



# Pictorial review of COVID-19 in the Lublin Region – Imaging disease progression with CXR and CT

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## Abstract

**Introduction.** COVID-19 is a disease caused by SARS-Cov-2 that has reached the pandemic status and has infected in one year more than 62 million people. Clinical symptoms range from barely noticeable to very severe. It is crucial to recognize imaging patterns of COVID-19, allowing for better diagnosis and treatment. Diagnostic imaging is also essential in monitoring patients in the course of the disease.

**Objective.** In our pictorial review we describe the most common pulmonary manifestations of COVID-19, and show the typical and non-typical features of COVID-19 encountered in our hospital in Lublin, Poland. Imaging the disease progression is also visualized to help realize how pulmonary changes occur over the time.

**State of knowledge and Conclusions.** COVID-19 involves both lung parenchyma and interstitium and has multiple imaging features, varying from ground glass opacities (GGO), consolidations, reticular interstitial pattern, honeycombing or crazy-paving. Mediastinal and hilar lymph node enlargement or pleural effusion may appear, but are rare and atypical. GGO are located peripherally, bilaterally and predominantly in the lower lobes, and in the early stage are better seen on CT imaging. Progression of imaging findings take different times, with the peak of imaging features appearing around 10–14 days after initial symptoms. While it is harder to discern subtle changes on CXR, progression can be very well monitored by his method. Final pulmonary consequences of the disease should be assessed with the use of CT.

## Key words

Covid-19, SARS-Cov2, pulmonary findings, imaging, CXR, CT, lungs

## INTRODUCTION

COVID-19 is a disease caused by SARS-Cov-2 that has reached pandemic status and has currently infected more than 62 million people [1]. The disease is highly infectious and can be transmitted by respiratory droplets, direct contact with infected people and contaminated objects, via airborne transmission and with fecal-oral route [2]. Clinical symptoms range from barely noticeable to very severe. The most common symptoms include fever, fatigue, cough, anorexia and dyspnea [3].

Poland faced a strong increase in the second wave of the world's pandemic, mostly in the last quarter of 2020. The number of infected people is rapidly approaching close to 1 million. Most cases seem milder in progress than the reported statistics in the USA or Western European countries. As COVID-19 is a new and still not well-known and highly infectious disease, it is crucial to recognize its patterns, allowing for better diagnosis and treatment. Diagnostic imaging can be essential in monitoring patients and helping doctors decide on the best treatment. Multiple case studies and reviews have helped determined imaging features considered characteristic for COVID-19.

## OBJECTIVE

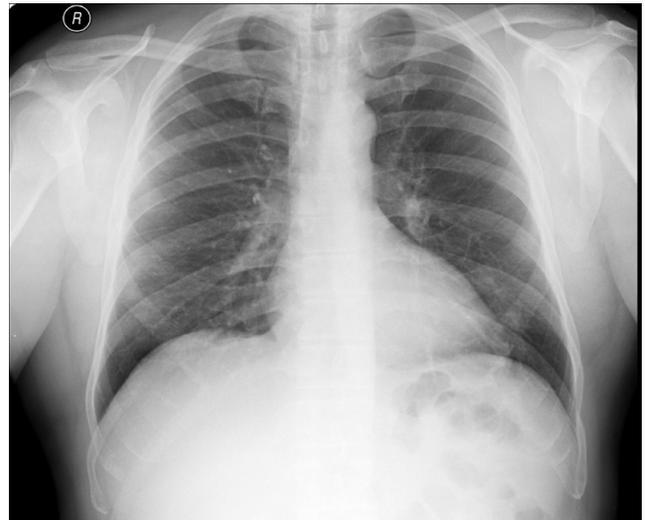
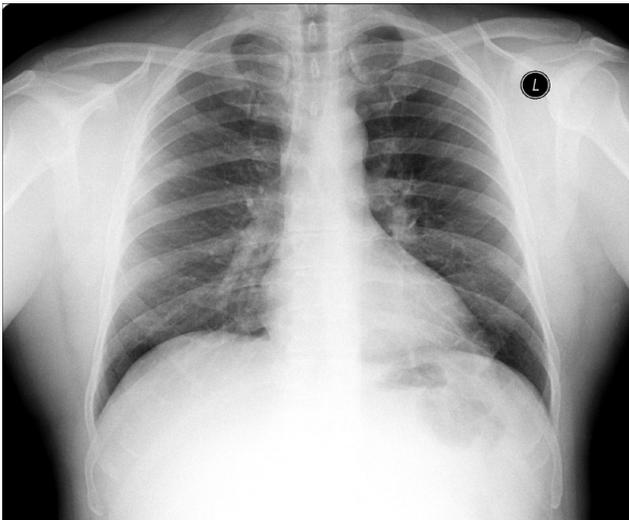
The aim of the pictorial review is to describe the most common pulmonary manifestations of COVID-19, and report the typical and non-typical features of COVID-19 encountered in our hospital in Lublin, Poland. Imaging the disease progression is also shown on numerous patient examples to realize how pulmonary changes occur over time.

**State of knowledge – Diagnostic imaging.** COVID-19 involves both lung parenchyma and interstitium and has multiple imaging features [4, 5]. Ground glass opacities (GGOs) are non-specific hazy opacities caused by incomplete obliteration of the alveoli, but bronchi and pulmonary vessels are not obscured (Fig. 1, 2). It is the most common manifestation of COVID-19, both on CT and CXR, often accompanied by consolidations [6–10]. During the early stages, GGOs are usually located peripherally or subpleurally [8, 11]; usually located bilaterally, with predilection to lower lobes or posterior parts of the lungs [9, 10, 12]. The right lower lobe is often affected. [13] Those findings may be related to the anatomy of the respiratory tract and positioning of the patients. Rarely, central nodular GGOs can be observed [8, 11].

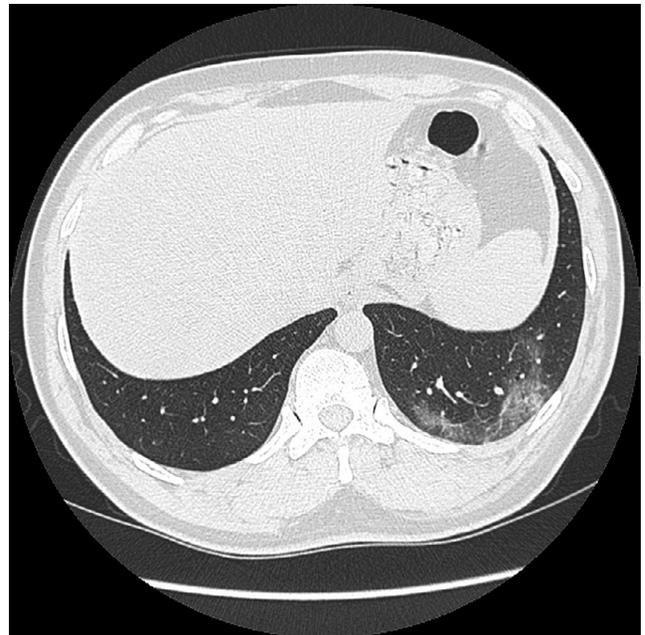
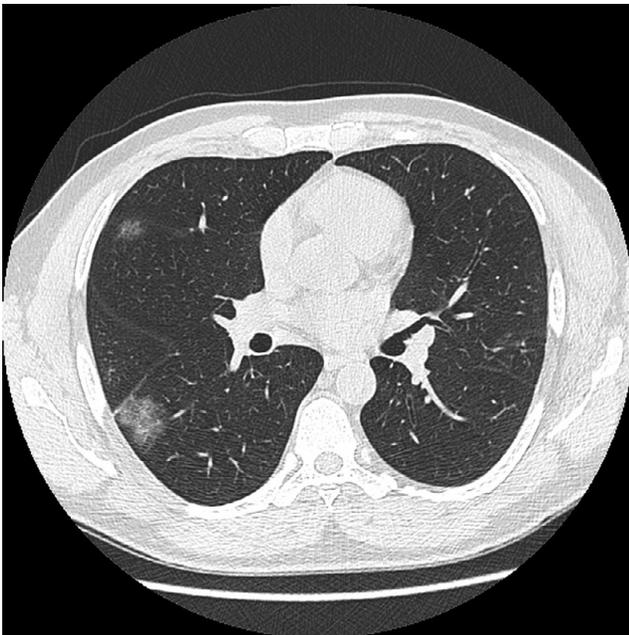
Consolidations differ from ground glass opacities by obscured bronchi and pulmonary vessels [7]. They can occur independently of GGOs, but it is uncommon [9, 13]. Air bronchogram sign is often visible [4]. If consolidations

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**Figure 1 a, b.** Male patient 56 y.o. Early and beginning changes on CXR, at admission (a) and 4 days later (b). Progression of more visible diffuse reticular pattern is seen.



**Figure 2 a, b.** Typical multiple, peripheral ground glass opacities, the same patient as in Fig. 1, 4 days after initial clinical symptoms.

surround GGO in a ring pattern it is called a reverse halo sign, strongly indicating organizing pneumonia. Consolidations may indicate a more severe disease and potential further complications, e.g. fibrosis (Fig. 3, 4) [14].

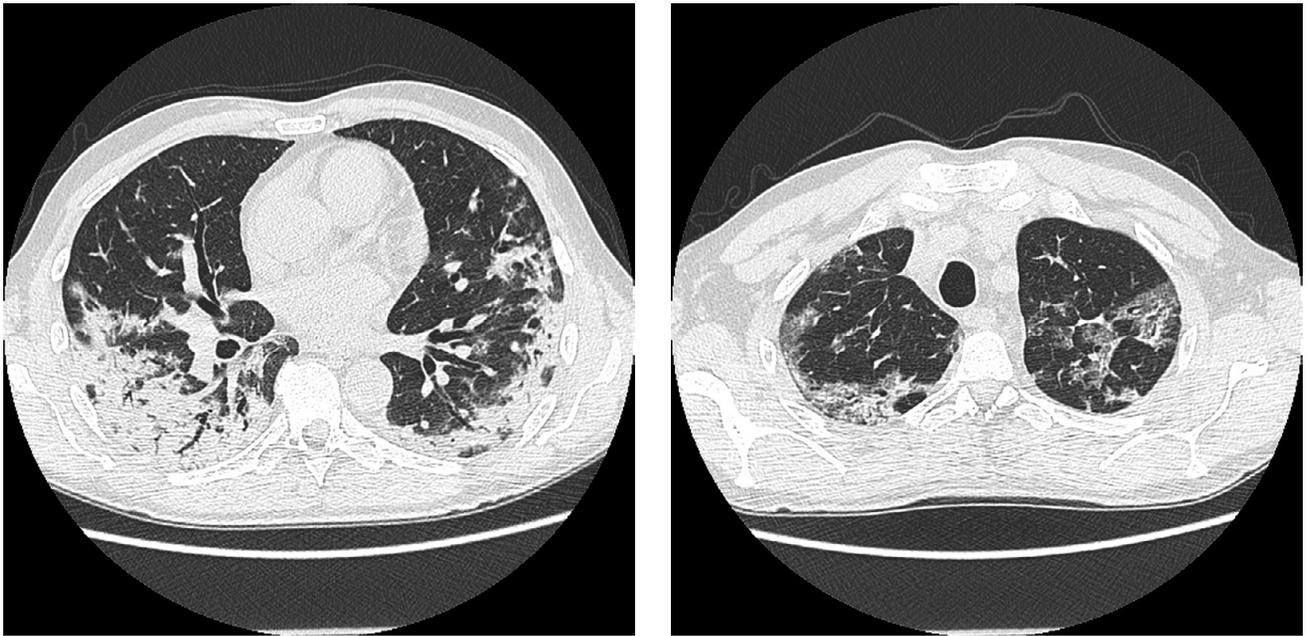
Reticular interstitial pattern is a non-specific feature of intralobular interstitial thickening, often accompanied by septal thickening caused by pathological changes in

interlobular septa. While interlobular septa are normally generally invisible on HRCT, thickened septa form a visible pattern [15]. This occurs in some COVID-19 cases and may persist for several weeks and possibly lead to fibrosis [11, 16]. Honeycombing – an advanced fibrosis and destruction of lung parenchyma – may also occur [3, 15].

Crazy-paving is an appearance of interlobular and



**Figure 3 a, b, c, d.** Male patient 54 y.o. Progression of Covid-19 during 3 weeks of hospitalization monitored by CXR: interstitial thickening at admission (a), GGO and small consolidations appear 5 days later (b), diffuse consolidations and reticular pattern in both lungs 12 days after admission (c) and partial clearing with developing fibrosis 3 weeks after admission (d).



**Figure 4 a, b.** CT scan of the same patient as in Fig.3, 12 days after the admission: large consolidations in the posterior parts of the lungs, air bronchogram visible, clearing GGOs, elements of fibrosis



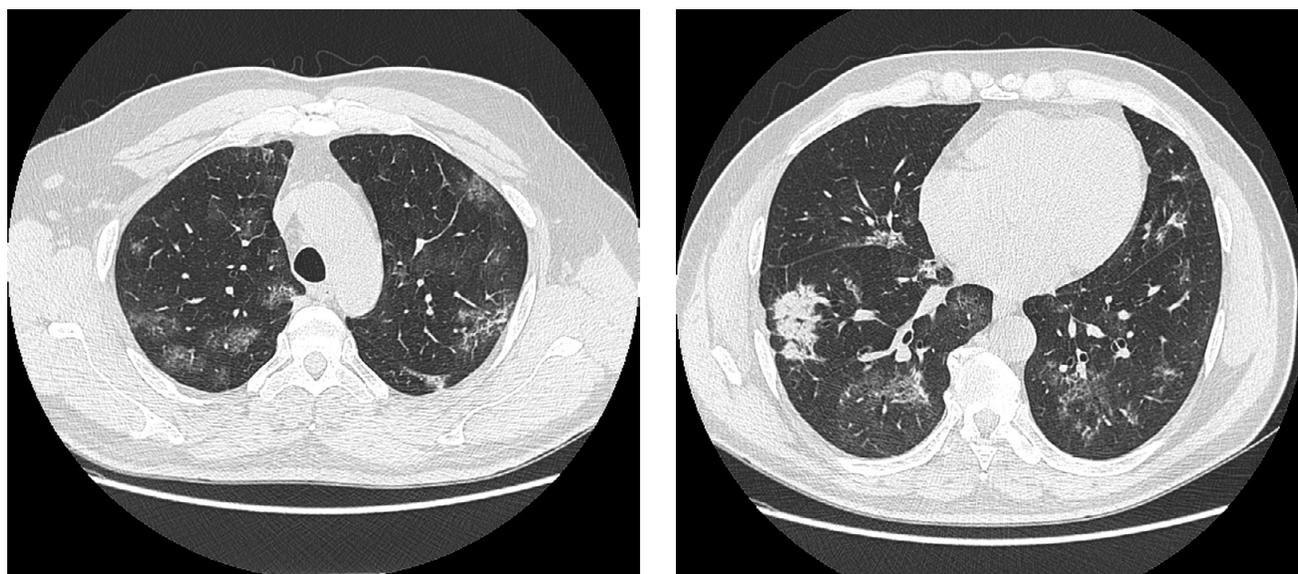
**Figure 5 a, b, c.** Example of little and slow progression in a 47-year-old male patient: X-ray at the admission with small peripheral opacities in the right lower lobe (a), multiple diffuse peripheral GGOs in middle and lower lobes 3 days later (b), persistence of multiple GGOs with little consolidations 16 days after admission (c)

intralobular thickened interstitium superimposed on ground glass opacities. The pattern is less regular than in reticulations and may be caused by enlarged blood vessels, which are also a recurrent COVID-19 feature [5]. Although this is less common, it may indicate a more severe disease, as it usually appears at the peak [4, 14]. Crazy paving and consolidations in earlier stages of the disease may indicate either a shorter course of the disease (good prognosis) or rapid progress (poor prognosis) [8].

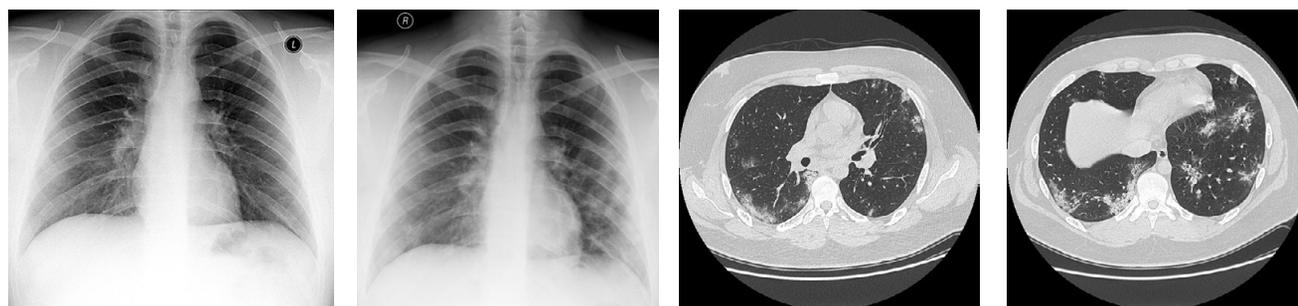
**Evolution with time.** Manifestations of COVID-19 evolve with time, along with severity of the disease [8, 16]. At the early stage, focal GGOs are seen predominantly subpleurally in the lower lobes, eventually becoming diffuse in progressive disease (Fig. 5, 6). Peak stage is associated with the appearance of dense consolidations and crazy paving. As the disease progresses, more lobes are affected, up to all 5 lobes [8, 18, 19]. The majority of confirmed cases have involved 3 or more lobes, and severity of the disease correlates with the number of the lobes involved (Fig. 7) [14]. Mediastinal and hilar lymph node enlargement or pleural effusion may appear, but are rare and atypical [9, 19]. The severe, life-threatening disease can manifest as white lung [16]. GGOs and consolidations resolving and no crazy paving indicate the

remission stage of the disease [4, 9]. Eventually, slow recovery and regression of changes in the lungs occur, although it is possible that residual fibrosis may remain (Fig. 8, 9, 10) [11, 16].

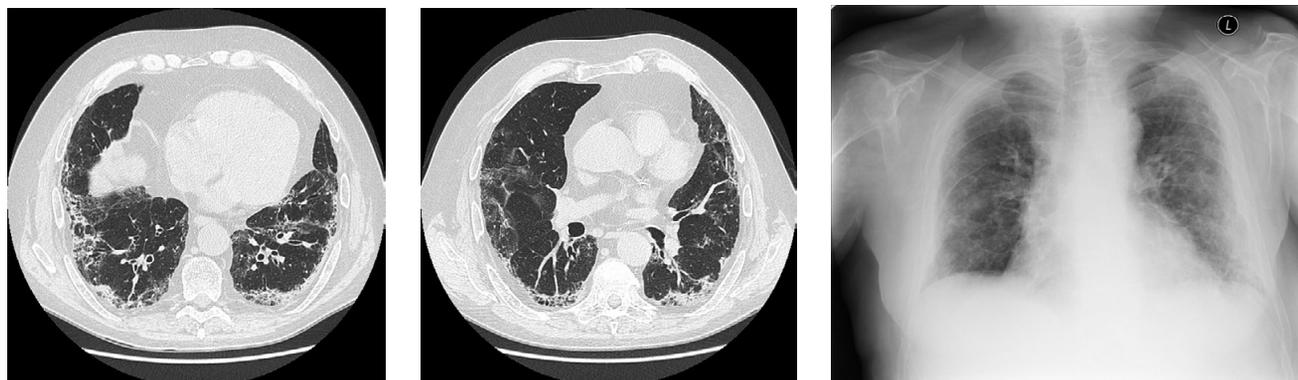
**The role of imaging in diagnosis and imaging disease progression.** While diagnostic imaging on its own is not enough to confirm the disease, it is invaluable in recognizing suspicious cases and evaluating the severity of the disease [20]. RT-PCR tests have their drawbacks (such as shortages and long waiting time to receive results), which can be compensated by combining them with chest CT, allowing the isolation of suspected patients and testing them later. Furthermore, initially negative RT-PCR tests with positive COVID-19 features on chest CT have been reported, necessitating careful analysis of all suspicious cases. Many confirmed COVID-19 cases, however, present initially with little or no changes on chest CT [21]. Sometimes, clinical symptoms may be atypical or regress, while imaging indicates a progressing viral pneumonia; in other cases, despite clear clinical symptoms, there are no imaging features of COVID-19. Because of this discrepancy, imaging should be supported with clinical, epidemiological and laboratory data [21].



**Figure 6 a, b.** The same patient as in Fig. 5 (47 M): CT at admission (a) showing multiple GGOs and CT after 16 days (b) showing singular consolidations and persistent GGOs.



**Figure 7 a, b, c, d.** Progression of a 26-year-old-man from subtle interstitial changes at admission (a) to multiple diffuse peripheral opacities, located mainly in middle and low lobes 10 days later (b). Chest HRCT done after 10 days of symptoms shows bilateral, peripheral GGOs and consolidations (c,d).

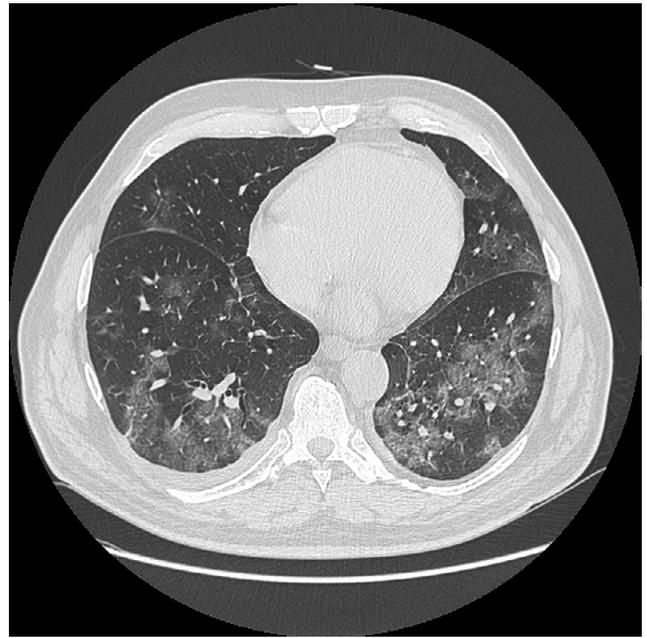
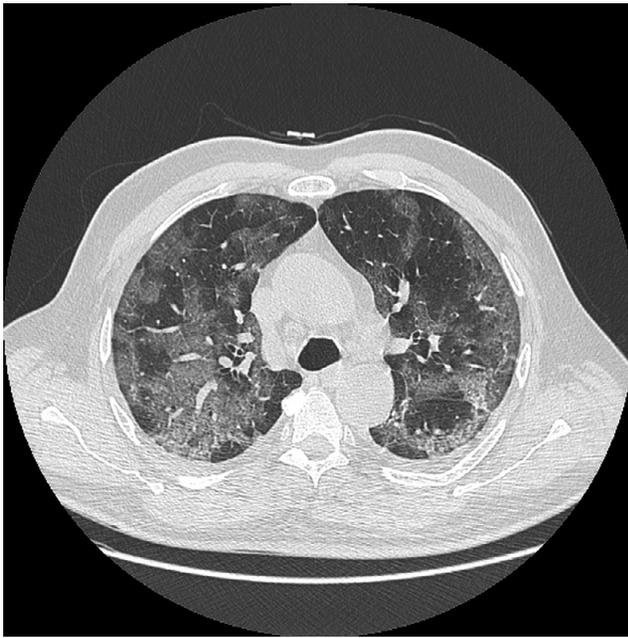


**Figure 8 a, b, c.** Important progression of pulmonary findings in a 72-year old-man on CT scan, 10 days after admission to hospital: clearing GGOs, crazy pavings, honeycomb pattern and fibrosis (a,b). CXR taken a month after the beginning of the disease still shows diffuse reticular interstitial opacities consistent with fibrosis (c).

The WHO discourages the transporting of patients unless necessary, and recommends using designated portable X-ray machines to reduce the risk of contagion. Radiology departments should introduce strategies, such as utilizing personal protective equipment, minimizing interaction between people, designating X-ray and CT machines exclusively for potentially infected patients, and disinfection after contact [22]. Access to CT may be disrupted due to disinfection protocols and limiting patients' transport; therefore, it is vital to recognize possible COVID-19

features on classic CXR which allows for sensitivity of around 69% [23].

The most common imaging feature of COVID-19 are ground glass opacities, sometimes with reticular thickening, and less commonly, consolidations (usually in progressing disease). Changes in the interstitium, manifesting as reticular pattern (visible both on CXR and CT) and crazy-paving sign, are also common [24, 25]. Short-term CT follow-up can reveal progress of the disease, from small opacities through multifocal ground glass opacities and consolidations, with



**Figure 9 a, b.** CT images in a 65 year-old man showing diffuse extensive GGOs in entire lungs and fibrotic changes in the clinical pic of the disease



**Figure 10 a, b, c, d.** A middle-aged man (M, 49) with subtle opacities in the middle lobe at admission (a) developing typical lobar pneumonia opacities at day 4 (b). CT scans taken 1 week after the onset of symptoms show organizing pneumonia (c) and further consolidations and GGOs in the right lower lobe (d).

occasional crazy-paving to eventual partial clearing [9]. Care must be taken, however, to limit patients' radiation exposure. Features characteristic to COVID-19, such as bilateral, peripheral consolidations, predominantly in the lower lungs, can be seen on CXR [26]. Both CT and CXR are useful, but due to overlapping of consolidations CT is better for initial diagnosis, while CXR can be used for further examinations [27, 28]. CXR may also be useful in monitoring severely ill patients and to recognize complications, such as cavitations and pneumothorax [29].

Both BSTI and RSNA introduce systems of classifying suspected COVID-19 patterns; notably, in both of them, multiple GGOs located peripherally and bilaterally are highly indicative of COVID-19, while consolidations, crazy-paving and organizing pneumonia are secondary criteria. While features such as lymphadenopathy, effusions, and tree-in-a-bud can rarely appear in COVID-19, alternate diagnosis is considered more likely [30, 31].

The imaging features of COVID-19 should be differentiated from other possible causes, such as pneumonia, caused by other viruses and *Mycoplasma pneumoniae*, heart failure, eosinophilic pneumonia, and organizing pneumonia caused by damage from drugs or smoking, or connective tissue diseases [25].

## CONCLUSIONS

Ground glass opacities, located peripherally, bilaterally and predominantly in the lower lobes, appear to be the most common manifestation of COVID-19.

COVID-19 cases can progress from subtle changes during admission, to multiple GGOs, consolidations and crazy-paving after a different range of time. The exact number of days from initial presentation to peak COVID can differ between cases, but usually oscillate around 10–14 days.

While it is harder to discern subtle changes on CXR, progression can still be very well monitored that way.

COVID-19 changes take a long time to regress, even several months. Comparison with the previous imaging helps with assessment of the course of the disease and its severity.

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