HRCT chest in COVID-19 pneumonia: correlation between duration of symptoms and CT severity score

Hegazy M.A. Rania, Salah E.L. Din Adel Lamia

Department of Radiology, Faculty of Medicine, Cairo University, Cairo, Egypt

Correspondence to Hegazy M.A. Rania, MD, 24 Youssef Kamel Street, Zamalek, Cairo, Egypt Tel: +20 102 379 0025/+20 965 556 18025; e-mails: raniahegazy@hotmail.com, hegazyrania@gmail.com

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Objective
The aim was to find the correlation between duration of symptoms and computed tomography (CT) severity score in patients with novel coronavirus pneumonia.
Patients and methods
This study was conducted on 108 patients with proven COVID-19 pneumonia.
Results
A total of 108 patients were enrolled in this study with proven diagnosis of COVID-19 infection with 81 positive swabs (75%) and 27 negative swabs (25%). The 27 patients with negative swabs had typical features of fever, laboratory studies consistent with infection, and CT features of bilateral pneumonic changes. The study included 72 (66.7%) men and 36 (33.3%) women, with mean age of 52.1 (age range: 34–81 years) years. Patients were categorized according to the duration of onset of initial symptoms and the date of CT scans: stage 1 (0–4 days, *n*=36); stage 2 (5–9 days, *n*=30); stage 3 (10–14 days, *n*=15); stage 4 (15–21 days, *n*=9); stage 5 (22–28 days, *n*=3); and stage 6 (>28 days, *n*=15). Each stage average CT chest score of severity and average percentages of both lung opacities were shown. The authors found that CT severity score increases, as the duration of initial symptom increases, up to 9 days, from the onset of symptoms. CT score has a second peak at less than or equal to 20-day duration of symptoms and a third peak at more than 28 days, where a plateau is reached. Although patient's clinical condition and oxygen saturation may improve, yet CT changes may persist with a high CT severity score for weeks thereafter.
Conclusion
CT severity score corresponds to the duration of symptoms only in the early stage of disease. In later stages, some patients develop residual lung affection after recovery from acute symptoms, yet lung changes take weeks to resolve, and in some cases, residual chronic changes may persist.

Keywords:
COVID-19, computed tomography severity score, high-resolution computerized tomography, pneumonia

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Introduction

In the early days of December 2019, the first pneumonia cases of a new coronavirus named SARS-CoV-2 were identified in Wuhan, the capital city of Hubei province (China) [1]. The common clinical presentations of COVID-19 are fever (85%), cough (70%), and shortness of breath (43%), but possibly abdominal and other symptoms may occur, as well as the disease being asymptomatic. The severity of illness can differ from mild to critical (Mild: no symptoms, mild cough, and fever; severe: dyspnea, hypoxia, or greater than 50% lung involvement on imaging; and critical: respiratory failure, shock, and multiorgan failure). Since the initial spread of this new illness, known as coronavirus disease 2019 (COVID-19), many patients have been hospitalized with respiratory problems [2,3]. The clinical spectrum is broad, including asymptomatic infection, mild upper respiratory tract disease, and severe interstitial pneumonia with respiratory failure requiring oxygenation support or intubation [4,5].

Computed tomography (CT) is the most sensitive radiological technique for the diagnosis of COVID-19, showing different lung alterations such as ground-glass opacities (GGO), parenchymal consolidations, crazy paving, vascular dilatations, traction bronchiectasis, subpleural bands, and architectural distortion; several radiological patterns are observed at different times throughout the disease course [6,7].

Yet not all changes correspond to the disease severity and duration of symptoms. Some patients may show

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clinical improvement, yet their CT findings remain aggressive with high CT severity score even after the symptoms have subsided [8].

Many cases diagnosed as COVID-19 pneumonia present with oxygen desaturation, and CT is requested for assessment of severity of chest affection to plan for management. This study attempts to find the correlation between duration of symptoms and CT severity score.

Patients and methods

Patients

This is a retrospective study. From March 2020 to June, 2020, 108 patients were enrolled in this study with proven diagnosis of COVID-19 infection through 81 (75%) positive test swab PCR and 27 (25%) negative swab with typical symptoms and were referred to the radiology department for high-resolution CT chest. Their symptoms included fever, shortness of breath, cough, and headache. This study was approved by the local ethics committee. The CT pneumonia analysis was done, and CT score recorded interrelated to the duration of patient's symptoms.

Methods

All CT scans were performed on a VCT GE 128 slice machine (General Electric medical systems, USA) dedicated for COVID-19 cases during the current pandemic to avoid cross-infection of other non-COVID-19-infected patients.

Imaging technique

All patients underwent scanning with 128-MDCT REVOLUTION (GE Healthcare, General Electric, USA). The acquisition parameters were set at 120 kVp; 100–200 mAs; pitch, 0.75–1.5; and collimation, 0.625–5 mm. All imaging data were reconstructed by use of a medium sharp reconstruction algorithm with a slice thickness of 0.625–5 mm. CT images were acquired at full inspiration with the patient in the supine position.

Imaging Interpretation

Two radiologists (20 and 15 years of experience) reviewed chest CT scans blindly and independently. All images were viewed with both lung (width, 1500 HU; level, −700 HU) and mediastinal (width, 350 HU; level, 40 HU) settings. Imaging features were GGO, consolidation, mixed GGO and consolidation, architectural distortion, tree-in-bud, bronchial wall thickening, reticulation, subpleural bands, traction bronchiectasis, lymph node enlargement, vascular enlargement in the lesion, and pleural effusions. A CT score system was used to evaluate the extent of the disease to assess severity. A final score was reached by consensus agreement of the two radiologists reporting, and when results did not match, reassessment was done to achieve consensus. CT severity score was calculated using a 20-point scale depending on the number of lung lobes affected as follows: visual assessment: the severity on CT can be estimated by visual assessment. This is the easiest way to score the severity. The CT images show a 25% involvement by visual assessment. Severity score: lung severity score: the lung severity score is computed to measure the extent of lung involvement across each lobe as described by Bernheim *et al.* [9] For each lobe, the percentage of affected lobe is calculated and scored between 0 and 4, where 0: lobe is not affected, 1: 1–25% of the lobe is affected, 2: 25–50% of the lobe is affected, 3: 50–75% of the lobe is affected, and 4: 75–100% of the lobe is affected. The scores for each of the five lobes are summed up to get the total lung severity score, resulting in a total score range from 0–20, where 0 indicates that none of the lobes are involved and 20 indicates that all five lobes are severely affected (Fig. 1b–4b). Patients were categorized according to the duration of onset of initial symptoms and the date of CT scans: stage 1 (0–4 days, *n*=); stage 2 (5–9 days, *n*=30); stage 3 (10–14 days, *n*=15); stage 4 (15–21 days, *n*=9); stage 5 (22–28 days, *n*=3); and stage 6 (>28 days, *n*=15) [10].

Table 1 Male/female and positive/negative swab distribution

	n (%)
Males	72 (66.7)
Females	36 (33.3)
Positive swab	81 (75)
Negative swab	27 (25)

Results

A total of 108 patients were enrolled in this study with proven diagnosis of COVID-19 infection with

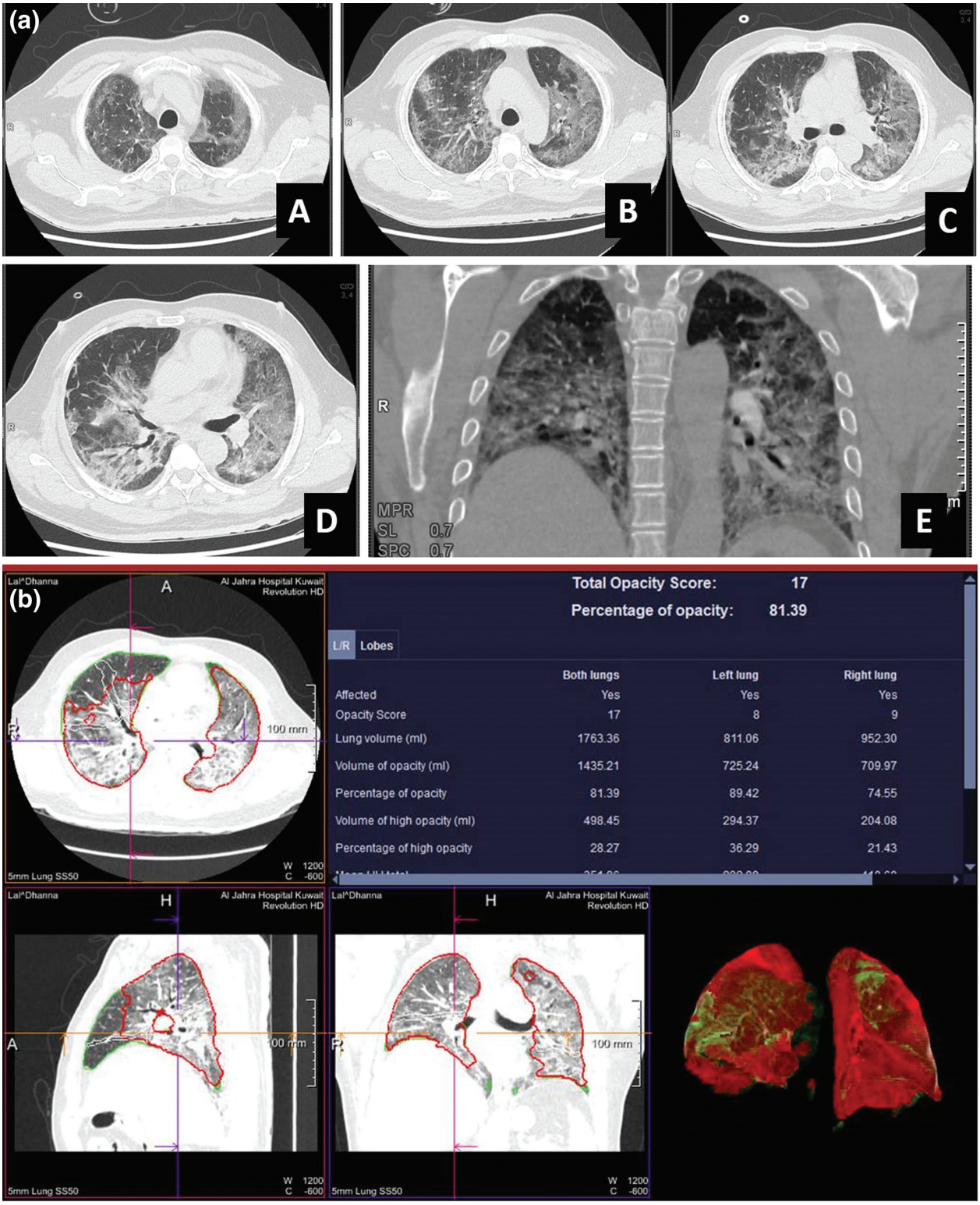
Table 2 Number of patients in each stage of disease duration with their average CT score of severity and average percentage of both lung opacities

Stage	*n* (%)	Average score	Average percentage of both lungs opacities
Stage 1 (1–4 days)	36 (33.3)	Average 8.8/20	Average 30.8%
Stage 2 (5–9 days)	30 (27.8)	Average 13.2/20	Average 49.8%
Stage 3 (10–14 days)	15 (13.9)	Average 8.6/20	Average 28%
Stage 4 (15–21 days)	9 (8.3)	Average 11.7/20	Average 49.2%
Stage 5 (22–28 days)	3 (2.8)	Average 2/20	Average 0.13%
Stage 6 (>28 days)	15 (13.9)	Average 14.6/20	Average 61.7%

CT, computed tomography.

81 positive swabs (75%) and 27 negative swabs (25%). The 27 patients with negative swab had typical features of fever, laboratory studies consistent with infection, and CT features of bilateral pneumonic changes. The patients included 72 men (66.7%) and 36 women (33.3%) with mean age of 52.1 years, as seen in Table 1. Patients were categorized according to the duration of onset of

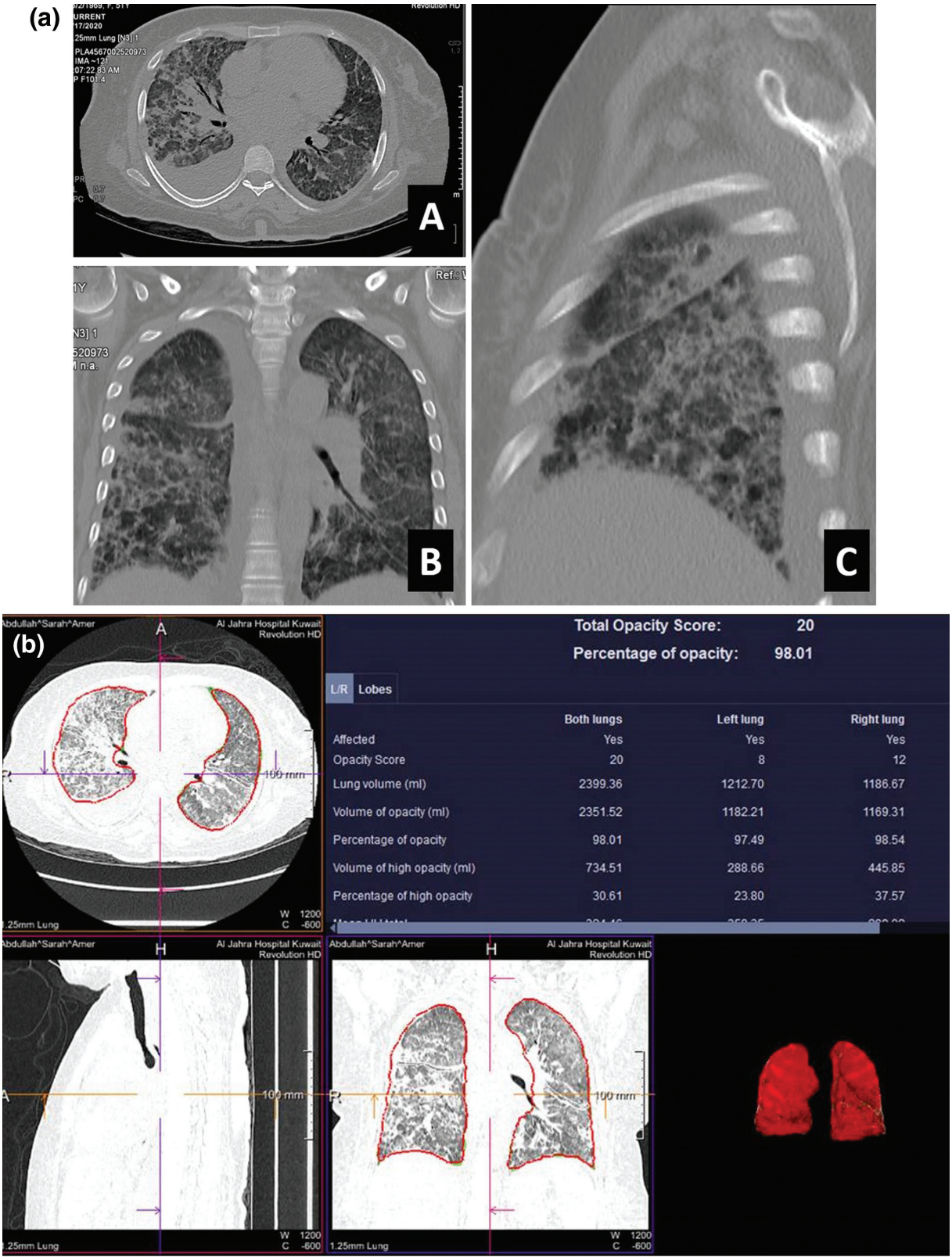
Figure 1



(a): High-resolution computerized tomography chest of a 56-year-old male patient with positive RT-PCR swab was hospitalized for 22 days, and then discharged, but developed hypoxia 75% on room air. (a–e) Typical bilateral peripheral GGO, predominantly basal with basal fibrosis and traction bronchiectasis. CT severity score 17. (b) The same patient as (Fig. 1a) showing CT pneumonia analysis. CT severity score 17. CT, computed tomography; GGO, ground-glass opacities.

initial symptoms and the date of CT scans: stage 1 (0–4 days, *n*=36); stage 2 (5–9 days, *n*=30); stage 3 (10–14 days, *n*=15); stage 4 (15–21 days, *n*=9); stage 5 (22–28 days, *n*=3); and stage 6 (>28 days, *n*=15). Each stage average CT chest score of severity and average percentages of both lung opacities are shown in Table 2. Results show that CT severity score increases as the duration of initial symptom

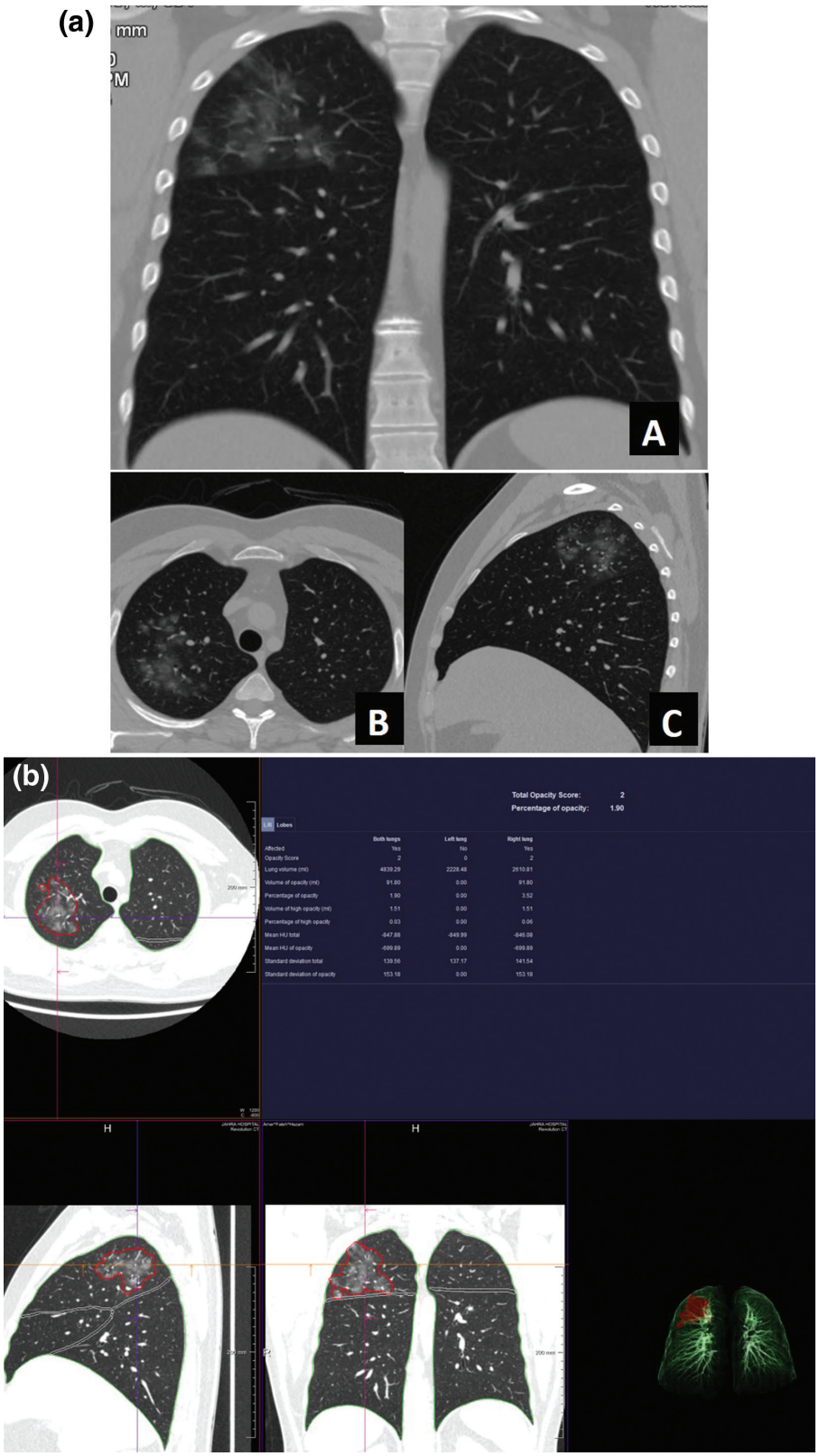
Figure 2



(a) High-resolution computerized tomography chest of a 57-year-old female patient with post-COVID-19 shortness of breath with extensive lung affection. CT severity score 20. (b) The same patient as (Fig. 2a) showing CT pneumonia analysis. CT severity score 20. CT, computed tomography.

increases, up to 9 days, from the onset of symptoms. The longer the duration of the initial symptom was, the more pneumonia infiltration and expansion will occur, and the more consolidation changes will occur up to 9 days from the initial symptoms. We found that CT score has a second peak at less than or equal

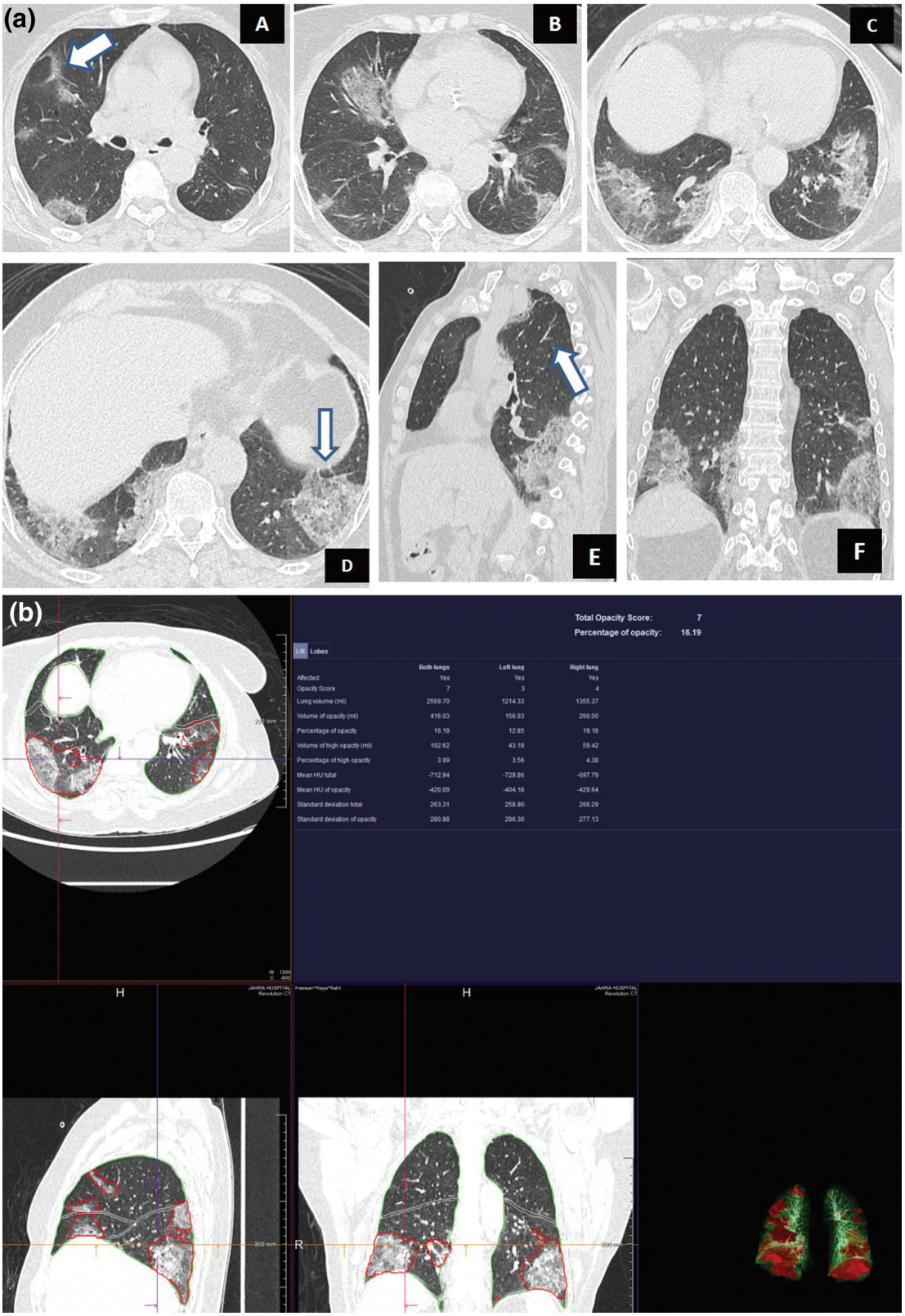
Figure 3



(a) High-resolution computerized tomography chest of a 35-year-old male patient with positive RT-PCR swab, 2 days since onset of symptoms. (a–c) Peripheral right apical GGO only. Early stage. (b) The same patient as (Fig. 3a) showing CT pneumonia analysis. CT severity score 2. Only a single lobe is affected by GGO less than 50%. CT, computed tomography; GGO, ground-glass opacities.

to 20-day duration of symptoms and a third peak at greater than 28 days where a plateau is reached. Although patient's clinical condition and oxygen saturation may improve, yet CT changes may persist with a high CT severity score for weeks thereafter.

Figure 4



(a) High-resolution computerized tomography chest of a 76-year-old female patient, 30 days since onset of symptoms. (a–e) Typical bilateral peripheral GGO, interlobular septal thickening and halo sign (arrows). Organizing pneumonia pattern, resorption stage. (b) The same patient as Fig. 4a showing CT pneumonia analysis. CT severity score 7. Resorption stage. CT, computed tomography; GGO, ground-glass opacities.

Discussion

Applying CT examination to the COVID-19-infected patients or suspected patients is an effective way to evaluate patient's condition. The PCR test is very specific but has a lower sensitivity of 65–95%, meaning even if the test can be negative, the patient is infected. Another difficulty is, the waiting for about a full day for the test results, whereas CT results are instantaneous combined with common laboratory findings such as decreased lymphocyte count, increased CRP, and C-reactive protein levels can be more helpful [11,12].

In our study, the CT score showed that the overall pulmonary inflammatory lesions increased after the duration of initial symptom increased, up to 9 days, and CT scores were higher in the group of initial symptom duration less than or equal to 9 days. The longer the duration of the initial symptom was, the more pneumonia infiltration and expansion will occur, and the more consolidation changes will occur up to 9 days from the initial symptoms. We found that CT score has a second peak at less than or equal to 20-day duration of symptoms and a third peak at more than 28 days where a plateau is reached. Although patient clinical condition and oxygen saturation may improve, yet CT changes may persist with a high CT severity score for weeks thereafter (Fig. 1). Our results are similar to those found by Lin *et al.* [13] who stated that the duration of the initial symptom was found to be positively correlated with the CT score of pulmonary lesions and the length of the largest inflammatory lesions in the lungs. The longer the duration of the initial symptom was, the higher the CT score was, and the more serious the CT manifestations of pulmonary lesions were, the larger the lesions were. In another study by Pan *et al.* [14] chest CT scans of the patients were re-examined after 3–14 days. It was found that, as the disease progressed, the range of ground-glass density patches and consolidation increased. On the contrary, in a study by Ding and colleagues, semiquantitative CT scoring could reflect the severity of different stages of this disease. The total CT scores of the bilateral lungs were lowest at stage 1 compared with other stages, but there was no significant difference among other stages, indicating that the disease changed rapidly within 10 days after the onset of the initial symptom, and then tended to be stable and lasted for a long time [15]. We found that CT severity score corresponds to the duration of symptoms in the early stage of disease. In later stages, some patients develop residual lung affection after recovery from acute symptoms, yet lung changes take weeks to resolve, and in some cases, residual chronic changes may persist (Figs 1–4).

Limitations

Our study has some limitations, such as limited number of patients, considering a pandemic, Second, we did not evaluate follow-up CT findings in our study. Exploring the CT changes and comparing them with the clinical parameters may help us monitor and predict outcome, and support clinical decision making.

Conclusion

CT severity score corresponds to the duration of symptoms in the early stage of disease. In later stages, some patients develop residual lung affection after recovery from acute symptoms, yet lung changes take weeks to resolve, and in some cases, residual chronic changes may persist.

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Conflicts of interest

There are no conflicts of interest.

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