Comparison of initial thin-section CT features in coronavirus disease 2019 pneumonia and other community-acquired pneumonia

Qiao Zhu
  Peking University Third Hospital
Cui Ren
  Peking University Third Hospital
Xiao Hua Wang (✉ medwxh@126.com)
  https://orcid.org/0000-0001-9767-8886

Research article

Abstract

Background

Coronavirus disease 2019 (COVID-19) pneumonia caused similar symptoms to other community-acquired pneumonia (CAP). It is important to early quarantine suspected patients with COVID-19 pneumonia from patients with other CAP to reduce cross infection. The purpose of the study is to review and compare initial thin-section computed tomography (CT) features in patients with coronavirus disease 2019 (COVID-19) pneumonia and other community-acquired pneumonia (CAP).

Methods

24 cases of COVID-19 pneumonia (14 males and 10 females; age range, 14-87 years; mean age, 48.0 years) and 28 cases of CAP caused by other pathogens (13 males and 15 females; age range, 24-85 years; mean age, 49.5 years) were included. Thin-section CT features of the lungs for all patients were retrospectively reviewed by two independent radiologists.

Results

There were no significant differences for the shape of main lesions, pure ground glass attenuation (GGA), mixed GGA with consolidation, air bronchogram, linear opacities, halo sign/reversed halo sign, cavitation and lymphadenopathy between the group of COVID-19 pneumonia and the group of other CAP. However, the frequency of crazy-paving appearance, vessel dilatation, bilaterally involvement and peripherally distribution were significantly higher in patients with COVID-19 compared with other CAP (p =0.031, p =0.000, p =0.029 and p =0.009, respectively). Conversely, the frequencies of pure consolidation, tree-in-bud sign and pleural effusion were significantly higher in patients with CAP than in patients with COVID-19 pneumonia (p =0.002, p =0.000 and p =0.048, respectively).

Conclusion

There are considerable overlaps in thin-section CT features between COVID-19 pneumonia and other CAP. However, the presence of crazy paving pattern, vessel dilation, bilateral involvement and peripheral distribution contributes to the diagnosis of COVID-19 pneumonia. While the presence of pure consolidation tree-in-bud sign, pleural effusion can be assisting in exclusive the diagnosis of COVID-19 pneumonia.

Background

In the last December of 2019, a novel coronavirus, named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV−2), emerged in Wuhan, Hubei province, China [1, 2]. It has raised world concern as it spread across the mainland of China and other countries around the world within several months. World Health Organization (WHO) named the disease caused by SARS-CoV−2 as Coronavirus Disease 2019 (COVID−19) on February 12, 2020[3]. As of March 12, 2020, a total of 80981 confirmed cases in

China and 44279 confirmed cases in 117 countries outside China was reported[4]. Common presenting symptoms of COVID−19 pneumonia include fever, cough, fatigue, dyspnea, and diarrhea [5]. The real-time fluorescence polymerase chain test of SARS-CoV2 RNA is regarded as the reference standard to make a definite diagnosis of COVID−19 infection [6]. However, nucleic acid testing has some defects, such as time lag, shortage of supply, and high false negative rate [7]. CT has become an effective modality for the diagnosis and management of patients with COVID−19 pneumonia. There are several studies described the radiological features of COVID−19 pneumonia. Multifocal areas of GGA and/or patches of consolidation with bilateral, subpleural, and lower lung zonal preponderance were reported as the common chest CT features of COVID−19 pneumonia [8, 9, 10].

The newly onset lower respiratory syndromes with new lung infiltrate on chest radiograph, especially when supported by laboratory findings and compatible physical examinations, is considered indicative for diagnosing community-acquired pneumonia (CAP) [11]. The clinical and radiological manifestations of COVID−19 may have some overlap with the manifestations of CAP caused by other pathogens, such as Influenza-A viral, Mycoplasma pneumoniae and Chlamydia pneumoniae and Streptococcus pneumoniae [12]. It is very important to early quarantine suspected patients with COVID−19 pneumonia from patients with other CAP to reduce cross infection. However, there are few reports of the comparison of CT features between the COVID−19 pneumonia and CAP caused by other pathogens. In our present study, we compared the pulmonary thin-section CT features of patients with COVID−19 pneumonia to those with other CAP.

Methods

1.patient populations

24 consecutive adult patients with COVID−19 pneumonia and 28 consecutive adult patients with CAP caused by other pathogens at our institution between January 17th 2020 and February 28th 2020 were enrolled in our study. The diagnosis of COVID−19 was determined by positive real-time fluorescence polymerase chain reaction of the patient's respiratory specimen for COVID−19 nucleic acid. Of the 24 patients, the chest thin-section CT scans were obtained on the same day when the initial throat swab test was performed. 28 patients with other community-acquired pneumonia (CAP) met the criteria of new symptoms of lower respiratory tract infection and new exudative lesions in chest CT, excluding patients with immunodeficiency, important organ transplantation, hormone therapy for more than 2 weeks and lung cancer. 23 cases of pathogens were detected by sputum culture, pharyngeal swab, blood culture, serum antibody testing and other etiological examination, including Mycoplasma pneumoniae (n = 11), influenza virus (n = 5), Klebsiella pneumonia (n = 2), Streptococcus pneumonia (n = 3), Staphylococcus aureus (n = 2). All the patients were excluded from the diagnosis of COVID−19 by twice negative RT-PCR test for COVID−19. Clinical, epidemiological and laboratory characteristics of the 52 patients were collected.

2. CT examinations

Thin-section CT scans were performed with multi-detector CT scanners (SOMATOM Definition AS, Siemens Healthineers, Germany; Discovery CT750 HD, GE Medical Systems, American; UCT 780 scanner, United Imaging, China). Thin-section CT images were obtained in a supine position during a breath hold at full inspiration. The scan range was from the lung apex to the top of the diaphragm. CT scans were performed with the following parameters: tube voltage, 120keV, tube current, 100−200mAs; pitch, 0.984~1.200; matrix, 512×512; FOV 350 mm×350 mm. The images were reconstructed into 0.625mm, 0.5mm and 1mm slice thickness, with an interval of 0.625mm, 0.5mm and 1mm for GE, United Imaging and Siemens images, respectively. Images were read and captured at lung window setting (window width, 1200−1600 HU; window lever 500 to 700 HU) and mediastinum setting (window width 350−400HU, window level, 20−40HU).

3. Interpretation of images

The CT images were interpreted independently in random order by two radiologists (with 5 years and 20 years' experience in chest CT imaging, respectively) who were unaware of the underlying diagnoses. The final decision was reached by consensus when an evaluation differed.

CT images were analyzed for the following presented radiological findings: (1) density of lesions: pure ground-glass attenuation (GGA), pure consolidation, mixed GGA and consolidation. GGA was defined as a hazy area showing increased attenuation without obscuring the underlying vascular markings. Consolidation was defined as parenchymal opacification that obscured the underlying vessels [13, 14]. (2) shape of lesions: the shape of main parenchymal abnormality (GGA and consolidation) in each patient was classified as patches with long axis parallel to pleural, patches with long axis parallel to the bronchovascular, and nodules with round morphology. (3) other findings: crazy-paving appearance, vascular dilatation within the lesions, tree-in-bud pattern, linear opacity, cavitation, halo sign/reversed halo sign, pleural effusion and mediastinal or hilar lymph node(s) enlargement. Crazy-paving appearance was characterized by a network of thickened interlobular or intralobular interstitial superimposed on a background of GGA [15]. Tree-in-bud pattern was used to describe the appearance of the constellation of small centrilobular nodules and concomitant branching opacities [16]. Linear opacity referred to intralobular septal line and parenchymal bands. Cavitation defined as a low-attenuation area within pulmonary consolidation [13]. Halo sign was defined as a CT finding of GGA surrounding a nodule or mass, and reversed halo sign was characterized by a focal GGA surrounded by a ring of consolidation [17,18]. Mediastinal and hilar lymphadenopathy were defined as lymph node with a short axis dimension of 10mm.

In addition, the distribution patterns of parenchymal abnormality were also analyzed. We recorded whether the main parenchymal lesions locate bilaterally or unilaterally. The cross-sectional distribution of each patient was classified as central, peripheral, or randomly distribution. The disease was classified as central distribution if the main lesions were predominantly located within the inner third of the lung, peripheral distribution if they were predominantly located within the outer third of the lung, and randomly distribution if the lesions presented with no predominant distribution. The zonal involvement was

classified as upper, middle, and lower zone by the following three lung levels: the upper zone was defined as lung field above the tracheal carina, the middle zone between the carina and inferior pulmonary vein, and the lower zone below the inferior pulmonary vein.

4. Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics Software (version 25; IBM, New York, USA). Quantitative data were expressed as mean ± standard deviation (minimum-maximum). Counting data were expressed as the count (percentage of the total). The mean ages, the mean days of CT scan after symptoms onset, the white blood cell counts and lymphocyte counts of COVID−19 and other CAP patients were compared using Student's t-test. The frequencies of each clinical, epidemiological and CT findings were compared using the Fisher's exact test and Pearson's $\chi2$ test. A p-value of less than 0.05 was considered as statistical significance.

Results

1.Patient profiles

14 men and 10 women (mean age 48.0±18.1 years; range 14−87 years) had COVID−19 pneumonia, and 13 men and 15 women (mean age 49.5±21.5; age range 24−85year) had other CAP. No statistically significant differences in age or gender distribution between the two groups were identified (p>0.05). 16 (66.7%) cases of COVID−19 pneumonia had exposure to the source of transmission within the past 14 days, significantly higher than the cases of other CAP (n = 2, 7.1%) (p = 0.000). The most common symptoms of COVID−19 pneumonia were fever (n = 20, 83.3%), fatigue (n = 13, 54.2%) and cough (n = 12, 50%). While diarrhea (n = 4, 16.7%) was the less common symptom. The most common symptoms of CAP were fever (n = 22, 78.6%) and cough (n = 20, 71.4%). While fatigue (n = 8, 28.6%) and diarrhea (n = 2, 7.1%) were the less common symptoms. The differences in clinical symptoms between the two groups were not significant (p>0.05). The mean time of HRCT after the onset of symptoms was similar in two groups (COVID−19 $vs.$ CAP, 4.3±2.9days $vs.$ 4.2±3.5days, p = 0.969). Patients in group COVID−19 had significantly lower white blood cell count (5.29±1.53 ×10^9/L) than patients in group of other CAP (8.39±4.97×10^9/L) (p = 0.005), while the lymphocyte count did not significantly different among groups (1.28±0.66×10^9/L $vs.$ 1.41±0.91×10^9/L, p = 0.576).

2.CT patterns

The thoracic CT manifestations of COVID−19 pneumonia and other CAP patients are summarized in Table 1. For 24 patients with COVID−19 pneumonia, pure GGA (n = 14, 58.3%) and mixed GGA with consolidation (n = 10, 41.7%) were the typical parenchymal abnormalities (Figure 1A). The main diseases were predominantly observed to be patches with long axis parallel to pleura (n = 14, 58.3%), followed by nodules with round morphology (n = 7, 29.2%), and patches with long axis along the bronchovascular (n = 6, 25.0%) (Figure 1B, 1C, 1D). No pure consolidation was detected in this retrospective case series. Air bronchogram (n = 13, 54.2%), vessels dilatation (n = 13, 54.2%) and crazy-paving appearance (n = 8,

33.3%) were the common findings (Figure 1E, 1F). Linear opacities (n = 5, 20.8%) and halo sign/reversed halo sign (n = 2, 8.3%) were also observed. No tree-in-bud sign, cavitary lesions, pleural effusion and lymphadenopathy was detected for any patients.

For the 28 patients with CAP, the parenchymal abnormalities were GGO with consolidation (n = 10, 35.7%), pure GGA (n = 9, 32.1%) and pure consolidation (n = 9, 32.1%) (Figure 2A, 2B). The main disease was predominantly observed to be patches with long axis parallel to bronchovascular (n = 14, 50.0%), followed by nodules with round morphology (n = 12, 42.9%), and patches with long axis parallel to pleura (n = 9, 32.1%). Air bronchogram (n = 16, 57.1%) and tree-in-bud sign (n = 12, 42.9%) were the most frequent findings (Figure 2C, 2D). Pleural effusion was presented in 6 of the patients with other CAP (21.4%). Crazy-paving appearance (n = 2, 7.1%), vessel dilatation (n = 2, 7.1%), linear opacities (n = 3, 10.7%), halo sign (n = 2, 7.1%) (Figure 2E, 2F)and lymphadenopathy (n = 2, 7.1%) were also observed. Cavitation was not detected in any patient.

The frequencies of crazy-paving appearance and vessel dilatation were significantly higher in patients with COVID−19 pneumonia compared with patients with other CAP (p = 0.031 and p = 0.000, respectively). Conversely, the frequencies of pure consolidation, tree-in-bud sign and pleural effusion were significantly higher in patients with CAP than those in patients with COVID−19 pneumonia (p = 0.002, p = 0.000 and p = 0.048, respectively). There were no significant differences in the shape of main lesions and other CT features, including pure GGA, mixed GGA with consolidation, air bronchogram, linear opacities, halo sign/reversed halo sign, cavitation and lymphadenopathy between the groups of COVID−19 pneumonia and other CAP.

3.Abnormality location and distribution

For the patients with COVID−19 pneumonia, main parenchymal abnormalities were noticed bilaterally in 17 patients (70.8%) and unilaterally in 7 patients (29.2%). Of the 24 patients, the predominant zonal distribution was the lower zone (n = 20, 83.3%), followed by the middle zone (n = 12, 50.0%) and the upper zone (n = 11, 45.8%). 17 patients (70.8%) had pulmonary parenchymal abnormalities predominantly distributed peripherally, and 7 patients (29.2%) had pulmonary parenchymal abnormalities distributed randomly. For patients with other CAP, main parenchymal abnormalities were observed to be bilaterally in 11 patients (39.3%) and unilaterally in 17 patients (60.7%). Of the 28 patients, middle zone was the predominant zonal distribution (n−18, 64.3%), followed by the lower zone (n = 16, 57.1%), and upper zone (n = 12, 42.9%). Main parenchymal abnormal findings were found to be randomly distributed in 11 patients (39.3%), peripherally distributed in 10 patients (35.7%), and centrally distributed in 7 patients (25.0%).

The frequency of bilaterally involvement and peripherally distribution was significantly higher in COVID−19 group than in the CAP group (p = 0.029, and p = 0.009, respectively). No significant differences in zonal involvement between the two groups were found.

Discussion

In December 2019, a major outbreak of respiratory disease later named as COVID−19 was reported by health authorities in Wuhan, Hubei province, China [19]. Followed by an exponential growth in a few weeks, the COVID−19 emerged as a new agent of community-acquired pneumonia, attracting extensive growth around the world. Early detection of suspected patients is the important way to control the spread of the disease. However, the caused symptoms of the virus are similar to those of other CAP (e.g., fever, cough, sputum), and screening for COVID−19 among these patients with CAP is not cost-effective and may lead to unnecessary social-disruption. It is very important for clinics to identify the infected patients. In this study, we comprehensively verified the clinical characteristics and CT features of COVID−19 pneumonia and other CAP, aimed to identify common requested clinical data and CT imaging variables that might discriminate COVID−19 patients from newly diagnosed CAP with other pathogens.

We report 24 patients with laboratory-confirmed COVID−19 pneumonia and 28 patients with CAP excluded COVID−19 infection. Current reports show that COVID−19 is generally susceptible. The onset age of COVID−19 in this group is from 14−87 years old, similar to previous study reports that infection can occur at all ages [20]. There was a slight predilection for males over females in patients with COVID−19 pneumonia in our cohort. However, another study reported s striking male predilection with 67(68%) of 99 COVID−19 patients being male [21]. This discrepancy might be due to the small cohorts. No obvious predilection was observed for patients with other CAP in our study, and there was no significant difference in gender distribution between the two groups. In this study, we found that there are some similarities in clinical manifestations for patients with COVID−19 pneumonia and patients with other CAP. Most respiratory infections are presented with nonspecific acute symptoms such as fever, fatigue, cough, sputum, dyspnea, and diarrhea, which make it difficult to differentiate COVID−19 pneumonia from CAP. In our study, the white cell count of patients with COVID−19 pneumonia was significantly lower than the patients with CAP, consistent with the laboratory test results for most respiratory viral infections [22]. However, there was no significant difference in lymphocyte count between patients with COVID−19 pneumonia and CAP, different from the previous study [9], which may be related to the small sample size and the complex pathogens in patients with CAP.

Radiological examinations play an important role in timely detection and management of pneumonia. Conventional chest radiography is usually the first imaging technique performed to evaluate for CAP. However, since chest radiography is not sensitive for the detection for GGA, it was not recommended as the first line imaging modality for COVID−19 pneumonia [23]. National Health and Health Commission of China had recommended the CT manifestations as important evidence of clinical diagnosis in Hubei province [24]. In our study, the characteristic CT findings in COVID−19 pneumonia include pure GGA or mixed GGA and consolidation, crazy paving appearance and vascular dilatation within the lesions, patches parallel to pleura or nodules with rounded morphology, with a peripheral and lower zone predominance and bilateral involvement. Our results agree with those reported elsewhere [9, 10, 25]. On the other hand, CT findings in patients with other CAP include patches of ground glass attenuation or multifocal areas of consolidation along the axis interstitium, tree-in-bud pattern, with a random

distribution and middle zone predominance and unilateral involvement. However, these findings are nonspecific and can be manifestations of a number of different types of bacterial, viral or atypical pneumonia.

Findings in our study demonstrated that ground glass opacities, mixed ground glass opacities and consolidation, air bronchogram were of consistent common initial features in both COVID–19 and other CAP group. On the contrary, cavitation, halo sign/reversed halo sign, and lymphadenopathy were rare features in both groups. The presence of crazy paving pattern, vessel dilatation, bilateral involvement and peripheral distribution occurred more frequently in the group of COVID–19 pneumonia. However, pure consolidation, tree-in-bud sign and pleural effusion occurred significantly more frequently in the group of other CAP. Therefore, these CT features and distribution pattern can be used as markers in differentiating patients with COVID–19 from patients with other CAP during the initial screening. Despite these seemingly positive findings, one should keep in mind that these CT features are nonspecific and can be noticed in pneumonias caused by different types of pathogen and other non-infectious diseases. Therefore, correlation with clinical, epidemiological and laboratory characteristics will play an important role in searching for a diagnosis.

Finally, a number of limitations need to be noted regarding the present study. First, this is a retrospective study with limited cases. Most of the patients with COVID–19 enrolled were mild or general cases. Therefore, it might be difficult to determine what are the characteristic thin-section CT findings for differentiating COVID–19 pneumonia from CAP caused by other pathogens. Second, we mainly focus on the clinical and imaging features at the initial medical contact, while the dynamic changes with appropriate therapy are definitely helpful to differential these two diseases. Third, the CT image interpretation was obtained by two radiologists rendering consensus and did not have pathological correlation.

In summary, the main purpose of this study was to characterize and compare the clinical characteristics and thin-section CT features between COVID–19 pneumonia and other CAP in the early course of the diseases. The overlapping thin-section CT features such as pure GGA, mixed GGA with consolidation, indicate difficulty in obtaining high accuracy in differentiation between the two groups. However, there are a number of significant radiological differences between COVID–19 pneumonia and other CAP. The presence of crazy paving pattern, vessel dilation, bilateral involvement and peripheral distribution contributes to the diagnosis of COVID–19 pneumonia. While the presence of pure consolidation tree-in-bud sign, pleural effusion can be assisting in exclusive the diagnosis of COVID–19 pneumonia.

Abbreviations

COVID–19: Coronavirus disease 2019

CAP: community-acquired pneumonia

SARS-CoV–2: severe acute respiratory syndrome coronavirus 2

GGA: ground-glass attenuation

Declarations

Ethics approval and consent to participate

This study was approved by decisions of the Ethics Committee of the Peking University Third Hospital. The data used in this study was anonymized before its use.

Consent for publication

Not applicable.

Availability of data and materials

All data generated and/or analyzed during the current study are available from the corresponding authors on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

Acknowledgments:

Authors' contributions

Wang XH designed the study and edited the manuscript. Zhu Q and Ren C analyzed and interpreted the patient data. Zhu Q performed the literature research and statistical analysis and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

References

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 2020; 382:727−733. Doi: 10.1056/NEJMoa2001017
2. Gorbalenya AE, Baker SC, Baric RS, de Groot RJ, Drosten C, Gulyaeva AA, et al. Severe acute respiratory syndrome-related coronavirus: the species and its viruses—a statement of the coronavirus study group. bioRxiv 2020.02.07.937862. Doi: https://doi.org/10.1101/2020.02.07.937862

3. World Health Organization. Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020. 2020. https://www.who.int/dg/speeches/detail/whodirector-general-s-remarks-at-the-media-briefing-on–2019-ncov-on–11-february–2020.

4. World Health Organization. Coronavirus Disease 2019 (COVID–19) Situation Reports—52. https://www.who.int/emergencies/diseases/novel-coronavirus–2019/situation-reports Published March 12, 2020. Accessed March 12, 2020.

5. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, et al. Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID–19) in China: A Report of 1014 Cases. Radiology 2020; 200642. Doi: 10.1148/radiol.2020200642.

6. Center for Disease Control and Prevention. Interim Guidelines for Collecting, Handling, and Testing Clinical Specimens from Persons Under Investigation (PUIs) for Coronavirus Disease 2019 (COVID–9). 2020. https://www.cdc.gov/coronavirus/2019-ncov/lab/guidelines-clinical-specimens.html.

7. Fang Y, Zhang H, Xie J, Lin M, Ying L, Pang P, et al. Sensitivity of Chest CT for COVID–19: Comparison to RT-PCR. Radiology 2020; 200432. Doi: 10.1148/radiol.2020200432.

8. Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, et al. CT Imaging Features of 2019 Novel Coronavirus (2019-nCoV). Radiology 2020; 200230. Doi: 10.1148/radiol.2020200230.

9. Shi HH, Han XY, Jiang NC, Cao YK, Alwalid O, Gu J, et al. Radiological findings from 81 patients with COVID–19 pneumonia in Wuhan, China: a descriptive study. Lancet Infect Dis 2020;20(4): 425–434. Doi:10.1016/S1473–3099(20)30086–4

10. Xu X, Yu C, Qu J, Zhang L, Jiang S, Huang D, et al. Imaging and clinical features of patients with 2019 novel coronavirus SARS-CoV–2. Eur J Nucl Med Mol Imaging 2020; 47(5): 1275–1280. Doi:10.1007/s00259–020–04735–9.

11. Kolditz M, Ewig S. Community-Acquired Pneumonia in Adults. Dtsch Arztebl Int 2017;114(49):838–848. Doi:10.3238/arztebl.2017.0838.

12. Zu ZY, Jiang MD, Xu PP, Chen W, Ni QQ, Lu GM, et al. Coronavirus Disease 2019 (COVID–19): A Perspective from China. Radiology 2020; 200490. Doi:10.1148/radiol.2020200490.

13. Hansell DM, Bankier AA, MacMahon H, McLoud TC, Müller NL, Remy J. Fleischner Society: glossary of terms for thoracic imaging. Radiology 2008;246(3):697–722.

14. Chiarenza A, Esposto Ultimo L, Falsaperla D, Travali M, Foti PV, Torrisi SE, et al. Chest imaging using signs, symbols, and naturalistic images: a practical guide for radiologists and non-radiologists. Insights Imaging 2019;10(1):114. Doi:10.1186/s13244–019–0789–4

15. Rossi SE, Erasmus JJ, Volpacchio M, Franquet T, Castiglioni T, McAdams HP. "Crazy-paving" pattern at thin-section CT of the lungs: radiologic-pathologic overview. Radiographics 2003;23(6):1509–1519.Doi:10.1148/rg.236035101

16. Gosset N, Bankier AA, Eisenberg RL. Tree-in-bud pattern. AJR. Am J Roentgenol 2009;193: W472–477. Doi:10.2214/AJR.09.3401

17. Ray A, Mittal A, Vyas S. CT Halo sign: A systematic review. Eur J Radiol 2020; 124: 108843. Doi: 10.1016/j.ejrad.2020.108843

18. Marchiori E, Rodrigues RS, Barreto MM. The Reversed Halo Sign: Criteria for Differentiation of Infectious and Noninfectious Diseases. AJR Am J Roentgenol 2019;213: W295. Doi:10.2214/AJR.19.21846

19. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020; 395: 497−506. Doi: 10.1016/S0140−6736(20)30183−5

20. Guan WJ, Ni ZY, Hu Y, Liang W, Ou C, He J, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. N Engl J Med 2020 Feb 28. doi:10.1056/NEJMoa2002032

21. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet 2020; 395: 507−513. Doi:10.1016/S0140−6736(20)30211−7

22. Ruuskanen O, Lahti E, Jennings LC, Murdoch DR. Viral pneumonia. Lancet 2011; 377: 1264−75. Doi: 10.1016/S0140−6736(10)61459−6

23. Ng M, Lee EYP, Yang J, Yang F, Li X, Wang H, et al. Imaging profile of the COVID−19 infection: Radiologic findings and literature review. Radiology: Cardiothoracic Imaging 2020;2(1): e200034. Doi:10.1148/ryct.2020200034

24. General Office of National Health Committee. Office of state administration of traditional Chinese medicine. Notice on the issuance of a programme for the diagnosis and treatment of novel coronavirus (2019-nCoV) infected pneumonia (trial fifth edition). http://bgs.satcm.gov.cn/zhengcewenjian/2020−02−06/12847.html

25. Li B, Li X, Wang Y, Hang Y, Wang Y, Wang C, et al. Diagnostic Value and Key Features of Computed Tomography in Coronavirus Disease 2019. Emerg Microbes Infect 2020; 1−14. Doi:10.1080/22221751.2020.1750307

Table

Table 1 Summary of CT findings in patients with COVID-19 pneumonia and other CAP

| Findings	COVID-19 (n=24)	CAP (n=28)	*p*-Value
Density of main lesions			
Pure GGO	14(58.3%)	9(32.1%)	0.058
Pure Consolidation	0	9(32.1%)	0.002
Mixed GGO and Consolidation	10(41.7%)	10(35.7)	0.660
Shape of main lesions			
Patches parallel to pleura	14(58.3%)	9(32.1%)	0.093
Patches parallel to bronchovascular	6(25.0%)	14(50.0%)	0.089
Nodules with round morphology	7(29.2%)	12(42.9%)	0.391
Other findings			
Air bronchogram	13(54.2%)	12(42.9%)	0.578
Crazy paving Pattern	8(33.3%)	2(7.1%)	0.031
Vessels dilation	13(54.2%)	2(7.1%)	0.000
Linear opacity	5(20.8%)	3(10.7)	0.533
Tree-in-bud pattern	0	12(42.9%)	0.000
Halo sign/reversed halo sign	2(8.3%)	2(7.1%)	0.872
Cavitation	0	0	/
Pleural effusion	0	6(21.4%)	0.048
Lymphadenopathy	0	2(7.1%)	0.493

Data are n (%).

Figures
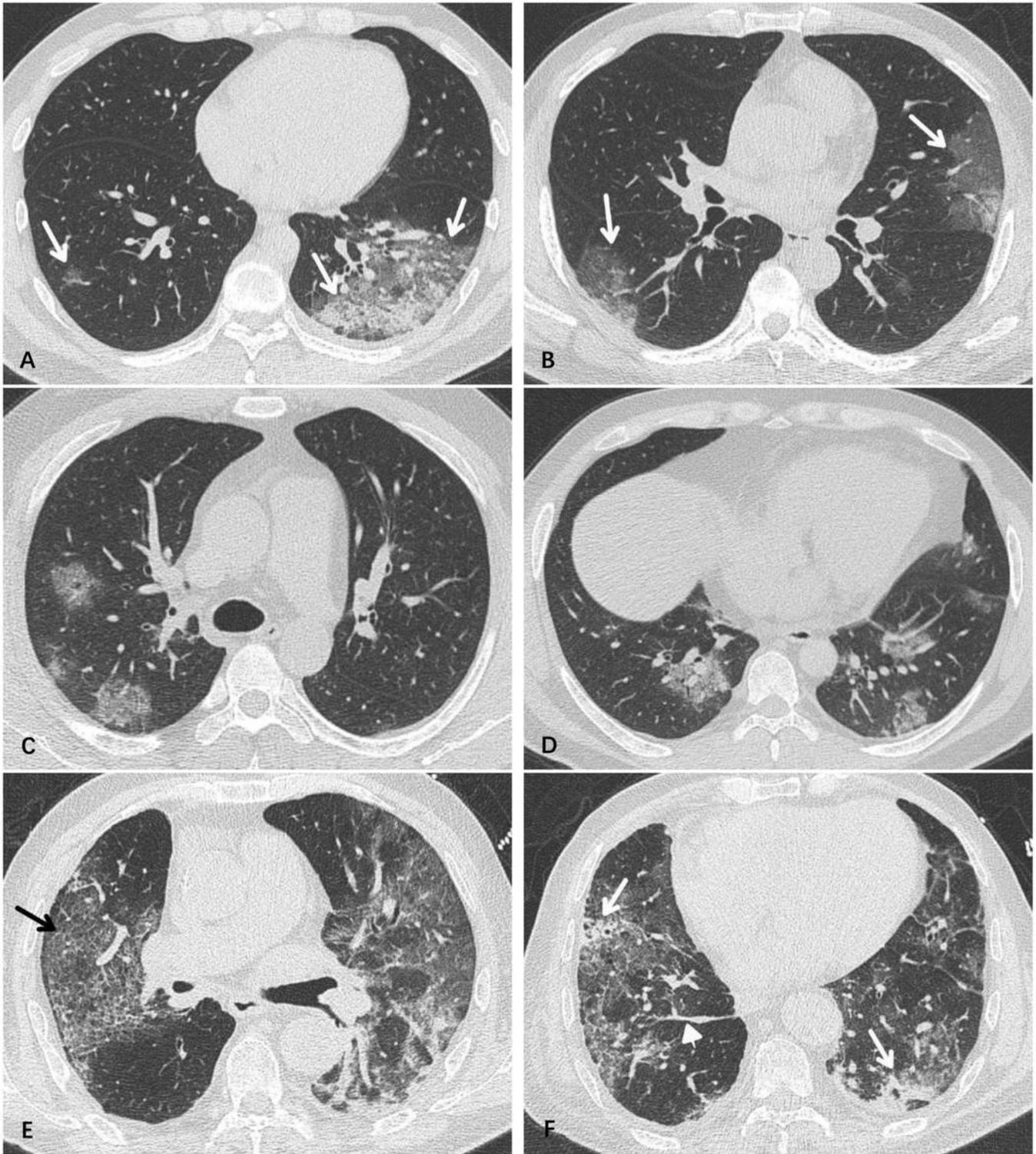
Figure 1

Transverse thin-section CT images in patients with COVID-19 pneumonia. (A) A male patient with COVID-19 pneumonia. Fever (38.6°C) with diarrhea for 6 days. Axial thin-section CT image in lung window shows patchy ground-glass attenuation (GGA) in the right lower lobe (arrow) and patchy mixed GGA and consolidation (arrow) in the left lower lobe with air-bronchogram inside. (B) A male patient with COVID-19 pneumonia. Fever (39.0°C) with fatigue and diarrhea for 4 days. Thin-section CT image shows multiple

patchy GGA (arrow) with long axis parallel to pleura in the peripheral field of the both lungs. (C, D) A male patient with COVID-19 pneumonia. Fever (38.5°C) with cough, sputum and fatigue for 1 day. Thin-section CT images show multiple patchy GGA with rounded morphology and randomly distribution in both lungs. (E, F) A male patient with COVID-19 pneumonia. Fever with fatigue for 12 days. Thin section CT images show diffuse GGA with interlobular septum thickening in both lungs to form a crazy-paving appearance (black arrow), parenchymal bands in right lower lobe (arrowhead), and consolidation in the both subpleural lung (white arrow).
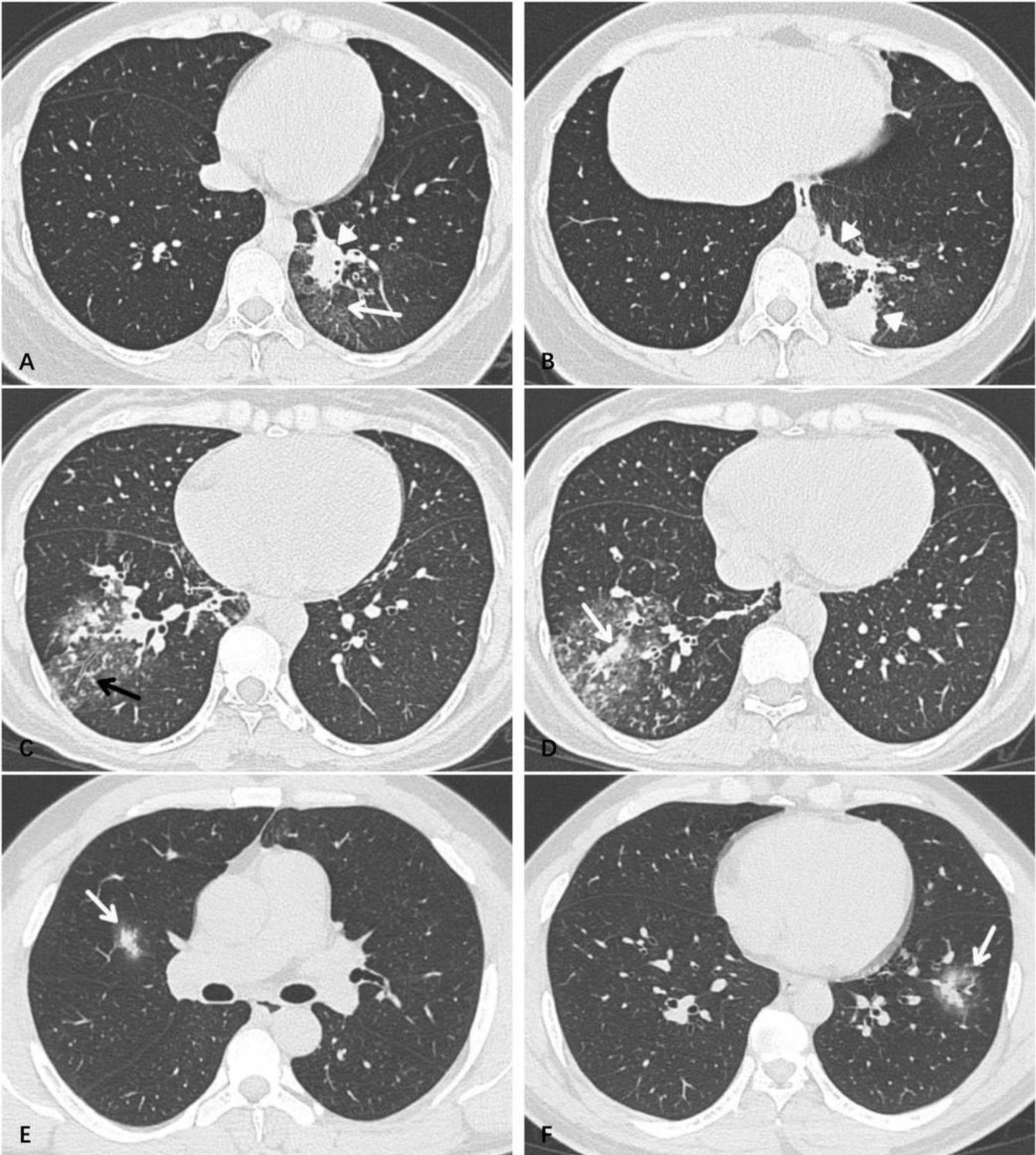
Figure 2

Transverse thin-section CT images in patients with other CAP. (A, B) A female patient with CAP caused by Streptococcus pneumonia. Fever (38.8°C) with cough for 1 day. Thin-section CT images show patchy consolidation (arrow head) and GGA (arrow) in the left lower lobe. (C, D) A female patient with CAP caused by Mycoplasma pneumoniae. Fever (38.6°C) with cough and sputum for 8 days. Thin-section CT images show peribronchovascular distribution of patchy GGA and consolidation (white arrow) in the right lower lobe, with ill-defined centrilobular nodules in it, creating a tree-in-bud pattern (black arrow). (E, F) A male patient with CAP caused by Mycoplasma pneumoniae. 1 day after the onset of fever (38.7°C). Axil lung window thin-section CT (a and b) thorax images show nodule with halo sign (white arrow) in the right upper lobe and the left lower lobe.