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PERSPECTIVE

INFECTIOUS DISEASES

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Evolution of computed tomography manifestations of eleven patients with severe coronavirus disease 2019 (COVID-19) pneumonia

Abstract

Purpose: Severe coronavirus disease 2019 (COVID-19) pneumonia is associated with high mortality. However, the evolution of computed tomography (CT) manifestations of severe COVID-19 pneumonia remains unclear, more evidence regarding its evolution process is urgently needed.

Method: The clinical, laboratory and imaging data of eleven patients with severe COVID-19 pneumonia were collected to investigate the evolution process of severe COVID-19 cases.

Results: The main initial CT manifestations of severe COVID-19 pneumonia were multiple ground-glass opacities and/or consolidation. The evolution of CT manifestations showed that acute exudative lesions of severe COVID-19 pneumonia could be gradually resolved after the active intervention.

Conclusions: Most of patients with severe COVID-19 pneumonia showed marked improvement of acute exudative lesions on chest imagings and satisfactory prognosis of severe COVID-19 pneumonia could be achieved after active treatment.

1 | BACKGROUND

The coronavirus disease 2019 (COVID-19) outbroke, which initially emerged in Wuhan City, Hubei Province, China, has spread to multiple countries around the world, with the number of confirmed cases increasing every day.[1-4] It poses a great threat to the global public health and human life. As of Mar 3, 2020, China reported 80 302 patients, including 2946 fatalities.[5] A severe type of COVID-19 pneumonia,[6] accounting for approximately 20% of COVID-19 cases,[5] caused the most COVID-19 deaths.[5] Based on the diagnostic and treatment protocols of COVID-19 (6th edition) published by National Health Commission of the People's Republic of China,[6] severe type of COVID-19 pneumonia need to meet any of the following conditions: (a) significantly increased respiration rate (RR): RR ≥ 30/min. (b) hypoxia in the resting state: pulse oxygen saturation (SpO2) ≤ 93%. (c) arterial partial pressure of oxygen (PaO_2)/fraction of inspiration O_2 (FiO_2) ≤300 mmHg. Chest computed tomography (CT) imaging plays an important role in early diagnosis and judgement of disease progress as well as efficacy evaluation of COVID-19 pneumonia; however, currently limited information exists regarding the evolution of chest CT manifestations of severe COVID-19 pneumonia. Here, we report the clinical, laboratory and evolution of chest CT manifestations of eleven patients with severe COVID-19 pneumonia.

2 | PATIENT'S CHARACTERISTICS

Eleven patients admitted to Taizhou Hospital of Wenzhou Medical University from January 24 to February 10, 2020, were diagnosed with severe COVID-19 pneumonia. Six patients were male and five patients were female, with a median age of 52 years (range 33-75 years). All eleven patients were confirmed by real-time-polymerase chain reaction (RT-PCR) tests of throat swabs. The initial symptoms of patients were fever (n = 10), cough (n = 8), and pharyngodynia (n = 3). Two patients with diabetes, one patient with hypertension, one patient with hypothyroidism, one patient with renal insufficiency, and one patient with gout.

3 | LABORATORY FINDINGS

On admission, ten patients had decreased lymphocytes count (0.4×10^9-0.8×10^9/L); three patients had increased white blood cell count (10.1×10^9-17.1×10^9/L); five patients had increased neutrophil count (7.0×10^9-15.9×10^9/L); 10 patients had elevated C-reactive protein (CRP) (10.40-101.89 mg/L), one patient

had elevated myoglobin (227.6 ng/mL) and two patients had decreased myoglobin (11.6-13.6 ng/mL).

4 | TREATMENTS

All patients were treated in isolation. Eleven patients received antiviral treatment (interferon alfa-2b injection, arbidol hydrochloride, lopinaviritonavir, oseltamivir), Four patients received antibiotic treatment (azithromycin, levofloxacin, roxithromycin). Eleven patients were treated with cortisol, immunoglobulin, and oxygen therapy.

5 | INITIAL CT MANIFESTATIONS

The main manifestations on initial chest CT scans were multiple ground-glass opacities (Figures 1A,E, 2C, 3A,G, 4A,G, 5A,E,I) with or without consolidation (Figures 1A,E,I, 2A,B, 3A,G, 4A,G, 5A,E) involving multiple lung lobes. A small amount of pleural effusion was observed in two patients (Figures 1E and 3A,D). Ten patients (Figures 1A,E,I, 2A-C, 3A,G, 4A, 5A,E,I) had bilateral involvement and the common involved areas were subpleural regions (Figures 1A,E,I, 2A-C, 3A,G, 4G, 5A,E).

6 | EVOLUTION OF CT MANIFESTATIONS

All eleven patients showed marked improvement of chest radiographic manifestations after active intervention. In the early and mid-term follow-up CT, one patient (Figure 2D-F) had increased consolidation and ground-glass opacities, ten patients (Figures 1B,C,F,G,J,K, 3B,H, 4B-E,H-K, 5B,C,F,G,J,K) had a decrease in consolidation and ground-glass opacities, a small amount of pleural effusion observed in two patients was gradually resolved (Figures 1F-G, 3B,E). In the late follow-up CT, all eleven patients showed

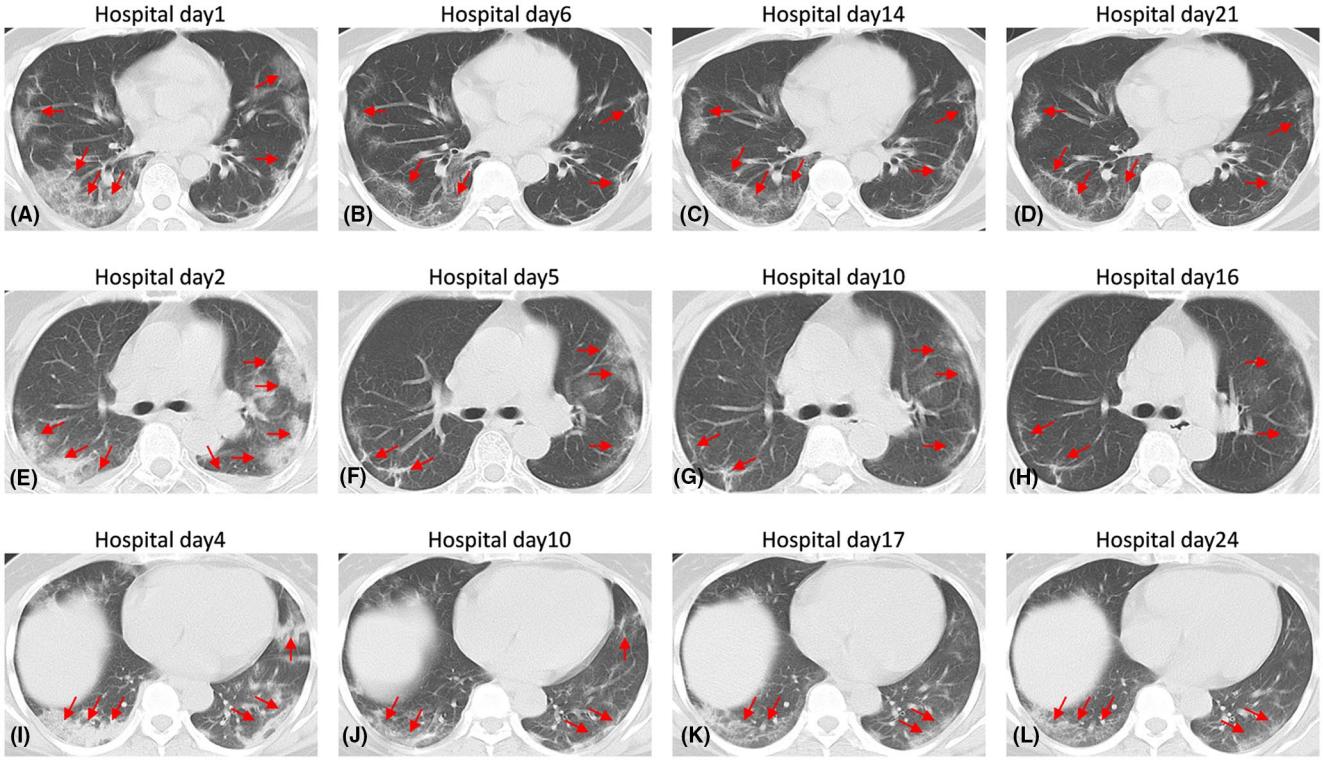

FIGURE 1 A-D, Images from case 1. A, First CT performed on hospital day 1 shows multiple ground-glass opacities and consolidation in the subpleural regions of bilateral lungs (red arrows); B, Second CT performed on hospital day 6 shows a significant decrease in the ground-glass opacities and consolidation in bilateral lungs (red arrows); C, Third CT performed on hospital day 14 shows no change in the extent of ground-glass opacities and consolidation in bilateral lungs(red arrows); D, Fourth CT performed on hospital day 21 shows no change in the extent of ground-glass opacities and consolidation in bilateral lungs (red arrows). E-H, Images from case 2. E, First CT performed on hospital day 2 shows multiple ground-glass opacities and consolidation as well as pleural effusion in the subpleural regions of bilateral lungs (red arrows); F, Second CT performed on hospital day 5 shows a significant decrease in the consolidation and resolved pleural effusion in bilateral lungs (red arrows); G, Third CT performed on hospital day 10 shows a mild decrease in the ground-glass opacities in the left lung (red arrows); H, Fourth CT performed on hospital day 16 shows a mild decrease in the ground-glass opacities in the left lung (red arrows). I-L, Images from case 3. I, First CT performed on hospital day 4 shows multiple consolidations in the bilateral subpleural regions (red arrows); J, Second CT performed on hospital day 10 shows a significant decrease in consolidation (red arrows); K, Third CT performed on hospital day 17 shows the density of ground-glass opacities decrease (red arrows); L, Fourth CT performed on hospital day 24 shows no change in the extent of ground-glass opacities (red arrows)

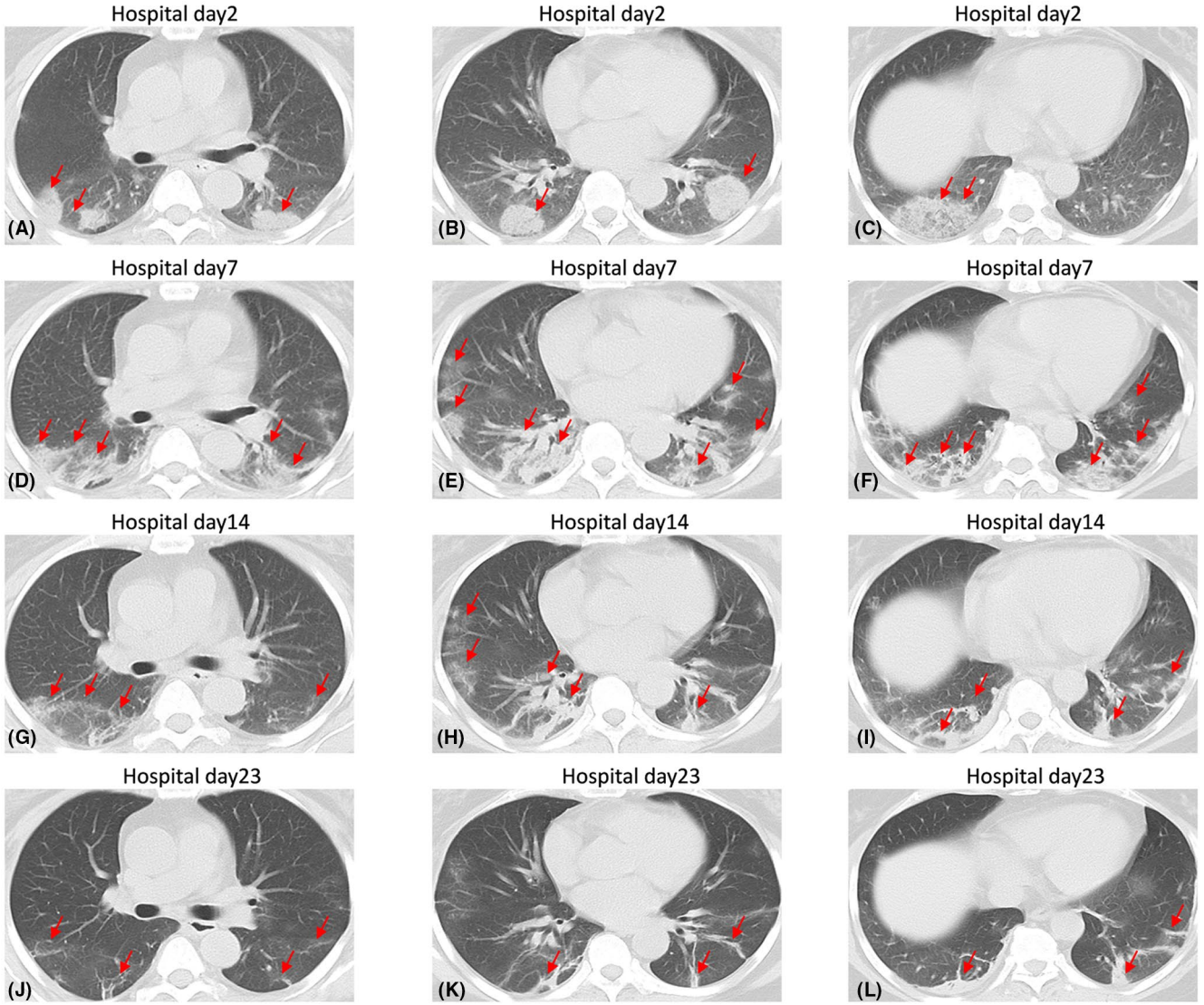

FIGURE 2 Images from case 4. A-C, Different slices on the same CT scan are horizontally arrayed; the same slices on the different CT scans are vertically arrayed. A-C, First CT performed on hospital day 2 shows multiple consolidations and ground-glass opacities in the subpleural regions of bilateral lungs (red arrows); D-F, Second CT performed on hospital day 7 shows an increase in the consolidation and ground-glass opacities in the subpleural regions of bilateral lungs (red arrows); G-I, Third CT performed on hospital day 14 shows a significant decrease in the consolidation and ground-glass opacities in bilateral lungs, and fibrosis-like stripes appear (red arrows); J-L, Fourth CT performed on hospital day 23 shows a further decrease in the ground-glass opacities and consolidation, fibrosis-like stripes still persist in bilateral lungs (red arrows)

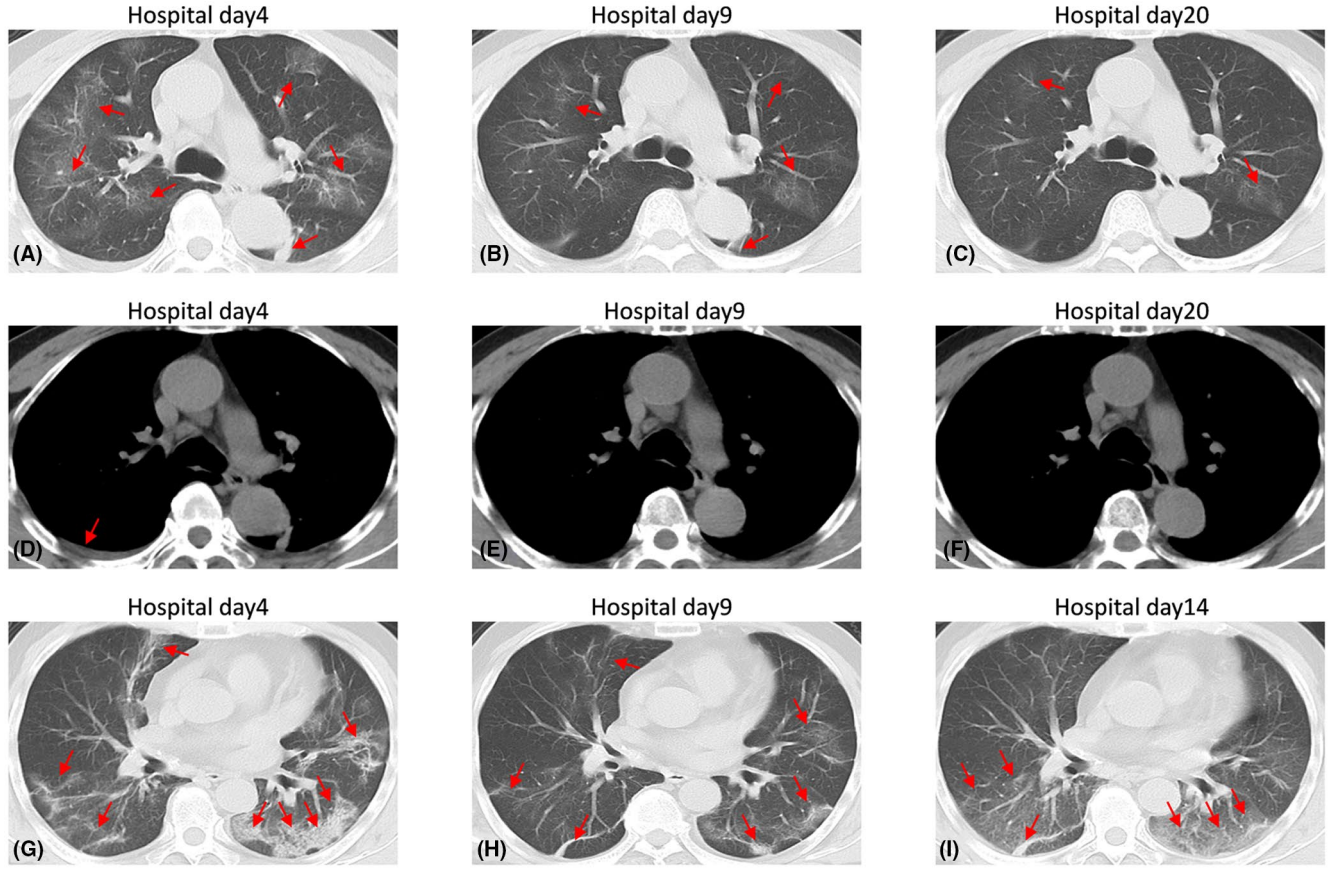

FIGURE 3 A-F, Images from case 5. A and D, First CT performed on hospital day 4 shows multiple ground-glass opacities and a small amount of consolidation as well as pleural effusion in bilateral lungs (red arrows); B and E, Second CT performed on hospital day 9 shows a significant decrease in the ground-glass opacities and consolidation in bilateral lungs, pleural effusion becomes almost invisible (red arrows); C and F, Third CT performed on hospital day 20 shows a further decrease in the ground-glass opacities in bilateral lungs, consolidation and pleural effusion have been completely resolved (red arrows). G-I, Images from case 6. G, First CT performed on hospital day 4 shows multiple ground-glass opacities and consolidation in the subpleural regions of bilateral lungs (red arrows); H, Second CT performed on hospital day 9 shows a significant decrease in the ground-glass opacities and consolidation in bilateral lungs, meanwhile, fibrosis-like stripes appear (red arrows); I, Third CT performed on hospital day 14 shows mildly increased ground-glass opacities in the subpleural regions of bilateral lungs, fibrosis-like stripes still persist (red arrows)

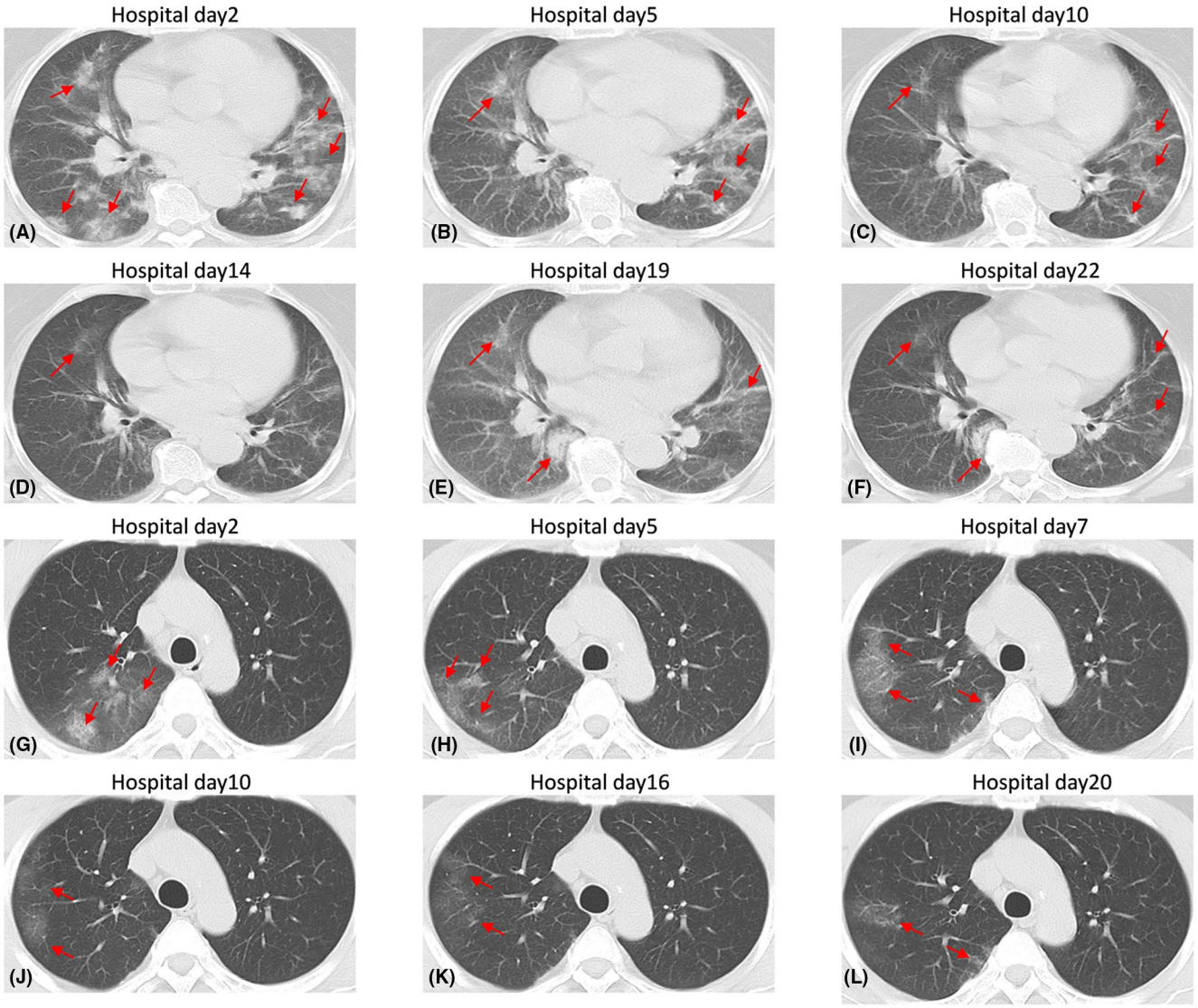

FIGURE 4 A-F, Images from case 7. A, First CT performed on hospital day 2 shows multiple ground-glass opacities and consolidation in bilateral lungs (red arrows); B, Second CT performed on hospital day 5 shows a significant decrease in the ground-glass opacities and consolidation in bilateral lungs (red arrows); C, Third CT performed on hospital day 10 shows a decrease in the ground-glass opacities and consolidation in bilateral lungs (red arrows); D, Fourth CT performed on hospital day 14 shows a further decrease in the ground-glass opacities and consolidation in bilateral lungs (red arrows); E, Fifth CT performed on hospital day 19 shows increased consolidation in the lower lobe of the right lung, fibrosis-like stripes appear in the upper lobe of the left lung (red arrows); F, sixth CT performed on hospital day 22 shows a decrease in the consolidation and ground-glass opacities as well as fibrosis-like stripes in bilateral lungs (red arrows). G-L, Images from case 8. G, First CT performed on hospital day 2 shows multiple ground-glass opacities and consolidation in the upper lobe of the right lung (red arrows); H, Second CT performed on hospital day 5 shows decreased ground-glass opacities and resolved consolidation in the upper lobe of the right lung (red arrows); I, Third CT performed on hospital day 7 shows a mild increase in the ground-glass opacities in the upper lobe of the right lung (red arrows); J, Fourth CT performed on hospital day 10 shows a decrease in the ground-glass opacities in the upper lobe of the right lung (red arrows); K, Fifth CT performed on hospital day 16 shows a further decrease in the ground-glass opacities in the upper lobe of the right lung (red arrows); L, sixth CT performed on hospital day 20 shows the size of ground-glass opacities decrease but the density increase (red arrows)

significantly reduced ground-glass opacities, ten patients (Figures 1H,L, 3C,I, 4F,L, 5D,H,L) showed a small amount of patchy ground-glass opacities remained, six patients (Figures 1D,H, 2J-L, 3I, 4F and 5H) showed fibrous-like stripes remained. The pleural effusion observed in two patients was completely resolved (Figures 1H, 3C,F).

7 | PROGNOSIS

As of Mar 3, 2020, four patients with severe COVID-19 pneumonia had been cured and discharged. Clinical cure standard[6] included temperature returning to normal for at least three

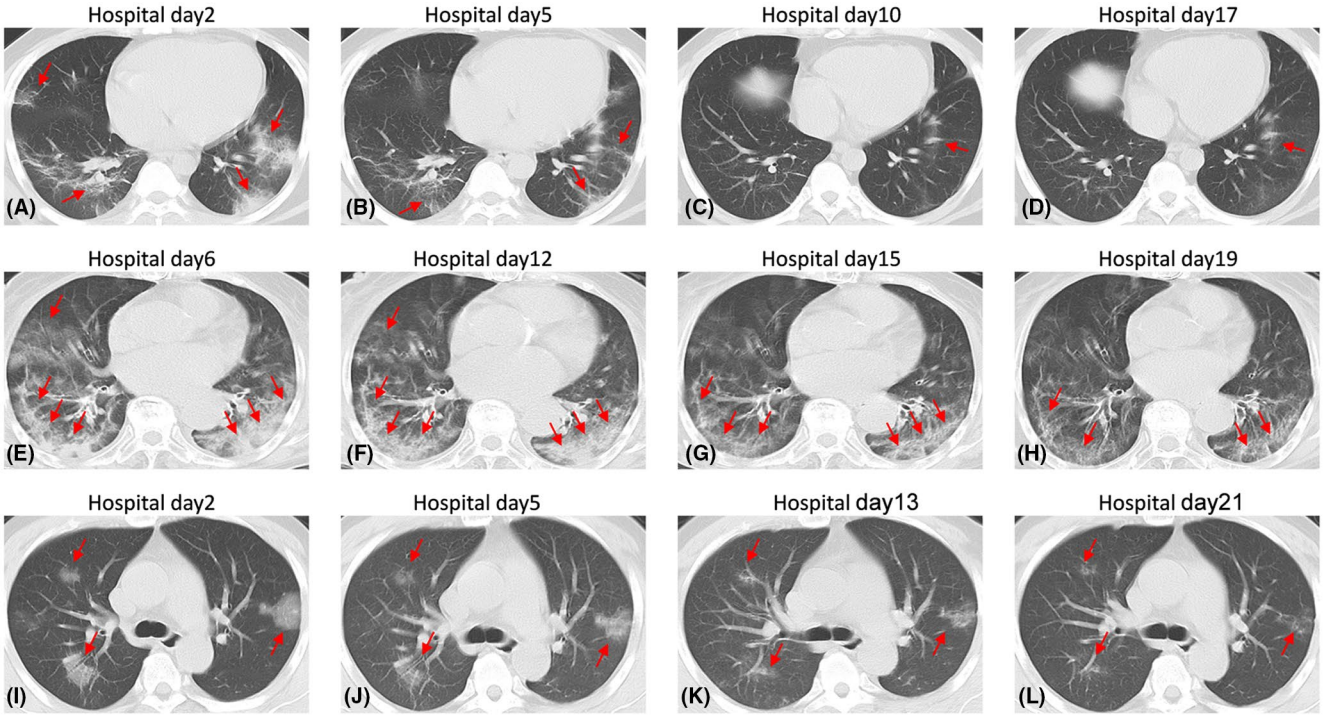

FIGURE 5 A-D, Images from case 9. A, First CT performed on hospital day 2 shows multiple ground-glass opacities and consolidation in the subpleural regions of bilateral lungs (red arrows); B, Second CT performed on hospital day 5 shows a significant decrease in the ground-glass opacities and consolidation in bilateral lungs (red arrows); C, Third CT performed on hospital day 10 shows a further decrease in the ground-glass opacities in bilateral lungs (red arrows); D, Fourth CT performed on hospital day 17 shows no change in the extent of ground-glass opacities in bilateral lungs (red arrows). E-H, Images from case 10. E, First CT performed on hospital day 6 shows multiple ground-glass opacities and consolidation in the subpleural regions of bilateral lungs (red arrows); F, Second CT performed on hospital day 12 shows a decrease in the ground-glass opacities and consolidation in bilateral lungs (red arrows); G, Third CT performed on hospital day 15 shows a significant decrease in the ground-glass opacities and consolidation in bilateral lungs (red arrows); H, Fourth CT performed on hospital day 19 shows a mild decrease in the ground-glass opacities in bilateral lungs (red arrows). I-L, Images from case 11. I, First CT performed on hospital day 2 shows multiple ground-glass opacities in bilateral lungs (red arrows); J, Second CT performed on hospital day 5 shows a decrease in the ground-glass opacities (red arrows); K, Third CT performed on hospital day 13 shows a significant decrease in the ground-glass opacities (red arrows); L, Fourth CT performed on hospital day 21 shows a further decrease in the ground-glass opacities (red arrows)

consecutive days, marked improvement of acute exudative lesions on chest CT imaging and viral clearance in respiratory samples from the upper respiratory tract (two consecutive negative results of COVID-19).

DISCLOSURE

The authors declare that they have no conflict of interest.

RESEARCH INVOLVING HUMAN PARTICIPANTS AND/OR ANIMALS

"All procedures performed in studies involving human participants were in accordance with the ethical standards of the Zhejiang Taizhou hospital research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards." "All applicable international, national, and/or institutional guidelines for the care and use of animals were followed."

INFORMED CONSENT

Written informed consent was obtained from all patients.

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