Imaging of COVID-19 simulators
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Abstract

Background: Coronavirus (COVID-19) pneumonia emerged in Wuhan, China, in December 2019. It was highly contagious spreading all over the world, with a rapid increase in the number of deaths. The reported cases have reached more than 14 million with more than 600,000 deaths around the world. So, the pandemic of COVID-19 became a surpassing healthcare crisis with an intensive load on the healthcare resources. In this study, the aim was to differentiate COVID-19 pneumonia from its mimickers as atypical infection, interstitial lung diseases, and eosinophilic lung diseases based on CT, clinical, and laboratory findings.

Results: This retrospective study included 260 patients, of which 220 were confirmed as COVID-19 positive by two repeated RT-PCR test and 40 were classified as non-COVID by two repeated negative RT-PCR test or identification of other pathogens, other relevant histories, or clinical findings. In this study, 158 patients were male (60.7 %) and 102 patients were female (39.3%). There was 60.9% of the COVID-19 group were male and 39.1% were female. Patients in the non-COVID group were significantly older (the mean age was 46.4) than those in the confirmed COVID-19 group (35.2y). In the COVID-19 group, there was exposure history to positive cases in 84.1% while positive exposure history was 20% in the non-COVID group.

Conclusion: The spectrum of CT imaging findings in COVID-19 pneumonia is wide that could be contributed by many other diseases making the interpretation of chest CTs nowadays challenging to differentiate between different diseases having the same signs and act as deceiving simulators in the era of COVID-19.

Keywords: COVID-19 coronavirus infections, CT computed tomography, Atypical pneumonia, Interstitial lung diseases

Background

In December 2019, the first case with acute lower respiratory tract infection caused by the novel coronavirus (nCoV-2019) was reported in China [1]. In March 11, 2020, the World Health Organization has announced that coronavirus disease 2019 (COVID-19) is a pandemic and public health emergency of a global scope [2]. In April 8, 2020, the epidemic had reached to the whole earth countries, and the first million of infected humans had been reached [3].

Clinically, COVID-19 has variable presentations from an asymptomatic infection or mild upper respiratory tract symptoms to vigorous viral pneumonia with respiratory failure and even death [4].

At the time of writing these words, the reported cases have reached more than 14 million with more than 600,000 deaths around the world. So, the pandemic of COVID-19 became a surpassing healthcare crisis with an intensive load on the healthcare resources [5].

This rapid wide explosion of the pandemic was due to the lack of the early detection and control of the infection. Also, not all patients are tested, especially asymptomatic cases, or cases with mild symptoms. The primary standard of COVID-19 confirmation is the microbiological tests namely real-time polymerase chain reaction (RT-PCR) [6].

Computed tomography (CT) is used as an important complementary tool to RT-PCR for diagnosing COVID-19 in this ongoing pandemic because these microbiological tests may be unavailable or slow in this emergency context [7].
As RT-PCR may be insufficient, shortage of kits, falsely negative, extended processing period, or long mean time interval between initial negative and positive lab tests as well as its variable sensitivity ranging from 37 to 71%, the chest CT shows a sensitivity of 97% in the diagnosis of COVID-19 [8].

So, the chest CT can play a main role in the early detection and management of COVID-19 pneumonia [6], especially for patients who have symptoms for more than 3 days [9].

Now, the systems of typical chest CT findings in COVID-19 have been established mainly involving the bilateral, peripheral, and basal predominant ground-glass opacities (GGOs) with or without consolidation with a peak of 9–13 days after the infection [10].

Also, atypical chest CT findings like central apical predominance, cavitations, masses, nodules, tree-in-buds, lymphadenopathy, and pleural thickening are included in the spectrum of imaging findings [11].

The spectrum of CT imaging findings in COVID-19 is wide and includes a lot of signs that could be contributed by many other diseases making the interpretation of chest CTs nowadays like an imitation game, for instance, not every GGO is a COVID-19, so it is a challenging to differentiate between different diseases having the same signs and act as deceiving simulators in the era of COVID-19.

In this study, the aim was to differentiate COVID-19 pneumonia from its mimickers based on CT findings, clinical, and laboratory details.

Methods
Two-hundred sixty patients were enrolled in this retrospective study in the period of the 30th of June and the 15th of August 2020. There were 158 males (60.7%) and 102 females (39.3%) with male to female distribution was 1.5:1.

All patients underwent high-resolution CT within 7 days after the onset of respiratory symptoms. Of those 260 patients, 220 cases of COVID-19 were confirmed with two consecutive positive PCR tests.

Inclusion criteria include
Patients presented with fever and/or respiratory symptoms within 7 days of CT examination and/or exposure history to confirmed cases or respiratory symptom-related patient.

The clinical data including the age, sex, exposure history, nasopharyngeal swab results, and laboratory parameters of all patients were collected.

The study protocol was approved by the local ethics committee. All patients provided a written informed consent.

CT image acquisition
CT scans were performed within 7 days after symptom onset on a helical 64-slice CT Philips (parameters Kv 120, mAs 200, field of view 350 mm, thickness 0.67 mm, increment 0.67 mm matrix 768, scan time 5.6 s). Image reconstruction was done at a slice thickness of 1–1.25 mm.

CT image analysis
The image analysis of each patient described:

- A number of lobes involved.
- Distribution characteristics of the lesions (e.g., peripheral distribution, central distribution, subpleural distribution, and posterior distribution).
- A pattern of the lesion (e.g., ground glass opacification (GGO) with or without consolidation, crazy-paving pattern, and the shape of the GGO).
- Associated signs in the lesion (e.g., bronchial and/or bronchiolar wall thickening), and tree-in-bud sign).

Based on the CT findings, the level of suspicion of COVID-19 infection is graded from very low or CORADS 1 up to very high or CORADS 5.

CORADS 1: The CT is normal or there are findings that indicate a non-infectious disease like congestive heart failure, sarcoid, histoplasmosis, malignancy, UIP, or fibrotic NSIP.

CORADS 2: Level of suspicion of COVID-19 infection is low. CT findings consistent with other infections like typical bronchiolitis with tree-in-bud and thickened bronchus walls.

CORADS 3: COVID-19 unsure or indeterminate. CT abnormalities indicating infection, but unsure whether COVID-19 is involved, like widespread bronchopneumonia, lobar pneumonia, and septic emboli with ground glass opacities.

CORADS 4: The level of suspicion is high. Mostly, these are suspicious CT findings but not extremely typical:

- Unilateral ground glass
- Multifocal consolidations without any other typical finding
- Findings suspicious of COVID-19 in underlying pulmonary disease.

CORADS 5: The level of suspicion is very high. CT findings: bilateral GGO and consolidation, basal preference, vascular thickening, and subpleural bands. PCR is positive.

Patients with low CORADS score (1 to 3) and patients with CORADS 4 with negative PCR test were the main
concern. All clinical and laboratory data were meticulously analyzed to reach the final diagnosis.

Three experienced radiologists (20 and 15 years of experience) independently reviewed all the scans. There was a perfect inter-observer agreement between the readers as regards CORADS scoring of the cases ($K = 0.83$).

Statistical analysis
Inter-observer agreement analysis was performed by the Cohen coefficient was to determine segmental lesion detection consistency among observers. Values were interpreted on the basis of the convention by Landis and Koch as follows: Kappa agreement $< 0$ less than chance agreement, $0.01 – 0.20$ slight agreement, $0.21 – 0.40$ fair agreement, $0.41 – 0.60$ moderate agreement, $0.61 – 0.80$ substantial agreement, and $0.81 – 0.99$ almost perfect agreement.

Results
This retrospective study included 260 patients, of which 220 were confirmed as COVID-19 positive by two repeated RT-PCR test, and 40 were classified as non-COVID by two repeated negative RT-PCR tests or identification of other pathogens, other relevant histories, or clinical findings.

In this study, 158 patients were male (60.7%) and 102 patients were female (39.3%). There were 60.9% of the COVID-19 group who were male and 39.1% who were female. Patients in the non-COVID group were significantly older (the mean age was 46.4) than those in the confirmed COVID-19 group (35.2 years). In the COVID-19 group, there was exposure history to positive cases in 84.1% while positive exposure history was 20% in the non-COVID group.

The duration between the start of symptoms and CT imaging was about 3 days in the COVID-19 group and about 5 days in the non-COVID group (Table 1).

The most presenting symptoms (Table 2) in the COVID-19 group were fever (95.4%) and cough (92.7%) while the most presenting symptom in the non-COVID group was cough in 92.5%.

In the non-COVID group, 55% had a high leucocytic count; however, in the COVID-19 group, 76.4% had a low leucocytic count. COVID-19 patients had a high ferritin level (86.4%) and high a D-dimer level (97.1%); however, the non-COVID group had predominant normal ferritin level (72.5%) and normal D-dimer (95%) (Table 3).

CT imaging findings (Table 4)
A high-resolution CT chest was done for all 260 examined patients. GGO with or without consolidation was the constant imaging feature seen in both groups. Rounded GGO was more prominent in the COVID-19 group ($n = 194, 88.2$%). Bilateral involvement with

| Table 1 | Demographic data of the cases |
|---------|-------------------------------|
| Parameter | COVID confirmed cases | Low CORAD score and COVID non-confirmed cases |
| Age | 35.2 (22–61) | 46.4 (10–63) |
| Gender | | |
| Male | 134 (60.9%) | 24 (60%) |
| Female | 86 (39.1%) | 16 (40%) |
| Exposure history | 185 (84.1%) | 8 (20%) |
| Duration between symptoms and CT imaging | 3 (1–6) days | 5 (1–7) |

| Table 2 | Clinical presentation of the cases |
|---------|----------------------------------|
| Presenting symptoms | COVID confirmed cases | Low CORAD score and COVID non-confirmed cases |
| | $n=220$ | $n=40$ |
| Fever | 210 | 25 |
| Cough | 204 | 37 |
| Sputum | 60 | 33 |
| Runny nose | 170 | 16 |
| Loss of smell and taste | 190 | 5 |
| Chest pain/tightness | 168 | 28 |
| Sore throat | 148 | 3 |
| Diarrhea and abdominal pain | 126 | 2 |
| Fatigue and muscle pain | 180 | 14 |
| Hemoptysis | 0 | 1 |

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Peripheral and lower lobe predominance was more evident in the COVID-19 group. Bronchial wall thickening and central predominance were more prominent in the non-COVID group (42.5% and 27.5%, respectively). Tree-in-bud opacity and cavitations were seen only in the non-COVID group. Table 5 representing the diagnostic clues for COVID-19 mimicker based on CT, laboratory, and clinical findings.

Discussion
COVID-19 pandemic is a severe and easily transmissible disease exploding all around the world. Chest CT scans play an essential role in the initial and early diagnosis of COVID-19 as it can show positive findings before the initial positive RT-PCR. So, it is important to focus on baseline CT findings and radiologists' capabilities to differentiate between non-COVID and COVID-19 in the first consultation to provide proper isolation and treatment [12].

Bai et al. [13] cited that radiologists were capable of differentiating COVID-19 from other viral pneumonias by chest CT with high specificity and moderate or varying specificity (24–94%) among 7 different readers from the USA and China, but an easy simple understood system is still needed especially in epidemic areas with poor medical resources and expert radiologists. According to previous studies, COVID-19 is more likely to present with some CT image features compared to non-COVID-19 diseases.

All studies indicate that the main CT feature of COVID-19 pneumonia is the presence of ground-glass

Table 3 Laboratory finding in the cases

| Laboratory finding | COVID confirmed cases | Low CORAD score and COVID non-confirmed cases |
|--------------------|-----------------------|---------------------------------------------|
|                    | n=220 | % | n=40 | % |
| Leucocytic count   |       |   |       |   |
| High               | 16    | 7.3 | 22    | 55 |
| Low                | 168   | 76.3 | 11    | 27.5 |
| Normal             | 36    | 16.4 | 7     | 17.5 |
| Ferritin           |       |   |       |   |
| High               | 190   | 86.4 | 4     | 10 |
| Low                | 10    | 4.5 | 7     | 17.5 |
| Normal             | 20    | 9.1 | 29    | 72.5 |
| d-dimer            |       |   |       |   |
| High               | 174   | 79.1 | 2     | 5 |
| Low                | 14    | 6.4 | -     | 0 |
| Normal             | 32    | 14.5 | 38    | 95 |

Table 4 CT findings in all cases

| CT imaging findings         | COVID confirmed cases | Low CORAD score and COVID non-confirmed cases | Total |
|-----------------------------|-----------------------|---------------------------------------------|-------|
|                             | n=220 | % | n=40 | %   |       |
| Bilateral involvement       | 210   | 95.5 | 31   | 77.5 | 241   |
| Peripheral distribution     | 188   | 85.5 | 22   | 55   | 210   |
| Lower lobe predominance     | 210   | 95.5 | 28   | 70   | 238   |
| Ground glass +/− consolidation | 220 | 100  | 40   | 100  | 260   |
| Rounded ground glass opacities | 194 | 88.2 | 3    | 7.5  | 197   |
| Crazy paving                | 172   | 78.2 | 4    | 10   | 176   |
| Subpleural bands            | 148   | 67.3 | 12   | 30   | 160   |
| One lobe involvement        | 6     | 2.7  | 5    | 12.5 | 11    |
| Central predominance        | 14    | 6.4  | 11   | 27.5 | 25    |
| Tree in bud                 | 0     | 0    | 12   | 30   | 12    |
| Bronchial wall thickening   | 44    | 20   | 17   | 42.5 | 61    |
| Cavitation                  | 0     | 0    | 5    | 12.5 | 5     |
| Pleural effusion            | 4     | 1.8  | 12   | 30   | 16    |
| Final diagnosis | Diagnostic clues | Number of cases |
|----------------|------------------|----------------|
| **Bronchial asthma** | History of bronchial asthma | 3 |
| **Eosinophilic lung** | Churg-Strauss syndrome, History of bronchial asthma, sinusitis, Pleural effusion | 1 |
| Drug rash with eosinophilia and systemic symptoms (DRESS) syndrome | Clinical history, skin rash, Pleural effusion | 1 |
| Löffler syndrome | Fleeting opacities, Peripheral blood eosinophilia and high IgE level | 1 |
| **H1N1** | PCR test revealed H1N1 virus | 1 |
| **ARDS** | Clinical criteria, Bilateral basal dense consolidation on a background of diffuse GGO in the non-dependent regions with bronchial dilatation in GGO and crazy paving appearance | 3 |
| **Hypersensitivity pneumonitis** | Clinical history of exposure to antigen (Bird fancier's Disease), Reproduction of symptoms following exposure, Poorly defined centrilobular nodules, Headcheese lung in subacute phase | 4 |
| **RB-ILD** | History of smoking, No fever, Ground-glass opacities and centrilobular nodules, Bronchoalveolar lavage (BAL) findings (the presence of smokers' macrophages and the absence of lymphocytosis) | 2 |
| **Amiodarone lung** | History of drug intake, Peripheral patches, Pulmonary nodules and septal thickening, Fiberoptic bronchoscopy with BAL and transbronchial biopsy | 1 |
| **SLE with diffuse alveolar hemorrhage** | History of SLE, hemoptysis, Upper lobe predominance, confluent consolidation sparing costophrenic angles and the lung periphery, | 1 |
| **Trauma** | History of recent trauma, Pneumothorax | 5 |
| **Atypical bacterial infection** | Mycoplasma bronchopneumonia, Pleural effusion, Peribronchial thickening, confined to lobes, GGO peribronchial thickening and pneumatocele | 1 |
| **SLE** | History of SLE, hemoptysis, Upper lobe predominance, confluent consolidation sparing costophrenic angles and the lung periphery, | 1 |
| Final diagnosis                                      | Diagnostic clues                                      | Number of cases |
|-----------------------------------------------------|-------------------------------------------------------|-----------------|
| Other bacterial pneumonia                          | Clinical history                                      | Unilateral lung affection                           | 6 |
|                                                     | Pleural/cardiac involvement                           | Pleural effusion                                      |   |
|                                                     | Pulmonary parenchymal involvement                     | Atoll sign                                             |   |
|                                                     | Laboratory/biopsy                                     | Confirmed by histopathological correlation            |   |
| Alveolar sarcoid                                     | History of sarcoid                                    | Upper lobe affection, peribronchial thickening, mediastinal lymph nodes | 1 |
|                                                     | No fever                                              | Bilateral asymmetric confluent GGO with consolidate patches more in the lower lobes |   |
| Acute Interstitial Pneumonia                        | Acute symptoms like ARDS                              | Bilateral asymmetric confluent GGO                    | 1 |
|                                                     |                                                      | Proved by transbronchial biopsy                        |   |
| Cryptogenic organizing pneumonia                    | Pleural effusion                                      | Pleural effusion                                      | 2 |
|                                                     |                                                      | Asymmetric lung involvement with crazy paving appearance |   |
| Pulmonary alveolar proteinosis                       | History of renal failure                              | High-density centrilobular ground glass nodules with superadded infection | 1 |
| Metastatic Calcifications with renal failure         | History of renal failure                              | Enlarged cardiac size +/- pericardial effusion, dilated pulmonary trunk, bilateral pleural effusion, |   |
|                                                     |                                                      | Thickened interlobular septal, peri-lymphatic, and peribronchovascular thickening |   |
|                                                     |                                                      | Perihilar distribution of ground glass opacities (bat wing) |   |

**Table 5** Diagnostic clues for COVID-19 mimicker (Continued)

**Fig. 1** A 10-year-old male patient with fever and cough. CT (a–d) showed bilateral scattered ground glass patches more central than peripheral (white arrows) with large pneumatocele at the medial segment of the right middle lobe (blue arrow). The diagnosis was staph pneumonia. A 45-year-old male patient with cough and fever. CT (e–h) showed unilateral right lung consolidative patch with tree-in-bud appearance and ground glass appearance (arrows in e and f) with cylindrical bronchiectasis at the middle and lower lobes (arrows in g and h) and peribronchial thickening. The diagnosis was bacterial pneumonia.
opacities (GGO), typically with a peripheral and subpleural distribution. The multiple lobes involvement with basal predominance is reported in the majority of cases with COVID-19 [10].

GGO can result from various pathologies of alveolar filling with water, pus, protein, blood, or cells including viral infections, like COVID-19, as well as bacterial infections [1].

In their study, Luo et al. [14] added some negative points to make a hierarchical diagnosis. As the most of the reported COVID-19 cases show affection of more than 2 lobes of the lungs, only one lobe involvement is considered as a negative scoring point and also the single-lobe affection has been reported in some cases of community-acquired pneumonia.
Many things in the lungs look exactly the same, and due to the tens of entities that contribute to GGO and/or consolidation, it is critical to understand the new and sometimes puzzling clinical presentations emerging in the current COVID-19 pandemic and it is important to have at hand concepts of non-COVID-19 conditions that act as “mimics and chameleons” of the COVID-19 pneumonia.

One of the major differentials of COVID-19 pneumonia is the pneumonia from other infectious causes like bacterial origin. Community-acquired pneumonia is usually characterized by an airspace consolidation affecting one segment or lobe, limited by the pleural surfaces. CT may also show ground-glass pattern, centrilobular nodules, bronchial thickening, and/or mucoid impaction. In the absence of superinfection, COVID-19 pneumonia has very different findings, with no centrilobular nodules or mucoid impactions [15].

In this study, there were 8 cases of atypical bacterial pneumonias, and they showed GGO with consolidative patches like COVID-19, but there were other features rarely seen in COVID-19. A large pneumatocele is seen in staph pneumonia (Fig. 1), unilateral lung affection with consolidative patch and tree-in-bud appearance with cylindrical bronchiectasis (Fig. 1). Also, consolidation confined to the lobes with peribronchial thickening and pleural effusion in Mycoplasma pneumoniae (Fig. 2). There was one case of CT feature typical to COVID-19. CT chest showed bilateral confluent consolidative patches with GGO and crazy-paving appearance, and it was proven H1N1 on PCR test (Fig. 3).

![Fig. 4](image1.png) A 68-year-old male patient with septicemia, presented with fever and cough. CT showed bilateral basal dense consolidations on background of GGO in the anterior non-dependent portions of the lungs and crazy paving appearance (white arrows) with bronchial dilatation in the ground glass opacities (small blue arrows) with no pleural effusion, and the diagnosis was ARDS.

![Fig. 5](image2.png) A 19-year-old male patient presented with chest tightness after trauma. He had a history of trauma 1 day ago. CT chest showed bilateral GGO at both the upper lobes and right lower lobes with peripheral predilection (white arrows), the thin rim of the left pneumothorax (black arrow) was seen on the left side, and the diagnosis was post-traumatic pulmonary contusions.
Elicker et al. [16] and Grudzinska et al. [17] stated that in the current epidemic, GGO in patients with fever and respiratory symptoms suggests COVID-19 until proved otherwise, but some pneumonias of other viral causes may show some different signs like H1N1 influenza, with bronchial wall thickening, centrilobular nodules, and a distribution more along the bronchovascular bundles. Pleural effusion, pneumothorax/pneumomediastinum may be present.

There are broad spectra of non-infectious conditions that cause diffuse GGO. In this study, there were 3 cases of cardiac pulmonary edema with cardiomegaly, dilated pulmonary trunk, interlobular septal and peribronchovascular thickening, pleural effusions, and perihilar distribution of ground-glass opacities.

Komiya et al. [18] stated that pulmonary edema (cardiogenic and non-cardiogenic) is one of the most common causes of diffuse GGO characterized by central predominance with sparing of the peripheral portions of the lung contrary to COVID-19. It is associated with other suggestive signs such as bronchovascular bundle

Fig. 6 A 61-year-old male patient presented with cough and fever. CT chest showed multifocal GGO, crazy paving and consolidation with Atoll sign (blue arrows) more in the upper lobes with subpleural sparing and bilateral pleural effusions more on the right side (arrow in d). The diagnosis was COP, confirmed by histopathology.

Fig. 7 A 46-year-old female patient with SLE, presented with hemoptysis. CT showed bilateral confluent consolidative patches with GGO (arrows) more predominant in the upper lobes with subpleural and costophrenic angle sparing. The diagnosis was diffuse alveolar hemorrhage.
thickening, interlobular septal thickening, and pleural effusions.

In this study, there were 3 cases of ARDS, and the diagnosis was based on acute clinical criteria and imaging features of bilateral basal extensive consolidation on the background of GGO in the anterior non-dependent portions of the lungs with bronchial dilatation in the ground glass opacities and crazy-paving appearance (Fig. 4).

Zompatori et al. [19] and Ferguson et al. [20] described acute respiratory distress syndrome (ARDS) diagnosis is based mainly on clinical criteria include lung injury of acute onset, within 1 week of an apparent clinical insult and with the progression of respiratory symptoms, respiratory failure not explained by heart failure or volume overload and decreased arterial PaO$_2$/FiO$_2$ ratio. According to the phase of the disease, in the early phase, CT imaging shows pulmonary opacification: with anteroposterior density gradient with basal dense consolidation on a background of diffuse GGO with normal or hyperexpanded lung in the non-dependent regions.

In this study, there were 5 cases of pulmonary contusions following trauma, they showed scattered GGO, the clue for the diagnosis was the clinical history with the presence of a thin rim of pneumothorax in 2 cases (Fig. 5).

Oikonomou et al. [21] stated that pulmonary contusions follow blunt or penetrating chest trauma and are almost always seen with other chest (and abdominal) injuries, typically seen as focal, non-segmental areas of parenchymal opacification, more common posteriorly, and in the lower lobes usually peripheral. The clinical history of trauma is always a distinguishing feature.

Wallis et al. [22] stated that some of interstitial lung disease (ILD) also involve the alveolar spaces that make an overlap with COVID-19 pneumonia. This includes COP, HP, RB-ILD, sarcoid, PAP, vasculitis, rheumatoid disease, and drug-induced.

In this study, there were 2 cases of cryptogenic organizing pneumonia with multifocal GGO, crazy-paving and consolidation with atoll sign more in the upper lobes and bilateral pleural effusions (Fig. 6). They were mimickers to COVID-19 pneumonia with histopathological results that were helpful for the final diagnosis.

Webb et al. [23] described that the most common HRCT features of cryptogenic organizing pneumonia (COP) with multifocal ground glass opacifications, crazy-paving and/or consolidation, small, ill-defined nodules, bronchial wall thickening, or dilatation.
stated that the reverse halo sign (atoll sign) is seen only in 20% of patients, and it is not considered to be highly specific.

In the current study, there was one case of diffuse alveolar hemorrhage (Fig. 7) with a patient known of SLE and presented with hemoptysis. The predominance of GGO in the upper lobes with subpleural and costophrenic angle sparing as well as the clinical history was the diagnostic clues.

Marten et al. [24] describe intra-alveolar hemorrhage secondary to extensive parenchymal small-vessel vasculitis like that caused by connective tissue disorders like systemic lupus erythematosus (SLE) which is typically diffuse and initially causes more widespread lobular ground-glass opacification with gravity-dependent density progressing to air-space consolidation +/- crazy-paving pattern.

In this study, there were 4 cases of hypersensitivity pneumonitis of both acute (Fig. 8) and subacute phases (Fig. 9). The diagnosis was made by the clinical history of exposure to antigen (Bird Fancier’s Disease), radiological findings with small poorly defined centrilobular nodules, ground-glass appearance in the acute phase or...
headcheese sign in the subacute phase, lymphocytosis on bronchoalveolar lavage, and reproduction of symptoms following exposure.

Lacasse et al. [25] described that acute hypersensitivity pneumonitis or acute extrinsic allergic alveolitis is usually occurring within few hours after antigen exposure and often recurs with the re-exposure and has the potential to resolve with treatment. In the acute phase, chest CT shows bilateral and symmetric homogeneous GGO (alveolitis) with multiple centrilobular opacities: usually < 5 mm in diameter also may be present with no fibrosis [26].

There were two cases of RB-ILD in this study presented by cough, dyspnea, and shortness of breath. Both were heavy smokers. The diagnosis was made by clinical history of smoking, typical HRCT findings of ground-glass opacities, and centrilobular nodules (Fig. 10) and proved by biopsy in the first case and bronchoalveolar lavage (BAL) findings (the presence of smokers' macrophages and the absence of lymphocytosis) in the second case.

Mavridou et al. [27] described CT findings of RB-ILD with smoking bronchial wall thickening and centrilobular emphysema in addition to ground-glass opacities.
with the slight upper zone predominance and ill-defined centrilobular nodules.

In this study, there was one case of pulmonary alveolar proteinosis (Fig. 11). It mimics CT features of COVID-19 pneumonia with bilateral asymmetrical GGO with crazy-paving appearance, and the diagnosis was confirmed by bronchoalveolar lavage.

Holbert et al. [28] stated that crazy-paving pattern of PAP on CT is non-specific occurring in other diseases.

In this study, there was one case of known sarcoidosis presented with cough. CT showed bilateral patchy ground-glass appearance, but the presence of mild bronchiectatic changes of upper lobe predilection, multiple enlarged prevascular, pre/paratracheal, and hilar

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**Fig. 14** A 65-year-old male patient presented with dyspnea and low-grade fever. CT chest showed bilateral scattered mainly peripheral consolidative patches with faint GGO (white arrows), associated bilateral basal interlobular septal thickening with small nodules (black arrows). The diagnosis was amidarone lung toxicity.

**Fig. 15** A 38-year-old female patient with fever and cough. Initial X-ray (a) showed bilateral small air space opacities (arrows). On CT chest, there was bilateral peripheral GGO (arrows). X-ray done 1 year before (e), and there was a left lower lobe air space opacity which was resolved on X-ray (f) 6 months later (fleeting). The diagnosis was Loffler's pneumonia.
LNS as well as the clinical history with no fever was the clue for the diagnosis of alveolar sarcoidosis (Fig. 12).

There was one case of acute interstitial pneumonitis (AIP) presented with severe dyspnea and desaturation; she was intubated. CT chest revealed bilateral asymmetric confluent patches of ground glass with crazy-paving appearance mixed with consolidative patches with air bronchogram more in the lower lobes. The presence of LT side mild pneumothorax was uncommon for COVID-19 pneumonia (Fig. 13). Bronchoalveolar lavage and transbronchial biopsy were done after exclusion of infectious cause.

Wittram et al. [29] described AIP or Hamman-Rich syndrome CT findings with ground-glass attenuation:
generally tend to be bilateral and symmetrical, traction bronchiectasis (80% of cases during the course of the disease), and parenchymal architectural distortion of the lung.

There was one patient in this study, presented with dyspnea and low-grade fever with CT chest showing bilateral scattered mainly peripheral consolidative patches with faint GGO, associated bilateral basal interlobular septal thickening with small nodules (Fig. 14). The patient had a history of amiodarone drug intake for 3 years. The patient was COVID-19 negative, and the presence of the pulmonary nodules and interlobular septal thickening was rare features of COVID-19. The case was confirmed by fiberoptic bronchoscopy with BAL and transbronchial biopsy to be amiodarone lung toxicity.

Wolkove et al. [30] stated that amiodarone lung toxicity is more common in patients exposed to amiodarone, usually for at least 6 months with risk factors like age over 60 years and daily dose > 400 mg. It has two main patterns, multiple peripheral GGO and interstitial fibrosis. One of the radiographic appearances of amiodarone pulmonary toxicity is the presence of peripherally located single or multiple pulmonary nodules, or mass-like opacities and may abut the pleura due to localized accumulation of the drug in an area of previous inflammation.

Another entity of diseases that may mimic COVID-19 is eosinophilic lung disease; we had 3 cases of the eosinophilic lung. The first case was Löffler’s pneumonia (Fig. 15). The diagnosis was made due to fleeting opacities (on X-ray done 1 year before the clinical symptoms, there was left lower lobe air space opacity which was resolved on X-ray 6 months later indicating fleeting opacities), elevated eosinophilic count in BAL, peripheral blood eosinophilia, and high IgE level.

Jeong et al. [31] described Löffler syndrome or simple pulmonary eosinophilia on imaging as a fleeting, non-segmental GGO which may be unilateral or bilateral peripheral predominance. Pleural effusions and lymphadenopathy are not features.

The second case of the eosinophilic lung was Churg-Strauss syndrome (Fig. 16) of asthmatic female patient presented with shortness of breath with cough and dyspnea. CT showed multiple consolidative patches with GGO and crazy-paving appearance, moderate right pleural effusion with extrapulmonary manifestations of pansinusitis, and arthritis, and it was confirmed by laboratory results of high eosinophils and IgE.

The etiology of Churg-Strauss syndrome may be allergic or immune pathogenesis for the disease with asthma, eosinophilia, and elevated serum IgE levels. It affects the lung followed by the skin. However, any organ can be involved. The most common thin-section CT findings include sub-pleural ground-glass opacity or consolidation with a lobular distribution, centrilobular nodules, bronchial wall thickening, and interlobular septal thickening and less commonly mediastinal or hilar lymphadenopathy, and pleural or pericardial effusion [31].

The third case of the eosinophilic lung (Fig. 17) was drug rash with eosinophilia and systemic symptoms (DRESS) with a history of drug intake (anticonvulsant), skin rash, fever, cough, and dyspnea. Bilateral confluent consolidative patches with upper lobe predilection, bilateral mild pleural effusions were seen on CT, and the diagnosis was confirmed by peripheral eosinophilia.

**Fig. 18** A 61-year-old female patient with bronchial asthma presented with cough and wheezy chest. On CT, there were bilateral mosaic patches of GGO due to air trapping (white arrows) with left upper lobe tree-in bud and subsegmental atelectasis (blue arrows), perilobronchial thickening, and bilateral mild basal bronchoectatic changes (black arrows).
The drug rash with eosinophilia and systemic symptoms or DRESS syndrome typically manifests as a skin rash, fever, and lymphadenopathy with variable internal organ involvement and represents a drug-induced hypersensitivity reaction. Chest CT findings are non-specific but may show diffuse multifocal infiltrative opacification [32].

There were 3 cases of bronchial asthma in this study (Fig. 18) presented with bilateral mosaic patches of GGO due to air trapping seen, but there was left upper lobe tree-in-bud, subsegmental atelectasis (due to superadded infection), and bilateral mild basal bronchoectatic changes; such features are uncommon for COVID-19.

In this study, there was a patient with ESRD on dialysis presented with fever and cough. CT showed bilateral high-density ground glass centrilobular nodules due to metastatic pulmonary calcification occurring in renal failure. Associated left lung consolidative patches with air bronchogram (Fig. 19). The diagnosis was metastatic calcification with superadded bacterial lung infection based on clinical history with laboratory testing.

**Conclusion**

The spectrum of CT imaging findings in COVID-19 pneumonia is wide that could be contributed by many other diseases making the interpretation of chest CTs nowadays challenging to differentiate between different diseases having the same signs and act as deceiving simulators in the era of COVID-19.

**Abbreviation**

nCoV: Novel coronavirus; RT-PCR: Real-time polymerase chain reaction; CT: Computed tomography; NPS: Nasopharyngeal swab; GGO: Ground glass opacification; UIP: Usual interstitial pneumonia; NSIP: Non-specific interstitial pneumonia; ARDS: Acute respiratory distress syndrome; DAD: Diffuse alveolar damage; COP: Cryptogenic organizing pneumonia; SLE: Systemic lupus erythematosus; HRCT: High-resolution computed tomography; ILD: Interstitial lung disease; RB-ILD: Respiratory bronchiolitis interstitial lung disease; PAP: Pulmonary alveolar proteinosis; HP: Hypersensitivity pneumonitis; ChP: Chronic hypersensitivity pneumonitis; BAL: Bronchoalveolar lavage; AIP: Acute interstitial pneumonia; PET: Positron emission tomography; DRESS: Drug rash with eosinophilia and systemic symptoms; ESRD: End-stage renal disease

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**Availability of data and materials**

All data and materials are available.

**Ethics approval and consent to participate**

The study protocol was approved by the local ethics committee (HSC Ethical Committee). All study procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. No available ethics committee’s reference number.

A written consent was taken from all patients prior to the study to be included in our study.

**Consent for publication**

A written consent was taken from all patients prior to the study for publication.
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