungs and the absorption of the lesions mainly occurred in bilateral inferior lobes. Three patients had normalized body temperature increased more than 1°C within 1 to 2 days after admission. Ten patients fluctuated more than 1°C within 1 to 7 days after admission and the second CT scans showed the disease was at the progressive stage.

Dynamic analysis of CT manifestations and body temperature have the potential to predict the severity of COVID-19 pneumonia.

Abbreviations: CK-MB = creatine kinase myocardial band, COVID-19 = 2019 novel coronavirus, LDH = lactate dehydrogenase, SARS = severe acute respiratory syndrome.

Keywords: evaluation studies, novel coronavirus, pneumonia, tomography, x-ray computed

1. Introduction

2019 novel coronavirus (COVID-19) pneumonia, a new acute infectious disease of respiratory system, posed a great threat to human health because of its strong infectivity and rapid progress.[1,2] Within 1 month, the novel coronavirus was spreading through droplet transmission and contact transmission, and the reported number of confirmed COVID-19 revealed a rising tendency.[3] Early diagnosis of the COVID-19 is essential for timely treatment of the patient. According to the "diagnosis and treatment of novel coronavirus pneumonia" issued by the National Health Committee, the diagnosis of COVID-19 mainly incorporates with epidemiology, clinical manifestations, medical imaging, and laboratory data. CT is easily available and can be used to screen patients for rapid confirmation of COVID-19. There are some valuable experiences of CT diagnosis and treatment for patients with COVID-19 in our hospital. To understand this disease comprehensively, the author included 22 cases of COVID-19 with complete clinical and CT examination data, further exploring the relationship between the clinical and CT findings during the dynamic change of the disease.

2. Materials and methods

2.1. Patient population

This study was approved by the institutional review board, and the requirement for written informed consent was waived for all patients in this retrospective study. From January 1 to February

Editor: Roxana Covali.

The authors report no conflicts of interest.

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

Department of Radiology, The First Affiliated Hospital, Zhengzhou University, Zhengzhou, China.

* Correspondence: Jian-bo Gao, Department of Radiology, The First Affiliated Hospital, Zhengzhou University, No. 1 Eastern Jianshe Road, Zhengzhou, 450052, China (e-mail: cjr.gaojianbo@vip.163.com).

How to cite this article: Liang P, Wang R, Ren Xc, Huang Wp, Gao Jb. Disease state prediction for 2019 novel coronavirus (COVID-19) pneumonia using CT manifestations and body temperature dynamic analysis: a SQUIRE-compliant study. Medicine 2021;100:27(e25938).

Received: 8 June 2020 / Received in final form: 29 March 2021 / Accepted: 16 April 2021

http://dx.doi.org/10.1097/MD.0000000000025938

20 in 2020, the clinical and CT image data of 22 patients with COVID-19 confirmed in our hospital were analyzed retrospectively. These 22 patients included 13 men and 9 women, aged from 25 to 75 years, with a median age of 38 years. The clinical symptoms and routine blood tests, including initial symptom, leucocytes, lymphocytes, C-reactive protein, neutrophils, platelets, creatine kinase myocardial band (CK-MB) and lactate dehydrogenase (LDH), were analyzed. The inclusion criteria are as follows: on the basis of "diagnosis and treatment of novel coronavirus pneumonia (the fifth edition on trial),"[4] patients confirmed by infectious disease and respiratory disease experts; clinical and CT imaging data are complete and continuous for each patient; without any treatment before the first diagnosis. The period from the first symptom to the first CT examination was divided into four stages[2]: early stage (0–4 days after onset of the initial symptom); progressive stage (5–8 days after the onset of the initial symptom); peak stage (9–13 days after the onset of the initial symptom); absorption stage (≥14 days after the onset of the initial symptom).

2.2. CT examination

All patients underwent a chest CT examination and regular reexamination, with an interval range from 3 to 10 days. CT examinations were performed using a single inspiratory phase in 2 commercial multidetector CT scanners (GE Revolution CT or Siemens SOMATOM Force CT). All patients were in the supine position placed in the middle of the examination bed and raised arms on the head. The imaging parameters were as follows: a tube voltage of 120 kV, a tube current of 50 to 200 mA with automatic tube current modulation techniques, rotation time of 0.5 to 1.0 s, the pitch of 1.0 to 1.5, and acquisition section thickness of 1 mm. Lung window was built by high-resolution algorithm. Conventional image reconstruction: the images of 5 mm thick were reconstructed to images with lung window (window width: 1200–1500 Hu, window position: −750 to −650 Hu) and mediastinal window (window width: 300–350 Hu, window position: 50–70 Hu). Thin section image reconstruction: the images of 5 mm thick were rebuilt to thin section images (high resolution) with lung window (lung window algorithm, window width 1000–1500 Hu, window position −750 to −600 Hu).

2.3. Image analyzes

The CT images were transferred to a GE ADW 4.6 workstation (GE Healthcare, Milwaukee, WI) and imaging features should be interpreted by 2 chest radiologists (1 deputy chief physician and 1 senior attending physician). As for the detail of imaging characteristics, 5 variables were evaluated seriously, including location (bilateral lung, unilateral lung, peripheral, and central distribution), multiplicity (single, 2, and multiple), shape (nodular, ground-glass, cord, and paving stone), lobe involvement (1 lobe, 2 lobes, and multiple lobes), and other lesions. Peripheral lung lesions referred to those far away from the lung hilum, whereas central lung lesions were near the lung hilum center. Nodular lesion was defined as a high-density lesion without lung texture. Ground-glass lesion was showed as a low-density lesion with lung texture crossing it in lung window, whereas it was not visible in mediastinal window. In addition, the CT features between 2 CT examinations for each patient were compared to access the development of lesion.

3. Results

3.1. Patient characteristics

In the 22 patients with COVID-19 pneumonia, 77% (17/22) patients had initial symptom of fever (>38°C). After taking antibiotics and antiviral drugs, they had their temperature down to normal within 1 to 2 days and for some of them temperature rising again in the next 2 to 3 days: 18% (4/22) of the patients were accompanied with fever, chest pain, and other uncomfortable symptoms and 27% (6/22) of the patients had obvious cough, mainly with irritating dry cough. Only 14% (3/22) of the patients had expectoration, mostly white sputum. Moreover, there was 1 case with dizziness and fatigue. Another case without overt clinical symptom (Table 1).

3.2. Laboratory examination

On admission, routine blood tests for these patients showed that leucocytes were below the normal level in 5 (23%) patients and above in 2 (9%) patients. Lymphocytes were lower than the normal range in 9 (41%) patients, and C-reactive protein and neutrophils were higher in 11 (50%) patients and 6 (27%) patients, respectively. Thrombocytopenia was detected in 4 patients. In addition, some patients had differing degrees of myocardium function abnormality, with CK-MB in 2 (9%) patients or LDH in 10 (45%) patients above the normal range. More pleasing, with the improvement of disease, myocardial enzymes gradually decreased to normal level in some people (Table 1).

3.3. Chest imaging findings of the first diagnosis

In addition to normal CT manifestation in 1 patient, lesions could be discovered on images of 21 COVID-19 patients at the first CT examination of the lung, including 7 cases in the early stage, 10 in the progressive stage, 2 in the peak stage, and 2 in the resolved stage (Table 2).

3.4. Location

We evaluated and recorded a variety of CT features for each patient. For the location of lesions, bilateral lung involvement was revealed in 16 cases (73%), and unilateral involvement in 5 (23%). In the unilateral lung involvement group, right lung involvement was found in 4 cases (18%) and left in 1 (5%). As to distribution of lesions, the lesion confined in the peripheral distribution of lung was revealed in 7 cases (32%), and simultaneous distribution of lung periphery and center in 14 cases (64%).

3.5. Multiplicity

The number of lesions varied from patient to patient, which was described as single lesion in 4 cases (18%), 2 lesions in 1 case (5%), and multiple in 16 case (73%).

3.6. Shape

The shape of lesions include nodular lesion, ground-glass lesion, cord lesion, and coexistence of multiple shapes, which corresponding to 4 cases (18%), 20 cases (91%), 7 cases (32%), and 10 cases (45%). Among the 20 cases (91%) showed as ground-

Table 1

Clinical symptoms and laboratory examination of 22 patients with 2019 novel coronavirus.

Case No.	Age, y	Sex	Initial symptom	Laboratory examination
1	55	Male	Fever, cough	CK-MB↑
2	30	Female	Fever	Leucocyte count↓,
3	25	Male	Fever, cough	Leucocyte count↓, C-reactive protein↑
4	30	Male	Fever, cough	C-reactive protein↑
5	55	Male	Fever	Lymphocyte count↓, neutrophil count↑, LDH↑
6	49	Male	Fever	C-reactive protein↑
7	33	Female	Fever	Leucocyte count↓, lymphocyte count↓, C-reactive protein↑
8	31	Male	Fever, chest distress	Lymphocyte count↓, neutrophil count↑, LDH↑
9	46	Female	Fever, chest distress	Leucocyte count↑, lymphocyte count↓, C-reactive protein↑, neutrophil count↑, LDH↑
10	56	Female	Fever	Leucocyte count↓, lymphocyte count↓, C-reactive protein↑, LDH↑
11	61	Male	Fever, chest distress	Leucocyte count↑, lymphocyte count↓, C-reactive protein↑, neutrophil count↑, CK-MB↑, LDH↑
12	73	Female	Fever, cough	Leucocyte count↓, lymphocyte count↓, C-reactive protein↑, neutrophil count↑, platelet count↓
13	38	Female	Dizziness, fatigue	Non
14	38	Female	Fever	Lymphocyte count↓, platelet count↓
15	75	Male	Fever	C-reactive protein↑
16	40	Male	Fever, cough	Non
17	26	Male	Fever	LDH↑
18	40	Male	Fever	Platelet count↓, LDH↑
19	38	Male	Physical examination	Non
20	70	Male	Fever	LDH↑
21	65	Female	Fever, cough	C-reactive protein↑, platelet count↓, LDH↑
22	30	Female	Fever	Lymphocyte count↓, C-reactive protein↑, neutrophil count↑, LDH↑

CK-MB = creatine kinase myocardial band; LDH = lactate dehydrogenase.

glass lesions, 18 cases (82%) had ground glass opacity (GGO) with air bronchogram and thick blood vessels and bronchus, 10 cases (45%) had lesion features showing paving stone, and 3 cases (14%) showed above 2 characteristics simultaneously.

3.7. Lobe involvement

Lesion involved 1 lobe was found in 5 cases (23%) and multiple lobes in 16 cases (73%). In another way, 18 cases (82%) were involved in the upper lobe of the lung and 3 cases (14%) were not.

Table 2

CT manifestations of 22 patients with 2019 novel coronavirus.

Case No	Location	Multiplicity	Shape	Lobe involvement	Enlarged mediastinal lymph nodes	Pleural effusion	Pericardial effusion	Pleural involvement/ thickening
1	Bilateral lung	Multiple lesions	Cord lesion + ground-glass lesion	Multiple lobes	–	–	–	–
2	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
3	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
4	Right lung	Single lesion	Nodular lesion+ground-glass lesion	1 Lobe	–	+	–	+
5	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
6	Right lung	Single lesion	Ground-glass lesion	1 Lobe	–	–	–	–
7	Left lung	Single lesion	Ground-glass lesion	1 Lobe	–	–	–	–
8	Bilateral lung	Multiple lesions	Cord lesion + ground-glass lesion	Multiple lobes	–	–	–	–
9	Bilateral lung	Multiple lesions	Cord lesion + ground-glass lesion	Multiple lobes	–	–	–	–
10	Bilateral lung	Multiple lesions	Nodular lesion + cord lesion	Multiple lobes	–	–	–	–
11	Bilateral lung	Multiple lesions	Cord lesion + ground-glass lesion	Multiple lobes	+	–	–	+
12	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
13	Non	Non	Non	Non	Non	Non	Non	Non
14	Right lung	Single lesion	Nodular lesion + ground-glass lesion	1 Lobe	–	–	–	–
15	Bilateral lung	Multiple lesions	Cord lesion + ground-glass lesion	Multiple lobes	+	–	–	–
16	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
17	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
18	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
19	Right lung	Two lesions	Nodular lesion + ground-glass lesion	1 Lobe	–	–	–	–
20	Bilateral lung	Multiple lesions	Ground-glass lesion	Multiple lobes	–	–	–	–
21	Bilateral lung	Multiple lesions	ground-glass lesion	Multiple lobes	–	–	–	–
22	Bilateral lung	Multiple lesions	Cord lesion + ground-glass lesion	Multiple lobes	–	–	+	+

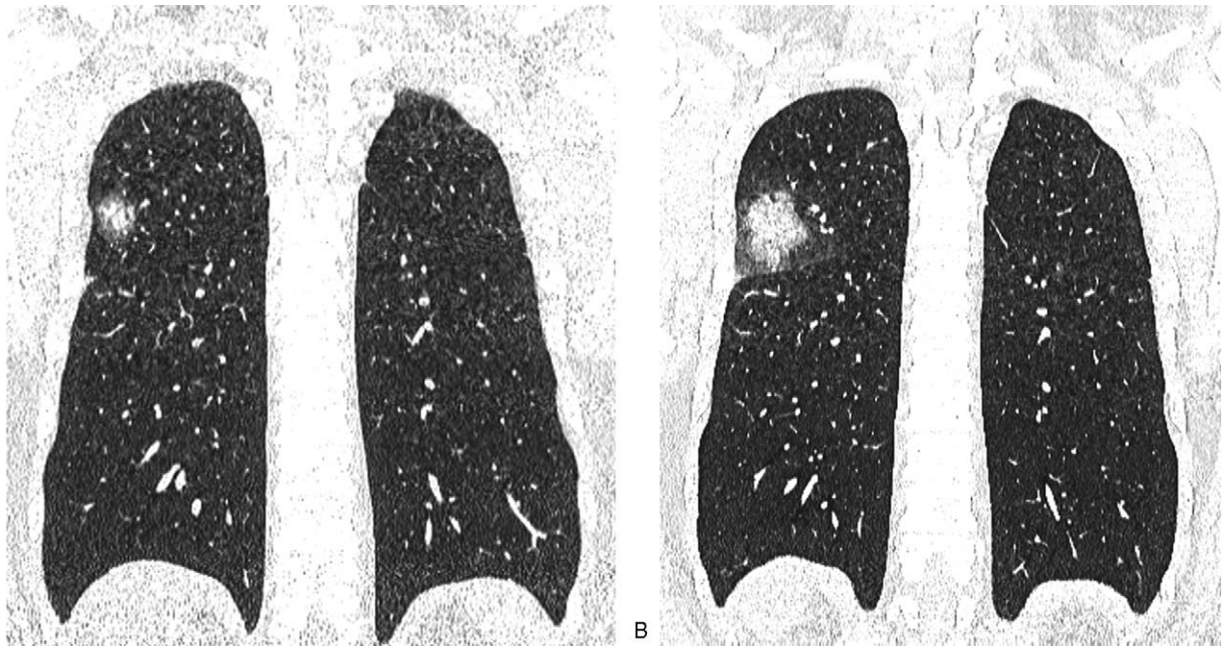

Figure 1. A 26-year-old male patient. A, The first computed tomography (CT) scanning showed a single ground glass opacity (GGO) in subpleural of right inferior lobe, with higher-density nodule shadow in uneven density. B, The second CT scanning showed the lesion area increased from smaller to larger, which indicated progress of disease.

3.8. Other lesions

There were also some cases with COVID-19 accompanied by other lesions, for example, enlarged mediastinal lymph nodes was found in 2 cases (9%), pleural effusion in 1 case (5%), pericardial effusion in 1 case (5%), and pleural involvement/thickening in 3 cases (14%).

3.9. Dynamic changes and outcomes of images

3.9.1. Lesion progress. The lesions strongly progressed in 10 cases within 5 to 11 days after admission: 1 case (5%) was characterized as increasing lesions and normal lobes involvement and 9 cases (41%) had lesion area enlarged. In these cases, 5 cases showed a single ground glass nodule with uneven density at the first diagnosis and the lesion increased from smaller to larger at the second CT scanning (Fig. 1). In 1 case, multiple ground glass opacities were distributed in subpleural, whereas at the second CT scanning, reticular lesions pervaded in bilateral lungs with consolidation shadow, with thick blood vessels, and bronchus of thickened wall passing through (Fig. 2). In another case, the ground glass opacities within uneven density were confined in superior lobe of unilateral lung. After reexamination, the lesions changed into multiple patchy ground glass opacities spreading in bilateral lungs, along with some reticular lung textures (Fig. 3).

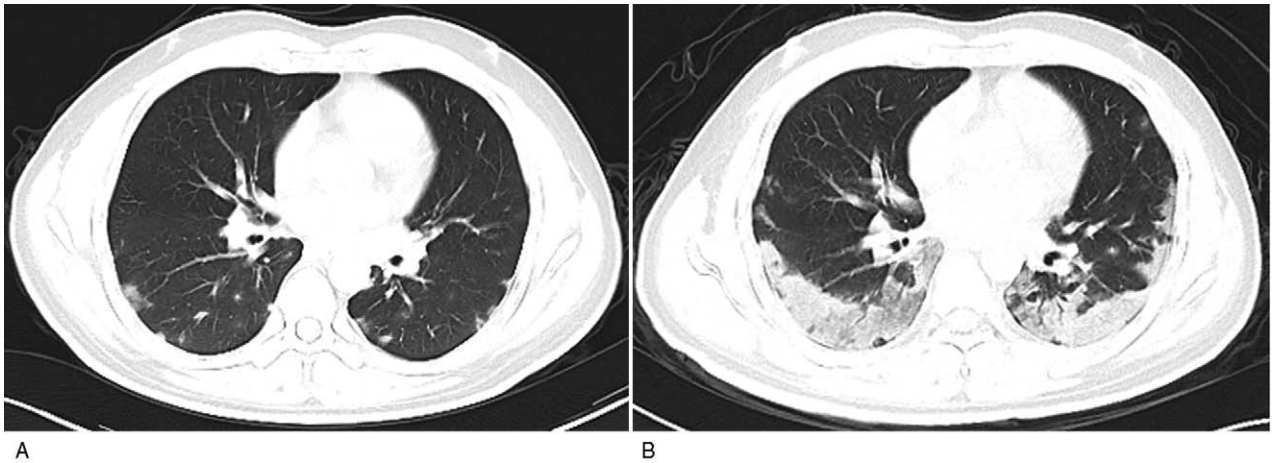

Figure 2. A 56-year-old female patient. A, Multiple ground glass opacity (GGO) were distributed in subpleural of bilateral lungs. B, The second computed tomography (CT) scanning showed that reticular lesions pervaded in bilateral lungs with consolidation shadow, which indicated progress of disease.

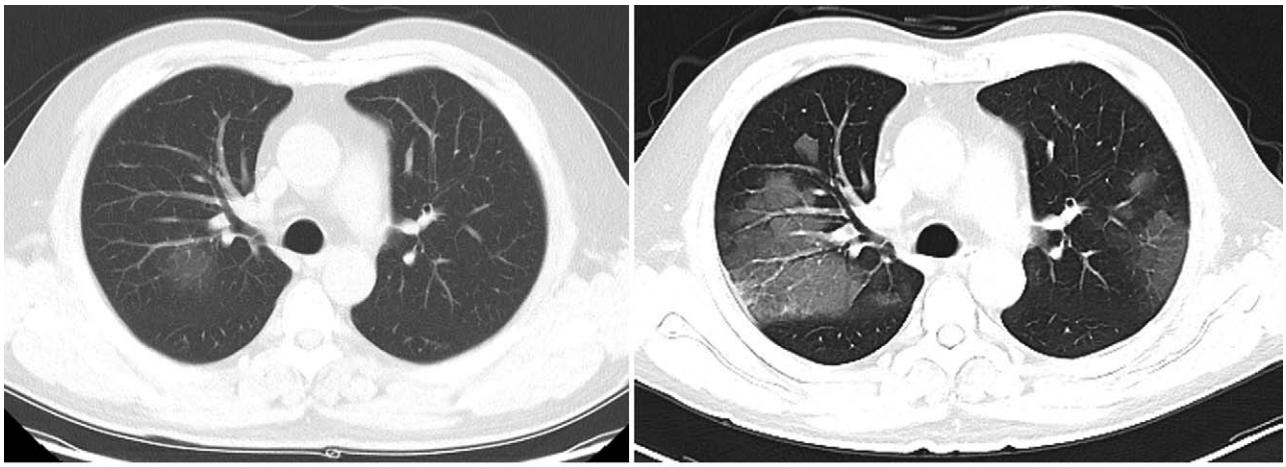

Figure 3. A 49-year-old male patient. A, The ground glass opacity (GGO) within uneven density were confined in right superior lobe. B, After reexamination, the lesions changed into multiple patchy GGO spreading in bilateral lungs, along with some reticular lung textures, which indicated progress of disease.

3.9.2. Lesion resolving. The lesions distinctly resolved in 5 cases (9.4%) within 9 to 15 days after admission, displayed as excellent change of lesions from multiple to localized on CT images. In 1 case, the lesion had a change from larger ground glass opacities with homogeneous density to smaller lesions with lighter density (Fig. 4). The lesion of other 4 cases involved in the bilateral lungs and the absorption of the lesions mainly occurred in bilateral inferior lobes. The significant changes of lesions were reduction of scope and decrease of density with cord shadow (Fig. 5).

3.10. The dynamic imaging manifestations of pulmonary and body temperature

There were 21 patients of abnormal CT findings in lung at the first diagnosis. Seven patients had normalized temperature within 1 to 2 days after admission, including 1 early-stage patient and 2 progressive-stage patients with temperature increased more than 1°C. The second CT scans showed the disease of these 3 patients were progressive and the rest were improved. Fourteen patients had normalized temperature within 1 to 7 days after admission, including 3 early-stage patients, 6 progressive-stage patients, and 1 peak-stage patient with temperature fluctuated more than 1°C and the second CT scans showed the disease of the 10 patients were at the progressive stage.

4. Discussion

The novel coronavirus disease is a highly infectious and rapidly developing infectious disease. The gene sequence similarity between the pathogen of new coronary pneumonia and severe acute respiratory syndrome (SARS) virus is as high as 79.5%. The novel coronavirus is known as the seventh human coronavirus with high mutation rate and strong infection ability.[3,5] The clinical characteristics of COVID-19 patients are complicated, which are commonly displayed as fever, chills, generalized myalgia, fatigue, diarrhea, cough, and shortness of breath. In

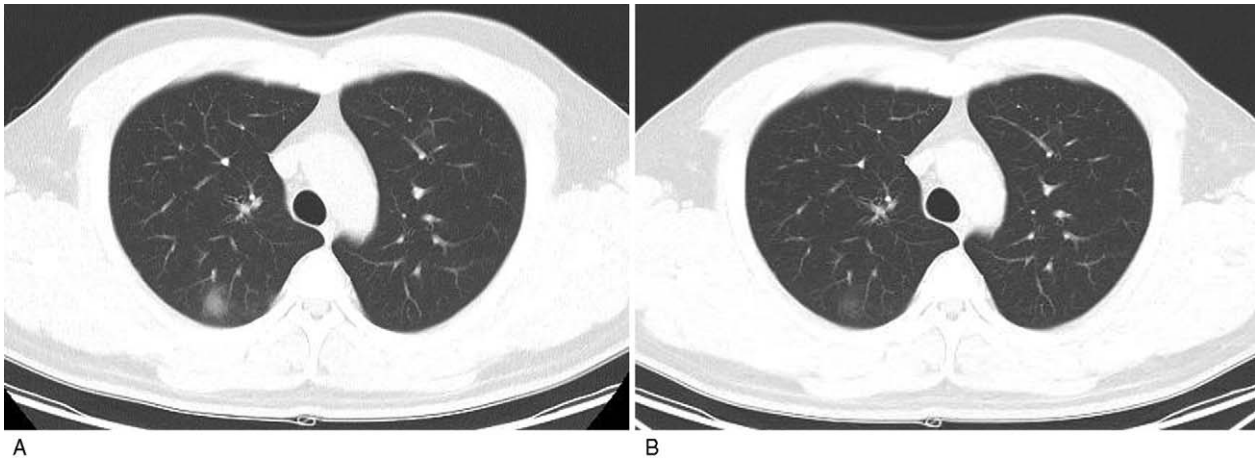

Figure 4. A 38-year-old male patient. A, In bilateral superior lobes, the ground glass opacity GGO with homogeneous density was found. B, There was a change from lager lesion to smaller with lighter density, which suggested the improvement of disease.

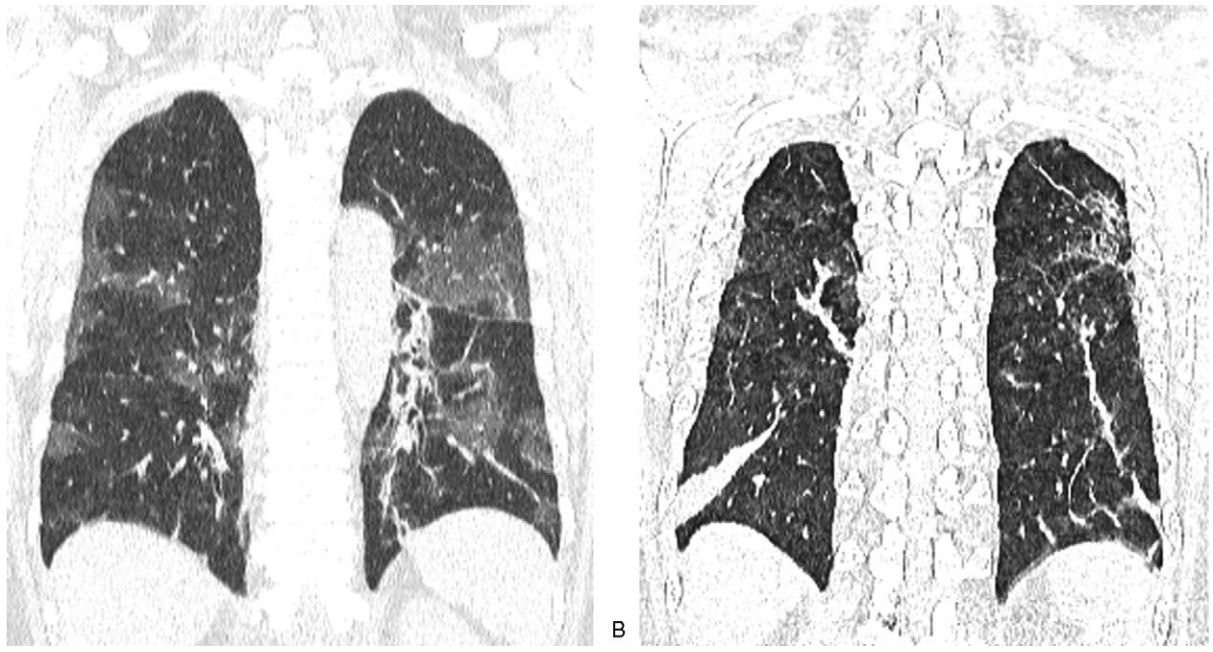

Figure 5. A 46-year-old female patient. A, The ground glass opacity (GGO) with uneven density involved in the bilateral lungs, especially in superior lobes. B, The absorption of the lesions mainly occurred in bilateral inferior lobes. The markable changes of lesions were reduction of scope and decrease of density with cord shadow, which suggested the improvement of disease.

addition, dyspnea or acute respiratory distress syndrome might be occurred in some severe patients.[6,7] The analysis of 138 COVID-19 patients in China showed that fever was found in 98.6% of patients, fatigue in 69.6%, and dry cough in 59.4%.[8] In our study including 22 patients with COVID-19, 77% of them had fever (>38°C) on admission. Seven patients had normalized temperature within 2 days after admission, and 14 patients (64%) had temperature fluctuated varying in a certain range. The temperature of patients could drop to normal level due to antibiotics and antiviral drugs, but bacterial infection after admission might be a related factor of temperature fluctuation. Accompanied by or later than fever, 27% of the patients had cough mainly featured as irritant dry cough. Only 14% (3/22) of patients had cough accompanied with expectoration, mainly white phlegm. Less expectoration patients in our study might be attributed to rational and timely use of antibiotics and antiviral drugs. Moreover, 5% (1/22) of the patients without clinical symptoms were only detected during routine examination.

The incubation period of COVID-19 is 1 to 14 days, generally 3 to 7 days. This disease occurs commonly in patients with the age of 40 to 60 years, male, or underlying diseases, rarely in children.[6] In this study, the sex distribution of male to female was 13:9, which is similar to that of SARS.[9,10] The apparent male predominance may indicate that the low virus susceptibility for women is related to the protection of X chromosome and sex hormone, which plays an important role in innate and adaptive immunity.[7,11] It is reported that[6] 25% of patients with COVID-19 had a decrease of white blood cell count and 63% of patients had lymphocyte count decreased. According to the published study in China, Chen et al[7] reported that leukocytes count decreased in 9% of patients while increased in 24%, neutrophils increased in 38% and lymphocyte decreased in 35%. Similarly, in the present study, 23% (5/22) of the patients on admission had a decrease in leukocyte count and 41% (9/22) of the patients had a decrease in lymphocyte count, which suggested that the multiple organ dysfunction of patients with COVID-19.[7] Subsequently, with the use of antibiotics and antiviral drugs, leukocytes count rapidly increased above the normal level and the proportion of lymphocytes decreased correspondingly. In addition, some patients with myocardial injury presumably were consistent with virus infection, with CK-MB in 9% (2/22) of patients or LDH in 45% (10/22) above the normal range. It should be noted that with the improvement of the condition, the myocardial enzymes in some patients gradually decreased to normal scale. It was worth noting that the myocardial enzymes of some patients gradually dropped to normal when they got better.

4.1. The value of CT examination in diagnosis of COVID-19

Remarkably, the novel coronavirus is common detected by nucleic acid detection method in clinical.[12] However, the reliability of this method is closely related to specimen collection technology, quality of test kit, complex evolution of diseases, and so on. The false negative rate of nucleic acid detection is relatively high, which makes no use to satisfy the diagnosis requirement of suspected patients. Of the 22 patients with COVID-19 in our study, 7 patients showed abnormal lung CT findings 1 to 2 days after the appearance of clinical symptoms, and 1 patient showed abnormal CT findings before fever. In addition, for some confirmed patients with negative results of the nucleic acid detection at the first time, CT imaging strongly indicated viral pneumonia, which further suggested the important value of CT examination in the diagnosis of COVID-19.

4.2. Chest imaging manifestations

The chest CT imaging features of COVID-19 patients are summarized as follows[6]: single or multiple; single segment, single lobe, multiple segments, or lobes of lung may be involved; located commonly in subpleural of lung periphery; the shape of lesions included nodular (solid nodule and solid nodule with halo sign in peripheral), patchy, ground-glass (GGO, paving stone shadow and GGO with central consolidation) and cord; and simultaneous existence of 2 or more shapes and most common shape is GGO. In resolved stage, the patients with COVID-19 commonly showed the cord lesion, which was displayed as irregular arc line parallel and/or vertical to pleura within ground glass lesions. For 21 patients with the first diagnosis, the lesions of them mainly were located in lung periphery. It was because that parvovirus particles with droplet spreading deposited in the peripheral bronchi and alveoli. Wong et al[13] reported that patients with SARS often involved bilateral inferior lobes. Unlike SARS, 3 patients only considered as unilateral or bilateral superior lobes lesions in our study. Therefore, lung involvement was of insufficiency value in the diagnosis and differential diagnosis of COVID-19. However, COVID-19 was featured as involvement of bilateral inferior lobes, especially in right lung. This phenomenon was in accordance with previous imaging findings in H7N9 avian influenza,[14] and the fact that principal bronchi of the right lung is relatively short and steep may be a credible interpretation. The first CT findings showed that there were more than 3 subpleural lesions in the inferior lobe of unilateral lung, and the shape was mainly patchy and/or segmental GGO. After 11 days of admission, these CT lesions could evolve into large and pervasive lesions. While in the short term, the single GGO on the first CT scan only turned into an enlarged or new lesion. These imaging dynamic changes indicated disease progression, which was consistent with clinical change of deterioration to peak stage in around 10 days.[2] In addition, we also found that some patients were accompanied by other lesions, including enlarged mediastinal lymph nodes in 2 cases, pleural effusion in 1 case, pericardial effusion in 1 case, and pleural involvement/thickening in 3 cases. Most of the patients in the early stage of COVID-19 were interstitial diseases, rarely involving the serous membrane, so there were no early patients in the above patients.

4.3. The value of CT manifestations based on the pulmonary lobes in the evaluation of the treatment course of COVID-19

Different from common pneumonia and other atypical pneumonia, CT examination is an important method to evaluate the dynamic change of COVID-19 disease.[12] The imaging changes of coronavirus pneumonia are not corresponding to disease development, and many factors of imaging evaluation should be taken into account. For instance, treatment method, therapeutic response, whether accompanied by other basic diseases or not (such as diabetes, hypertension, chronic bronchitis, emphysema, etc), age, body mass, and so forth.[15] Compared with patients with superior lobes involvement, the patients without superior lobes involvement had longer absorption time in this group. And it was most common that the lesions were completely or radically absorbed in the bilateral inferior lobes. According to this, the author suggested that the CT manifestations based on pulmonary lobes, especially whether the superior lobe was involved, could be used to develop an effective guidance for COVID-19 patients with the treatment course of the disease.

4.4. The separation between dynamic lung imaging manifestations and temperature

The results of this study showed that the larger the lesions range, the longer the fever time, and the longer the course of disease generally in other word. So the range of imaging findings was probably consistent with the severity of the disease. The repeated aggravation, prolongation, and malabsorption of pulmonary lesions also affected the duration of the disease. Based on the second CT findings of the lung, the patchy and/or segmental GGO lesions were absorbed gradually in 3 days after the body temperature restored to normal. Meanwhile, the pervasive lesions in bilateral lungs and lung parenchyma with extensive effusion and consolidation were absorbed about 5 days after the temperature returned to normal. That is to say, the CT manifestations of lung lesions were later than the body temperature recovering. In general, the symptoms of the COVID-19 were not in accord with the CT features, which further indicated that lesions range and disease recurring were able to reflect the duration of the disease. The imaging manifestations, including size, range, and severity of the lesions, could give indication to the state of disease for patient. In addition, there were another result shown that 3 patients' temperature increased more than 1°C within 2 days after admission, and the temperature of 14 patients obviously fluctuated within 1 to 7 days after admission, whose diseases were progressive as was showed in the second CT imaging. Our study is still at the preliminary stage, so we will go deep into the observation and investigation for the long-term therapeutic response and imaging changes.

Limitations of the present study include the retrospective nature of our analysis and a relatively small number of patients. It would be better to include as many patients as possible in China, and even in other countries to get a more comprehensive understanding of COVID-19.

In conclusion, chest CT examination is the critical method in diagnosis of novel coronavirus pneumonia. During the treatment, it is necessary to dynamically observe the distribution, shape, and range of lung lesions, so as to know well the therapeutic response and the process of disease. Furthermore, second CT examination should be arranged reasonably according to change of body temperature.

Author contributions

Data curation: Pan Liang, Wenpeng Huang.
Investigation: Pan Liang, Rui Wang.
Methodology: Xiuchun Ren.
Supervision: Pan Liang, Jian-bo Gao.
Writing – original draft: Pan Liang, Jian-bo Gao.
Writing – review & editing: Pan Liang, Jian-bo Gao.

References

[1] Pan Y, Guan H. Imaging changes in patients with 2019-nCov. Eur Radiol 2020;30:3612–3.
[2] Pan F, Ye T, Sun P, et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiology 2020;295:715–21.

[3] Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 2020;382:727–33.
[4] Feng Y, Ling Y, Bai T, et al. COVID-19 with different severities: a multicenter study of clinical features. Am J Respir Crit Care Med 2020;201:1380–8.
[5] Zhou P, Yang XL, Wang XG, et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 2020;579:270–3.
[6] Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020;395:497–506.
[7] Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet 2020;395:507–13.
[8] Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA 2020;323:1061–9.
[9] Badawi A, Ryoo SG. Prevalence of comorbidities in the Middle East respiratory syndrome coronavirus (MERS-CoV): a systematic review and meta-analysis. Int J Infect Dis 2016;49:129–33.
[10] Channappanavar R, Fett C, Mack M, Ten Eyck PP, Meyerholz DK, Perlman S. Sex-based differences in susceptibility to severe acute respiratory syndrome coronavirus infection. J Immunol 2017;198: 4046–53.
[11] Jaillon S, Berthenet K, Garlanda C. Sexual dimorphism in innate immunity. Clin Rev Allergy Immunol 2019;56:308–21.
[12] Pan Y, Guan H, Zhou S, et al. Initial CT findings and temporal changes in patients with the novel coronavirus pneumonia (2019-nCoV): a study of 63 patients in Wuhan, China. Eur Radiol 2020;30: 3306–9.
[13] Wong KT, Antonio GE, Hui DS, et al. Thin-section CT of severe acute respiratory syndrome: evaluation of 73 patients exposed to or with the disease. Radiology 2003;228:395–400.
[14] Wang Q, Zhang Z, Shi Y, Jing Y. Emerging H7N9 influenza A (novel reassortant avian-or-igin) pneumonia: radiologic findings. Radiology 2013;268:882–9.
[15] Wu YC, Chen CS, Chan YJ. The outbreak of COVID-19: an overview. J Chin Med Assoc 2020;83:217–20.