

A Comparative Study of Chest Computed Tomography Features in Young and Older Adults With Corona Virus Disease (COVID-19)

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Objective: To analyze the most common computed tomography (CT) findings of pneumonia caused by new coronavirus in younger patients (60 and younger) and older adults (older than 60).

Materials and Methods: The chest CT images of 72 symptomatic patients with corona virus disease (COVID-19) were analyzed retrospectively, including 44 younger patients (47.5 ± 8.7 y old) and 28 older patients (68.4 ± 6.0 y old). CT findings including density (pure ground-glass opacities, ground-glass opacities with consolidation, consolidation), the number of lobes involved, lesion distribution, and the main accompanying signs were analyzed and compared.

Results: Characteristic CT findings included the lobes of bilateral lung extensively involved, ground-glass opacity and ground-glass opacity with consolidation in the peripheral area, sometimes accompanied by interlobular septal thickening, and subpleural line and pleural thickening. Compared with the younger group, the proportion of extensive involvement of lung lobes was higher in the elderly group (71.4% vs. 36.4%, $P=0.009$), and subpleural line and pleural thickening were more likely to occur (50.0% vs. 25.0%, and 71.4% vs. 40.9%, $P=0.030$ and 0.011 , respectively).

Conclusion: Elderly and younger patients with corona virus disease have some common CT features, but older patients are more likely to have extensive lung lobe involvement, and subpleural line and pleural thickening. These differentiated characteristics may be related to the progress and prognosis of the disease.

Key Words: corona virus disease, pneumonia, computed tomography (*J Thorac Imaging* 2020;35:W97–W101)

In December 2019, an unexplained pneumonia broke out in Wuhan City, Hubei Province of China. The causative agent is a novel coronavirus. The International Committee on Taxonomy of Viruses announced that the official classification of the 2019 Novel Coronavirus is severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) on February 11,

2020.¹ On the same day, the disease caused by the virus was officially named corona virus disease (COVID-19) by the World Health Organization.² The presumptive modes of transmission of the disease are close person-to-person contacts via droplets and fomites.³ Since the discovery of the pneumonia for more than a month, COVID-19 has spread widely in China and even other countries.

An initial prospective analysis of the clinical features of 41 patients in Wuhan with laboratory-confirmed COVID-19 demonstrated that all the patients had abnormal findings on chest computed tomography (CT).⁴ Chest CT is recommended as one of the main diagnostic criteria.⁵ At present, SARS-CoV-2 infection can be seen in young individuals to octogenarians. Preliminary data show that the mortality rate of COVID-19 is about 1.36%.⁶ All individuals are generally susceptible, but the elderly are more likely to develop severe infection or even die.⁷ Therefore, in this article, we retrospectively analyzed the CT characteristics of cases with COVID-19 in our hospital, and compared the CT imaging manifestations of patients aged 60 years and younger with patients older than 60 years to determine the common and differentiated details between them. This will allow for disease recognition and response to this communicable disease.

MATERIALS AND METHODS

This study was approved by the institutional review board. The ethics committee of our institute waived the informed consent for this retrospective study. Anonymous data were collected and analyzed to facilitate better clinical decisions.

Patients and Chest CT

A retrospective study was carried out in 72 patients with COVID-19 in our hospital. The enrollment period began from January 18, 2020, and ended on February 3, 2020. All patients were positive for SARS-CoV-2 nucleic acid antibody via laboratory testing of respiratory secretions obtained by nasopharyngeal or oropharyngeal swab. In all, 42 men and 30 women were studied (age range: 30 to 83 y, mean age: 55.6 ± 12.8 y). Seventy-two patients were divided into 2 groups: (1) age 60 years and younger group, 44 patients, including 26 men and 18 women, age range 30 to 58 years, mean age 47.5 ± 8.7 years; (2) age older than 60 years group, 28 patients, including 16 men and 12 women, age range 61–83 years, mean age 68.4 ± 6.0 years. The clinical data were reviewed from the electronic medical records. The chief complaints, symptoms of the disease, and the time interval (in days) from disease onset to CT examination were recorded.

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The authors declare no conflicts of interest.

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All the patients underwent a thin-section CT scan. The CT protocol was as follows: 80 to 120 kV; default 130 mAs, use of the mA automatic modulation function; pitch 0.9125; collimation 0.625 mm; rotation time 0.5 seconds; section thickness 5 mm; layer spacing 5 mm; and use of the reconstruction algorithm of the lung window to reconstruct a thin-layer thickness of 1 mm. All patients were scanned in the supine position and held their breath.

CT Review

All CT images were reviewed by 2 radiologists with 5 to 10 years of experience in chest diagnosis. Imaging was reviewed independently and a final decision was reached by consensus. The following characteristics were evaluated: (1) number of lobes involved: the lingual segment of the upper lobe of the left lung as an independent lobe; the minimum involved scope was recorded as 1 (single lobe involved) and the maximum as 6 (all lobes involved). (2) Lesion distribution: peripheral areas, central areas, and peripheral and central areas (division by 3 cm under pleura).⁸ (3) Lesion density (presence of pure ground-glass opacities, ground-glass opacities with consolidation, consolidation). (4) Interstitial changes (presence of reticular and/or interlobular septal thickening, subpleural line). (5) Accompanying signs (presence of vacuolar sign, air bronchogram, vascular enlargement). (6) Pleural reactions (presence of pleural thickening, pleural traction, and pleural effusion).

Statistical Analysis

All data were statistically analyzed using the SPSS 20.0 software package. The continuous variables were expressed as mean \pm SD. The classification variables were expressed by case number (n) and percentage (%). The comparison of the disease course distribution between the 2 groups was performed using the Mann-Whitney *U* test, and the Pearson χ^2 or Fisher test was used for the comparison of other discrete variables. All analyses were considered statistically significant at *P*-values <0.05.

RESULTS

Clinical Features

Among the 72 patients, 42 (58.3%) were men and 30 (41.7%) were women, with slightly more men than women. All 72 patients had clinical symptoms. The most common symptoms were fever (59/72, 81.9%) and cough (28/72, 38.9%). Other chief symptoms included fatigue (20/72, 27.8%), dyspnea or shortness of breath (16/72, 22.2%), and abdominal pain or diarrhea (9/72, 12.5%). The rate of symptoms of the digestive tract was slightly higher in the elderly group than that in the young group. However, there was no significant difference between the 2 groups in the incidence of these major clinical symptoms (Table 1). There was no significant difference in the distribution of time intervals from disease onset to CT examination between the elderly group and the young group (*P*=0.297) (Table 1).

CT Imaging Findings

For 72 COVID-19 patients, 59 patients (81.9%) demonstrated ground-glass opacity with consolidation (Table 2, Figs. 1–4). Pure ground-glass opacity appeared in 44 cases (61.1%) (Figs. 1, 2), and 16 of 72 cases (22.2%) demonstrated consolidation. Reticular and/or interlobular septal thickening were observed in 44 patients (61.1%) (Fig. 5), and subpleural line was also more common (25/72, 34.7%) (Figs. 2, 6A). Pleural reactions such as pleural thickening (38/72, 52.8%) (Fig. 6B) and pleural traction (43/72, 59.7%) but pleural were

TABLE 1. Clinical Characteristics of Elderly and Young Groups With COVID-19

Clinical Characteristics	n (%)		<i>P</i>
	Young Group (Aged \leq 60) (44 Cases)	Elderly Group (> 60 y Old) (28 Cases)	
Male	26 (59.1)	16 (57.1)	0.870
Chief complaint			
Fever	35 (79.5)	24 (85.7)	0.507
Cough	15 (34.1)	13 (46.4)	0.295
Fatigue	11 (25.0)	9 (32.1)	0.509
Dyspnea	8 (18.2)	8 (28.6)	0.301
Abdominal pain or diarrhea	3 (6.8)	6 (21.4)	0.140
Time interval (from disease onset to CT)			0.297
\leq 3 d	19 (43.2)	8 (28.6)	—
> 3 d, \leq 7 d	12 (27.3)	10 (35.7)	—
> 7 d	13 (29.5)	10 (35.7)	—

common. Only 5 patients (6.9%) presented a small pleural effusion. Vacuolar sign, air bronchogram, and vascular enlargement were often observed as accompanying signs (Figs. 1B, 4). Compared with the young group, the incidence of subpleural line was higher in the elderly group (50.0% and 25.0%, *P*=0.030), and pleural thickness was more common (71.4% and 40.9%, *P*=0.011).

There were 35/72 (48.6%) patients with lesions that involved all lobes, and extensive lung involvement was the most common (Figs. 1, 2, 5). For young patients, the incidence only one lobe (10/72, 22.7%) was extensive involvement. Among the 10 patients, the right lower lobe was involved in 7 cases, the right upper lobe was involved in 1 case, the right middle lobe was involved in 1 case, and the left tongue segment was involved in 1 case. Single-lobe

TABLE 2. Opacification Patterns of Elderly and Young Groups With COVID-19

Opacification Patterns	n (%)		<i>P</i>
	Young Group (Aged \leq 60) (44 Cases)	Elderly Group (> 60 y Old) (28 Cases)	
Density			
Pure ground-glass	21 (47.7)	15 (53.6)	0.629
Ground-glass opacity with consolidation	34 (77.3)	25 (89.3)	0.196
Consolidation	10 (22.7)	6 (21.4)	0.897
Interstitial change			
Reticular pattern or honeycombing	24 (54.5)	20 (71.4)	0.152
Subpleural line	11 (25.0)	14 (50.0)	0.030
Pleural reaction			
Pleural thickening	18 (40.9)	20 (71.4)	0.011
Pleural traction	24 (54.5)	19 (67.9)	0.262
Pleural effusion	3 (6.8)	2 (7.1)	—
Other findings			
Vacuolar sign	21 (47.7)	15 (53.6)	0.629
Air bronchogram	30 (68.2)	18 (64.3)	0.732
Vascular enlargement	20 (45.5)	13 (46.4)	0.936

Bold values indicate significant differences between young group and elderly group.

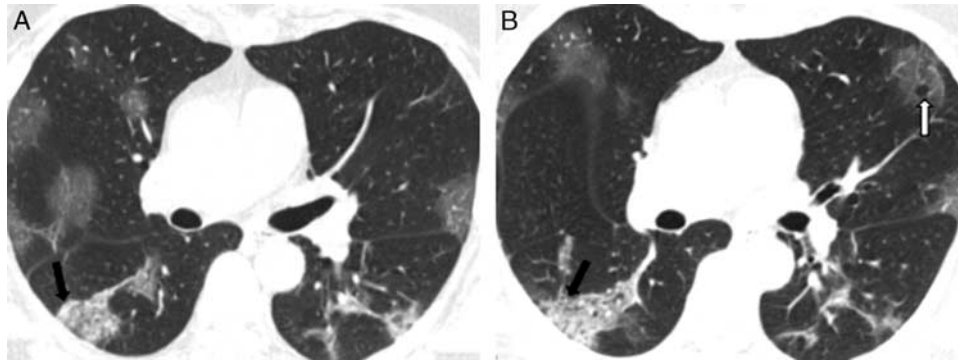


FIGURE 1. A 57-year-old woman who presented with fever for 4 days. A, CT shows multiple ground-glass opacities (GGO) distributed in the peripheral area and GGO with consolidation in the lower lobes (arrow). B, GGO with vacuolar sign in the upper tongue segment of the left lung (white arrow) and GGO with interlobular septal thickening in the right inferior lobe (black arrow).

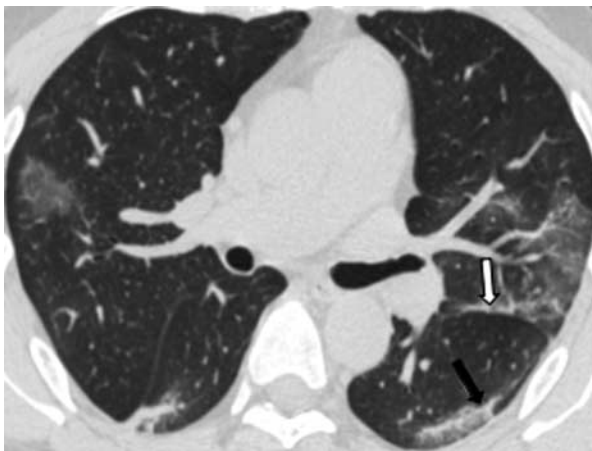


FIGURE 2. A 57-year-old man who presented with fever and fatigue for 7 days. CT scan shows GGO with streak consolidation (white arrow) and subpleural line in the lower left lung (black arrow).

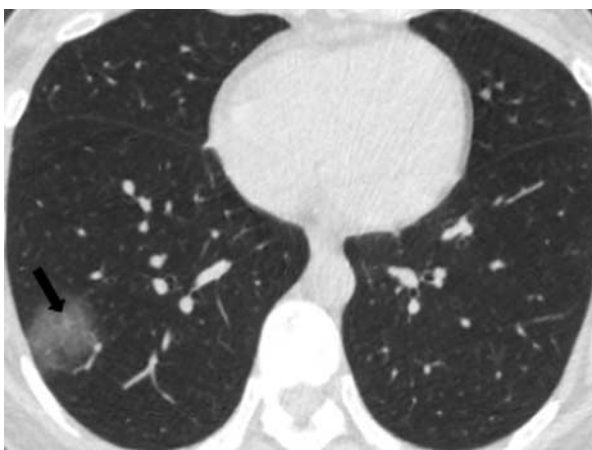


FIGURE 3. A 43-year-old woman who presented with dry cough for 2 days. CT scan shows a rounded, peripheral GGO with slight consolidation in the right lower lobe (arrow).

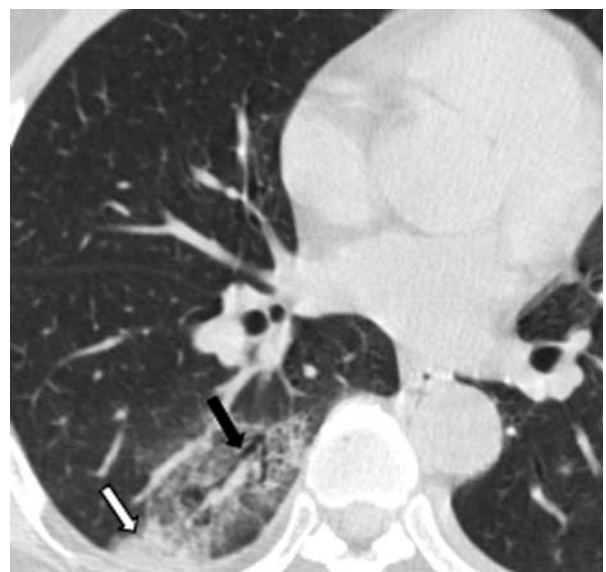


FIGURE 4. A 41-year-old man who presented with fever for 3 days. CT shows GGO with consolidation (white arrow) in the right lower lobe, accompanied by air bronchogram (black arrow).

involvement was most likely in the right inferior lobe in the younger group. In the 72 cases, 51 (70.8%) patients showed a peripheral distribution of disease and 19 (26.4%) patients had disease affecting both the peripheral area and the central area. In the younger group, in one case, only the central area was affected. In the older group, no lesion was only located in the central area of the pulmonary lobes, and lesions showed diffuse involvement of whole lungs in one case. There was no significant difference in the distribution of lesions between the 2 groups (Table 3).

DISCUSSION

The novel coronavirus pneumonia is a severe acute respiratory syndrome whose pathogen has not been previously discovered in humans. It is highly contagious and involves fever, cough, fatigue, and other symptoms at the beginning of infection. In severe cases, dyspnea, respiratory distress, or septic shock may occur, develop into severe disease, or even



FIGURE 5. A 61-year-old man who presented with fever and cough for 12 days. CT scan shows GGO distributed around the periphery with a reticular pattern or honeycombing changes (arrows).

result in death.⁴ Chest CT is a key component of the diagnostic workup for suspected infection patients. In the COVID-19 diagnosis and treatment quick advice guide issued on January 30, 2020,⁵ the typical CT manifestations of COVID-19 are as follows: (1) multiple ground-glass opacities with patch, subsegment, or segmental bilateral involvement, and opacities can be accompanied by reticulation or “crazy paving” changes. (2) Multiple variegated or large-flake honeycomb-shaped interlobular and lower lobes. This type of change is common in the elderly or critically ill patients.

Our investigation has shown that most (81.9%) of the patients had ground-glass opacities with consolidation. The probability of pure ground-glass opacity was slightly lower than that of ground-glass opacity with consolidation. However, pure pulmonary consolidation was seldom seen, possibly due to the fact that the pure ground-glass opacity was mostly present in the early stage of the disease, and the proportion of early-stage (course of disease ≤ 3 d) patients (27/37.5%) in our group was slightly low. The early stage of viral pneumonia involves interstitial alveolar wall inflammation, that is, the alveolar interval contains various degrees of infiltrates of inflammatory cells, but no collagen tissue forms interstitial fibrosis. Proliferation of protein and cells occurs in the alveolar cavity, but the tissue structure inside the alveoli is intact.^{9,10} On the CT, the

TABLE 3. Opacification Distribution in Elderly and Young Groups With COVID-19

Distribution (%)	n (%)		P
	Young Group (Aged ≤ 60) (44 Cases)	Elderly Group (> 60 y Old) (28 Cases)	
Single lobe	10 (22.7)	2 (7.1)	0.084
2 lobes	5 (11.4)	0	—
3 lobes	6 (13.6)	2 (7.1)	—
4 lobes	4 (9.1)	2 (7.1)	—
5 lobes	3 (6.8%)	3 (10.7%)	—
Whole lung	16 (36.4)	19 (67.9)	0.009
Peripheral	34 (77.3)	17 (60.7)	0.132
Peripheral+Center	9 (20.5)	10 (35.7)	0.152
Center distribution	1 (27.3)	0 (28.6)	—

Bold values indicate significant differences between young group and elderly group.

ground-glass opacity was observed. With the decrease of inflammatory cells, fibroblasts and collagen fibers grew, and the alveolar wall was obviously thickened. Therefore, reticular and/or interlobular septal thickening were observed within the ground-glass opacity.¹¹ As the disease progressed, a large number of cell-rich exudates and fibroblasts and collagen fibers accumulated in the alveolar cavity, and the edema was aggravated.¹² As a result, the ground-glass opacities gradually solidified, and the CT signs of reticular and/or interlobular septal thickening were more obvious. In addition, the air bronchogram could be delineated. Vacuolation signs may occur when the remaining pulmonary tissue or partial obstruction within the lesion results in focal bronchiectasis and alveolar enlargement.¹³ In this group of cases, the presence of ground-glass opacity with consolidation, with reticular and/or interlobular septal thickening, air bronchogram, and vacuolation, were observed, which may be related to the pathological basis.

In this study, there was no significant difference in the distribution of time intervals from disease onset to CT examination between the elderly group and the young group. The interference of different imaging manifestations caused by the course of disease was excluded. However, for the elderly patients, the ratio of subpleural line and pleural thickness was higher than that in the young patients. It was generally believed that subpleural the formation of alveolar atrophy caused by surrounding bronchitis and pulmonary fibrosis,¹² suggesting

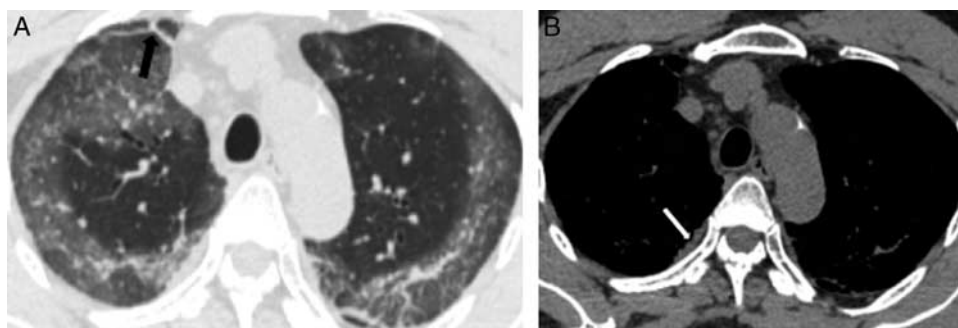


FIGURE 6. A 67-year-old man who presented with fever for 6 days. A, CT shows GGO with streak consolidation distributed in the peripheral area and subpleural line in the right upper lobe (arrow). B, Mediastinal window shows right thickening of the right pleura (arrow).

pulmonary fibrosis. Due to the deterioration of lung structure and function and the low immune function of the body,¹⁴ lung compliance was reduced, and discoid atelectasis or edge fusion of honeycomb were more likely. Pleural thickening was mainly caused by the direct spread of the lesion, lymphatic reflux, and pleural inflammation. This may indicate that the elderly patients show a more severe inflammatory response. At the same time, in the elderly patients, whole lung lobes were more likely to be involved. This may indicate that in the same disease course, disease progression in elderly patients was faster than that in the young patients.

Extensive lung lobe involvement was the most common form of COVID-19. However, the single-lobe involvement rate in the young group was second only to this pattern. Most of them were located in the right lower lobe. Therefore, corona virus pneumonia cannot be excluded according to single-lobe involvement on CT images in clinical workup. In this study, 51 of the 72 patients (70.8%) had a peripheral distribution of lesions, possibly due to the involvement of viral pneumonia in the end-stage bronchiole and respiratory bronchiole surrounding parenchyma.

In conclusion, the most common characteristics of COVID-19 on CT images are ground-glass opacity with consolidation, pure ground-glass opacity, with a peripheral distribution, and widespread involvement of all lobes, usually accompanied by reticular and/or interlobular septal thickening. The elderly patients are more likely to have extensive lung lobe involvement, interstitial changes, and pleural thickening. These differentiated characteristics may be related to the progress and prognosis of disease. However, chest CT imaging studies of COVID-19 are preliminary, and unknown aspects need to be further researched.

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