Atypical chest CT findings of COVID-19 pneumonia: a pictorial review

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ABSTRACT

Coronavirus disease 2019 (COVID-19) first emerged in China and rapidly spread in the world causing a pandemic. Chest computed tomography (CT) continues to play an important role in the diagnosis and follow-up of the disease due to shortcomings of the real-time reverse transcription-polymerase chain reaction test, which is the gold standard in the diagnosis of this disease. Typical chest CT findings of COVID-19 pneumonia have been widely reported in the literature. However, atypical findings such as central involvement, peribronchovascular involvement, isolated upper lobe involvement, nodular involvement, lobar consolidation, solitary involvement, pleural and pericardial fluid, and subpleural sparing can also be seen. Knowing these atypical findings is important to avoid misdiagnosis. This review summarizes the atypical findings that can be seen in the course of the disease and may be confused with other diseases.

Coronavirus disease 2019 (COVID-19) spread rapidly all over the world causing a pandemic since it was first seen in China at the end of December. Until the beginning of May, nearly 4 million diagnoses and 280 000 deaths have been reported (1). The early diagnosis of this disease, which causes clinical findings in a wide range of spectrum from asymptomatic patient to severe symptoms, is vital to prevent contagiousness and rapid treatment of severe patients. The real-time reverse transcriptase-polymerase chain reaction (RT-PCR) test, which is the gold standard in the diagnosis of the disease, has shortcomings such as late reporting, sampling errors, and sensitivity rates varying among the test kits (2). Many publications have shown that the sensitivity of the RT-PCR test is low, especially in the early period of the disease. Chest computed tomography (CT) is an important complementary diagnostic tool in patients with negative initial RT-PCR test and clinically high suspicion (2, 3).

Chest CT findings of COVID-19 pneumonia have been described in many publications (4–8). Typical and most common signs of the disease are bilateral, multifocal, lower lobe and posterior-dominant ground-glass opacities (GGOs) and crazy-paving appearance. Consolidation mostly appears in the peak stage of the disease (6). In addition, many signs such as vascular dilation, air bubble sign, subpleural lines, halo and reverse halo sign, and bronchial dilatation can be seen in this disease. These findings are accepted as typical findings that are frequently mentioned in the diagnosis of the disease (9). However, atypical chest CT findings can be seen in COVID-19 pneumonia. There is no sole publication that discusses these atypical CT findings collectively in the literature. In addition, COVID-19 pneumonia can lead to a misleading and different CT appearance when it develops in the background of chronic lung diseases and immune system disorders. Knowing these CT findings is vital to prevent misdiagnoses and delays in the isolation of these patients.

The purpose of this review is to show the atypical and rare chest CT findings of COVID-19 pneumonia and to demonstrate different images of COVID-19 pneumonia observed in patients with other lung diseases. Through these findings, we aim to learn the lung involvement of COVID-19 pneumonia in detail.

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Imaging protocol

Chest CT examination should be acquired with high-resolution non-contrast CT protocol and a cross-section thickness of 1.0–1.5 mm. According to the patient's age and weight, initial chest CT can be performed with low-dose or standard-dose radiation. In patients with clinical progression or complications, follow-up CT is recommended (10). In cases where vascular complications are considered such as pulmonary embolism, thorax-angiography CT protocol is recommended. In these patients, renal function should be taken into consideration when applying the contrast agent.

Atypical chest CT findings

Central involvement

Peripheral and subpleural involvement is seen as one of the most common patterns in COVID-19 pneumonia. Isolated central involvement or central predominant involvement is relatively rare, but can be seen in the course of the disease (Fig. 1). The diagnosis can be more difficult, particularly in case of cardiac insufficiency. Central involvement can be seen in the organized pneumonia pattern with bronchovascular distribution (Fig. 2).

Isolated upper lobe involvement

In general, lower lobe predominant involvement has been reported in the disease (11). However, isolated upper lobe involvement can also be seen in the course of the disease (Fig. 3). Particularly in the early period of the disease, upper lobe involvement can be observed in the form of GGO. In the literature, no exact data on the percentage of isolated upper lobe or upper lobe pre-
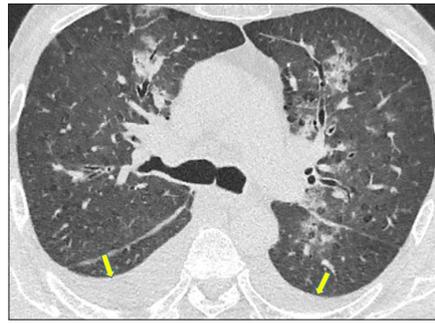
Main points

- Typical and most common signs of COVID-19 are mostly bilateral, multifocal, lower lobe and posterior-predominant ground-glass opacities, accompanying crazy-paving appearance, and consolidations.

- Atypical chest CT findings such as central and peribronchovascular involvement, isolated upper lobe involvement, solitary involvement, lobar consolidation, nodule formation, subpleural sparing, pleural and pericardial effusion can be seen in COVID-19 pneumonia.

- Knowing the atypical findings that may be confused with other diseases is vital to prevent misdiagnosis.

Figure 1. Axial CT image of a 60-year-old male patient with confirmed COVID-19 pneumonia presenting with fever and cough shows irregular consolidation and GGO in central areas of both lungs. Bilateral pleural effusion is also seen *(arrows)*.

Figure 2. Axial CT image of a 40-year-old female COVID-19 pneumonia patient shows crazy-paving pattern in central peribroncovascular area of right upper lobe *(arrows)*.
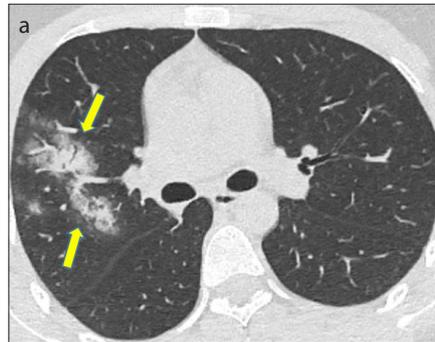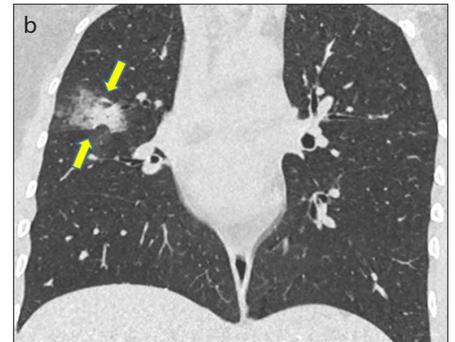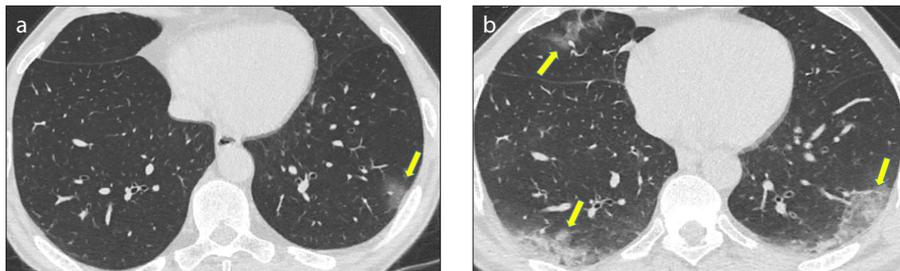

Figure 3. a, b. CT images of a 24-year-old COVID-19 pneumonia patient with isolated upper lobe involvement. Axial **(a)** and coronal reformatted **(b)** images show GGOs with consolidation in the right upper lobe *(arrows)*. Right lower lobe and left lung are entirely normal.

dominant distribution has been reported to date, but it should be kept in mind as a possibility.

Solitary involvement

Multifocal involvement, mostly bilateral, is one of the most evident signs of the disease (6, 7). However, single isolated involvement in any lobe can also be seen during the course of the disease (Fig. 4). Solitary involvement may be mostly ground-glass density or more solid. It can be observed especially in the early period and may become multifocal in later stages (Fig. 5).

Peribronchovascular involvement

Peribronchovascular involvement can be seen in many diseases such as sarcoidosis and organized pneumonia. In COVID-19 pneumonia, peripheral-predominant and irregular GGO and consolidation that do not fit a certain distribution are reported as the most common findings (9, 12). However, this disease may involve the peribronchovascular bundle from the central area to the periphery (Fig. 6). This pattern can be

Figure 4. A 46-year-old male COVID-19 patient presenting with fever and dry cough for 8 days. Axial CT image shows a single solid nodule surrounded by a ground-glass halo in the left upper lobe *(arrow)*.

confused with parenchymal involvement of diseases that may have peribronchovascular involvement, such as organized pneumonia (13).

Lobar consolidation

Multifocal consolidations are frequently observed in the peak period of COVID-19 pneumonia (6). Widespread involvement has been reported as a poor prognostic factor. It has been reported that the ap-

Figure 5. a, b. Axial CT images of a 34-year-old male COVID-19 patient presenting with fever and dry cough for 3 days. Image **(a)**, taken at presentation, shows a small subpleural nodular GGO in the left lower lobe *(arrow)*. Image **(b)**, taken one week later, shows an enlarged region of GGO with superimposed consolidations in both lower and middle lobes *(arrows)*.
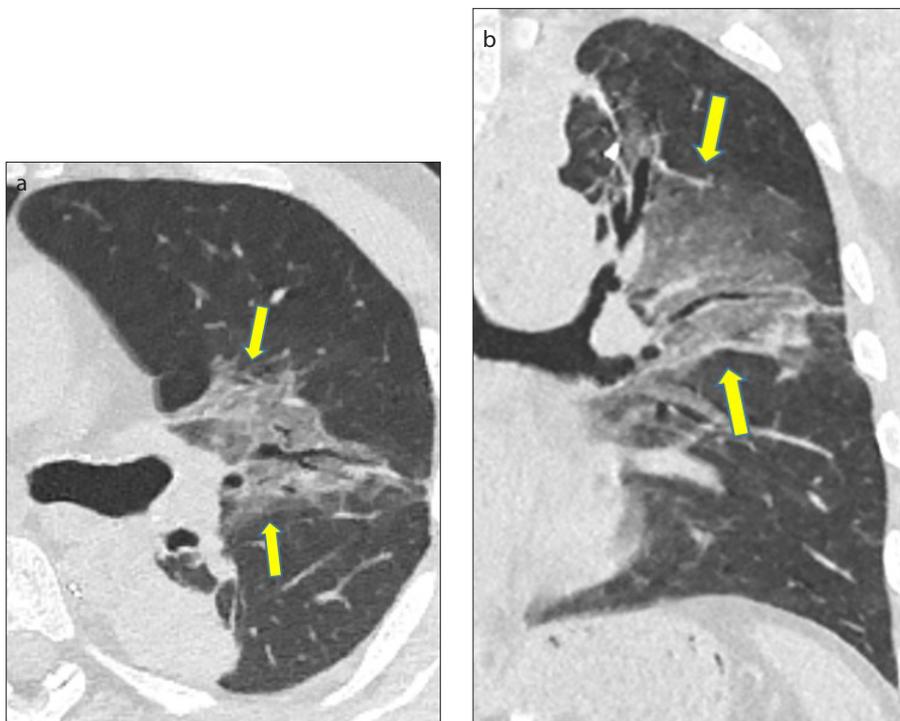

Figure 6. a, b. CT images of a 52-year-old COVID-19 pneumonia patient with atypical involvement. Axial **(a)** and coronal reformatted **(b)** images show GGO along peribronchovascular bundle from the central area to the periphery of the left upper lobe *(arrows)*.
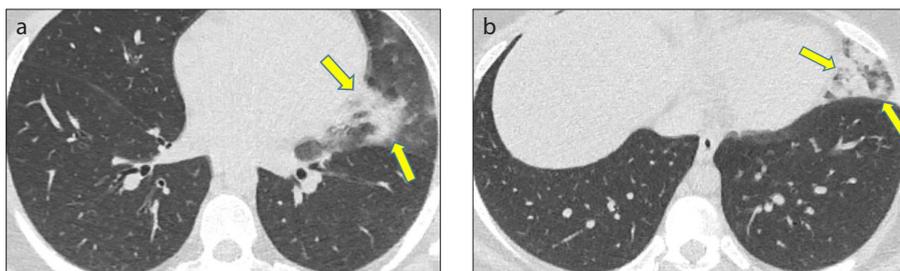

Figure 7. a, b. Axial CT images **(a, b)** of a 47-year-old male patient with confirmed COVID-19 pneumonia presenting with fever and cough show isolated lobar consolidation in the left upper lobe *(arrows)*.

pearance of single lobar consolidation may be due to another pneumonia agent other than COVID-19 (14). Lobar consolidation can be seen due to many pneumonia agents, but it can be observed in cases with positive RT-PCR test (Fig. 7). Isolated lobar consolidation may be seen as an atypical involvement pattern of COVID-19 pneumonia (Fig. 8). Therefore, it is important to evaluate all the findings together in patients with suspected COVID-19 pneumonia.

Tree-in-bud pattern

Tree-in-bud sign describes the CT appearance of multiple areas of centrilobular nodules with a linear branching pattern. It is recognized in a large number of conditions such as tuberculosis and infective bronchiolitis (15). It has been reported as an atypical finding in COVID-19 pneumonia and should suggest the possibility of concomitant infection (Fig. 9) (12). However, there is no clear information on whether it will depend only on disease involvement.

Nodules

Nodules were reported in a small percentage of patients with COVID-19 pneumonia. It is seen less frequently than in other types of viral and bacterial pneumonia (12). It should be kept in mind that it can be seen with common findings such as GGO and consolidation, as well as rarely observed sole findings in COVID-19 pneumonia (Fig. 10).

Pleural effusion

Pleural effusion is reported as a low frequency finding, which is present in more severe cases of COVID-19 pneumonia. The prevalence of pleural effusion in COVID-19 patients has been reported to range from 0% to 20% (9). It can be isolated or due to another accompanying disease (Fig. 11). The accompanying interlobular septal thickening should suggest cardiac failure.

Pericardial effusion

Pericardial effusion is a rare finding in COVID-19 pneumonia and is considered to be a poor prognostic factor in many publications (9, 16). Secondary diseases of cardiac origin that may accompany this disease may lead to pericardial effusion (Fig. 12). However, myocarditis or myopericarditis due to COVID-19 can lead to pericardial effusion. This involvement has been rarely reported in the literature and its true frequency is unknown (17). Therefore, patients should be evaluated for cardiac involvement in the presence of pericardial fluid, especially in patients without a history of cardiac disease.

Subpleural sparing

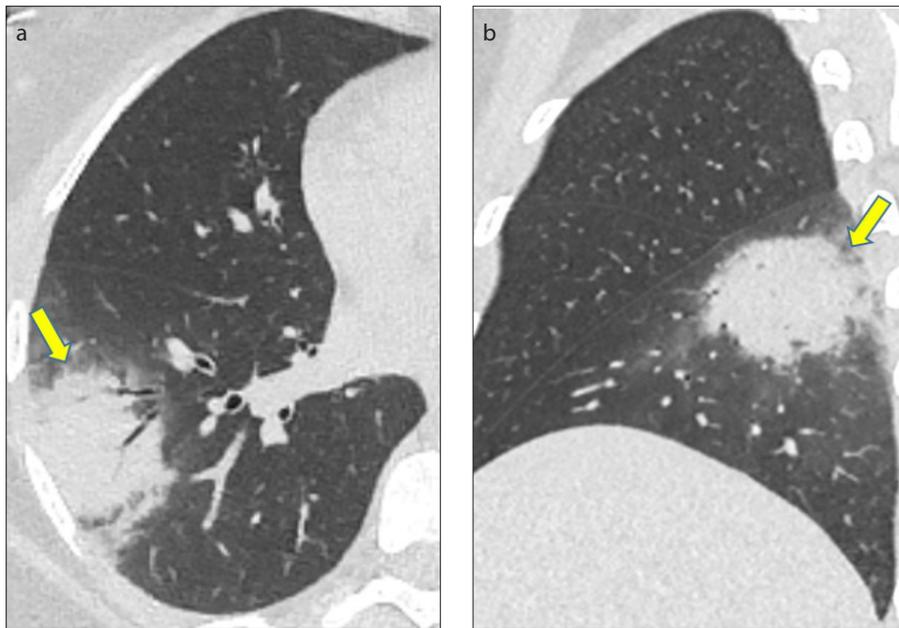Subpleural sparing describes involvement of the periphery of the lung, while

Figure 8. a, b. A 51-year-old female COVID-19 pneumonia patient. Axial **(a)** and sagittal reformatted **(b)** CT images show round consolidation *(arrows)* in the right lower lobe.

Figure 9. Axial CT image of a patient with positive RT-PCR test shows tree-in-bud pattern in the right lower lobe *(arrows)*.
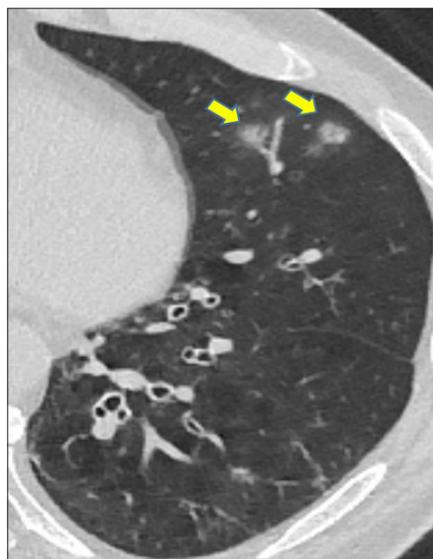

Figure 10. Axial CT image of a 44-year-old man with COVID-19 pneumonia shows two nodules in the left upper lobe *(arrows)*.
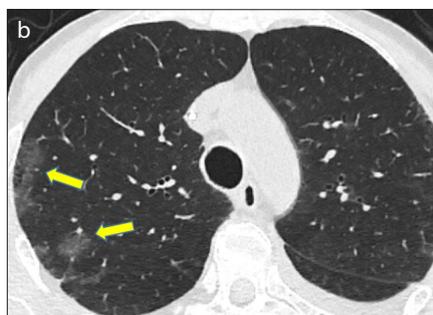

Figure 11. a, b. CT images of a 57-year-old patient with mild symptoms of COVID-19 pneumonia. Axial image **(a)** demonstrates left-predominant bilateral pleural effusion (mediastinal window). Image **(b)** shows peripheral GGOs in the right upper lobe *(arrows)*.

the area just below the pleura is protected. Nonspecific interstitial pneumonia is one of the most typical diseases that cause this involvement pattern. It can also be seen in conditions such as alveolar proteinosis and parenchymal contusion (18). Subpleural sparing can be seen in COVID-19 pneumonia (Fig. 13). There are no publications in the literature about the relationship of this finding with COVID-19 pneumonia. Therefore, it is important to differentiate between suspected COVID-19 pneumonia and other diseases when this finding is observed.

White lung

Diffuse infiltration involving the lung is considered to be a rare involvement seen particularly when disease progresses to acute respiratory distress syndrome (ARDS), and it is considered to indicate poor prognosis (Fig.14) (9). However, similar appearances can also be observed in patients with moderate symptoms. It can be seen as diffuse GGO or widespread consolidation (Fig. 15). This appearance can also be observed in other viral infections, pulmonary edema patterns, and drug toxicity. Therefore, detailed clinical evaluation and other findings is important to prevent misdiagnosis.

COVID-19 pneumonia and concomitant disease findings

Many diseases involving lung parenchyma and COVID-19 pneumonia can be seen together, which may change the appearance from the typical findings defined for COVID-19 pneumonia and lead to diagnostic difficulty. In a case with interstitial fibrosis, COVID-19 pneumonia can mimic acute exacerbation of this disease and may lead to diagnostic error (Fig. 16). Involvement in the background of emphysema may create an image similar to other infections (Fig. 17). Parenchymal infarction areas due to pulmonary embolism may be confused with disease involvement (Fig. 18). Fungal infections may lead to diagnostic difficulties in neutropenic cases treated for malignancy (Fig. 19). COVID-19 pneumonia accompanying various diseases of the lung can manifest with a different appearance. For accurate diagnosis, it is very important

Figure 12. a, b. CT images of a 63-year-old patient with moderate symptoms of COVID-19 pneumonia. Axial image **(a)** demonstrates pericardial effusion on mediastinal window settings *(arrows)*. Image **(b)** shows bilateral GGOs in both lower lobes *(arrows)*.
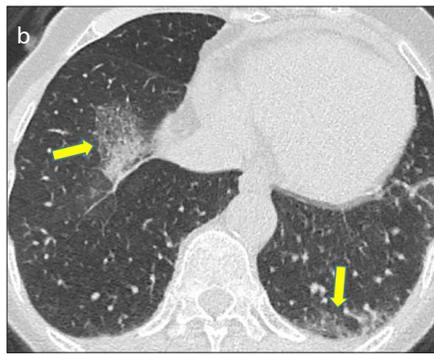

Figure 13. a, b. A 47-year-old patient with COVID-19 pneumonia. Axial **(a)** and sagittal reformatted **(b)** CT images show extensive peripheral consolidation with GGOs in the right lower lobe. The subpleural area appears protected *(arrows)*.

Figure 14. A 74-year-old male COVID-19 patient presenting with fever, chills and cough for 5 days. Axial CT scan shows bilateral extensive consolidations. The patient died 10 days later.

Figure 15. Axial CT image of a 59-year-old patient with moderate symptoms of COVID-19 pneumonia shows diffuse GGOs in both lungs.

Figure 16. A 63-year-old male patient with confirmed COVID-19 pneumonia presenting with fever and dry cough. Axial CT image shows combined pulmonary fibrosis and emphysema findings in both lungs *(white arrows)*. There is also peripheral GGO in the fibrosis area in the left lower lobe *(yellow arrows)*.
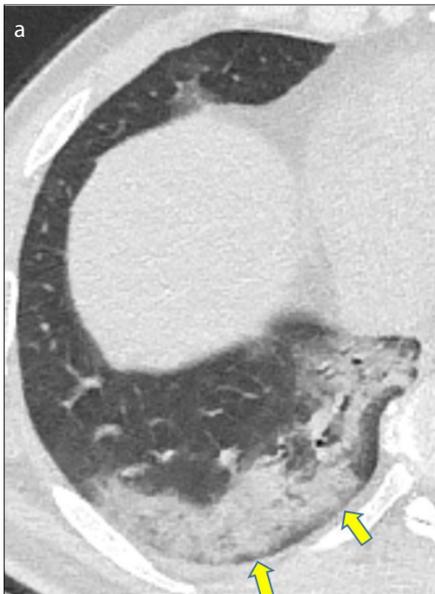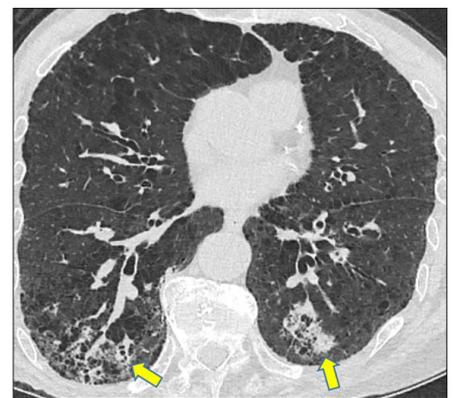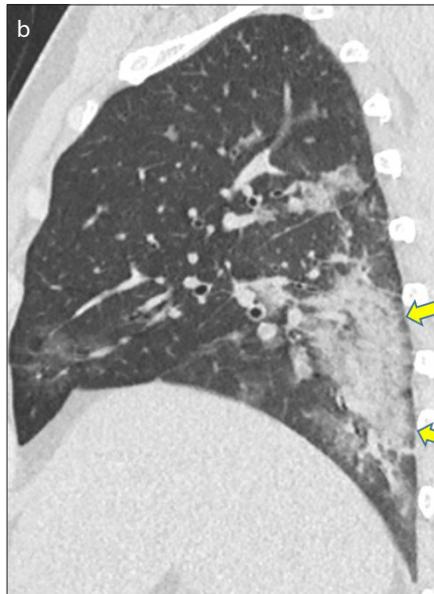

Figure 17. Axial CT image of a 74-year-old patient with confirmed COVID-19 pneumonia shows extensive emphysema in both lungs. There is also irregular consolidation in both lower lobes, mimicking nonspecific bronchopneumonia *(yellow arrows)*.
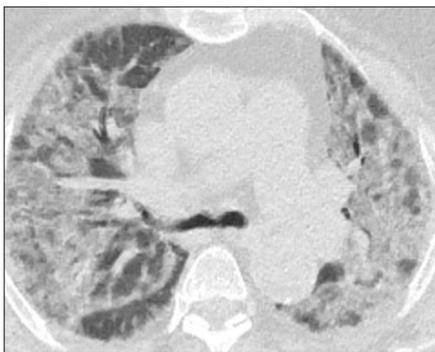
Conclusion

Typical CT findings of COVID-19 pneumonia are bilateral lower lobe predominant and multifocal involvement, GGO and accompanying consolidations. On the other hand, atypical chest CT findings such as central and peribronchovascular involvement, isolated upper lobe involvement, solitary involvement, lobar consolidation, nodule formation, subpleural sparing, pleural and pericardial effusion can be seen in COVID-19 pneumonia. Recognition of atypical, less common findings that can be confused with other diseases is vital to avoid misdiagnosis. Epidemic factors, clinical findings, RT-PCR test and radiological findings are complementary in the diagnosis of the disease. Therefore, multidisciplinary cooperation is important in the diagnosis of COVID-19 pneumonia, and it is of great

to evaluate these patients in comparison with their previous examinations. Although cavity is mostly secondary to the concomitant disease, an isolated cavitary lesion has been reported in COVID-19 pneumonia (19).
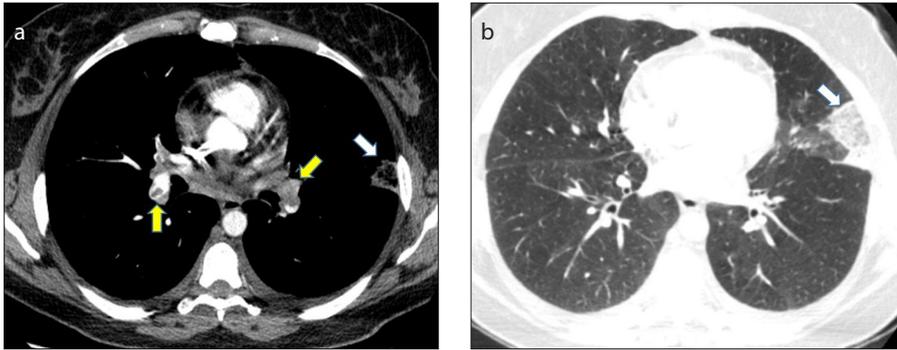
Figure 18. a, b. Contrast-enhanced CT scan of a 41-year-old female patient with COVID-19 pneumonia. Axial image **(a)** shows pulmonary embolism in the branches of the right and left pulmonary arteries *(yellow arrows)* on mediastinal window settings. Peripheral infarction due to embolism *(white arrows)* is seen on mediastinal **(a)** and lung window **(b)** settings.
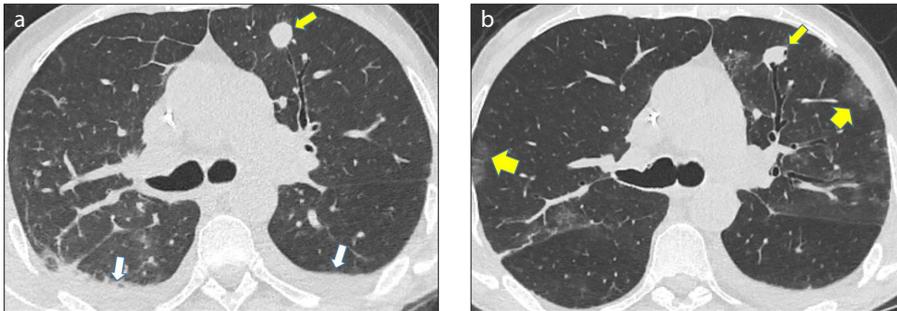

Figure 19. a, b. Axial image **(a)** shows the focus of fungal pneumonia *(yellow arrow)* developing after neutropenia in a patient with chronic lymphocytic leukemia. Bilateral pleural effusion *(white arrows)* is also seen. One week later, the patient was diagnosed with COVID-19 pneumonia and newly developed peripheral GGOs are observed in follow-up CT (**b,** *thick yellow arrows*).

importance in preventing misdiagnosis and treatment, especially in patients with atypical course.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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