
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Current Problems in Diagnostic Radiology 000 (2020) 1–8

Current Problems in Diagnostic Radiology

journal homepage: www.cpdrjournal.com

# Chest Imaging in Patients Hospitalized With COVID-19 Infection - A Case Series

Roopa Bhat, MD[a], Aws Hamid, MD[a], Jeffrey R. Kunin, MD[a], Sachin S. Saboo, MD, FRCR[b,*], Kiran Batra, MD[c], Dhiraj Baruah, MD[d], Ambarish P. Bhat, MD[a]

[a] *Department of Radiology, University of Missouri, Columbia, MO.*
[b] *Department of Radiology, University of Texas Health Science Center, San Antonio, TX.*
[c] *Department of Radiology, University of Texas Southwestern Medical Centre, Dallas, TX.*
[d] *Department of Radiology, Medical College of Wisconsin, Wauwatosa, WI.*

A B S T R A C T

COVID-19 (Corona Virus Disease-19) is a zoonotic illness first reported in the city of Wuhan, China in December 2019, and is now officially a global pandemic as declared by the World Health Organization. The infection is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). COVID-19 infected patients can be asymptomatic carriers or present with mild-to-severe respiratory symptoms. Imaging, including computed tomography is not recommended to screen/diagnose COVID-19 infections, but plays an important role in management of these patients, and to rule out alternative diagnoses or coexistent diseases. In our multicenter case series, we outline the clinical presentations and illustrate the most common imaging manifestations in patients hospitalized with COVID-19.



## Background

COVID-19 (Corona Virus Disease-19) is a zoonotic illness first reported in China in December of 2019, linked to a seafood wholesale market in the city of Wuhan, the capital city of Hubei province.[1,2] On March 11, 2020, COVID-19 was declared a global pandemic by World Health Organization (WHO),[3] having rapidly spread by human to human contact across 177 territories, in 6 continents. Confirmed cases in the United States as of April 1, 2020 have exceeded 200,000 with more than 4400 deaths as per the online virus tracker created by The Lancet, and hosted by John Hopkins University.[4] Common clinical symptoms of patients infected with COVID-19, include fever, fatigue, dry cough, nasal congestion, runny nose, sore throat, and diarrhea. In severe cases, patients present with dyspnea and/ or hypoxemia 1 week after the onset of the disease, and rapidly deteriorate to acute respiratory distress syndrome (ARDS), septic shock, metabolic acidosis, and coagulation abnormalities.[5] Cheng et al found that there was no statistical difference in clinical features in patients with COVID-19 pneumonia and those with non-COVID-19 infection except for leukocyte and platelet counts. Patients with positive reverse transcription polymerase chain reaction (RT-PCR) results had lower median leukocyte and platelet counts than those with negative results.[6] Although viral nucleic acid detection using RT-PCR remains the gold standard of diagnosis, imaging may play a vital role in reinforcing the diagnosis, can assess disease progression, and identify complications that may need additional procedures or changes in management. This case series aims to outline the clinical features, illustrates the most common reported imaging findings of COVID-19 infection, and demonstrates different management plans used.

## Case 1

Sixty-year-old morbidly obese female, history of mild asthma, presented with cough and high-grade fever to the family medicine clinic. She had a recent history of international travel. Influenza A and B tests were negative, and initial swab testing for COVID-19 was negative. She was subsequently hospitalized with worsening respiratory symptoms and tested RT-PCR positive for COVID-19. Chest radiograph (CXR) (Fig 1A) and CT chest (Fig 1B-D) showed bilateral, peripheral lower lung predominant ground glass opacities (GGOs) and subpleural curvilinear consolidation. The patient subsequently succumbed to respiratory and cardiac arrest.

## Case 2

Twenty-five-year-old male without history of recent travel presented to the emergency department (ED) with 4 days of fever, sore throat and dry cough, runny nose, and mild shortness of breath (SOB). Initial CXR showed patchy peripheral airspace opacities in the bilateral middle and lower lungs, concerning for multifocal infection (Fig 2A). The patient was discharged on doxycycline, with recommendations to self-quarantine for 14 days. Patient did not meet criteria for COVID-19 testing at that time. Patient returned after 3 days with worsening symptoms, and a positive contact history. Frontal

*Reprint requests: Sachin S.Saboo, MD, FRCR, Department of Radiology, University of Texas Health Science Center, 7703 Floyd Curl Drive, San Antonio, TX 78229.
*E-mail addresses:* saboos@uthscsa.edu, saboo_100@yahoo.com (S.S. Saboo).

https://doi.org/10.1067/j.cpradiol.2020.04.001
0363-0188/

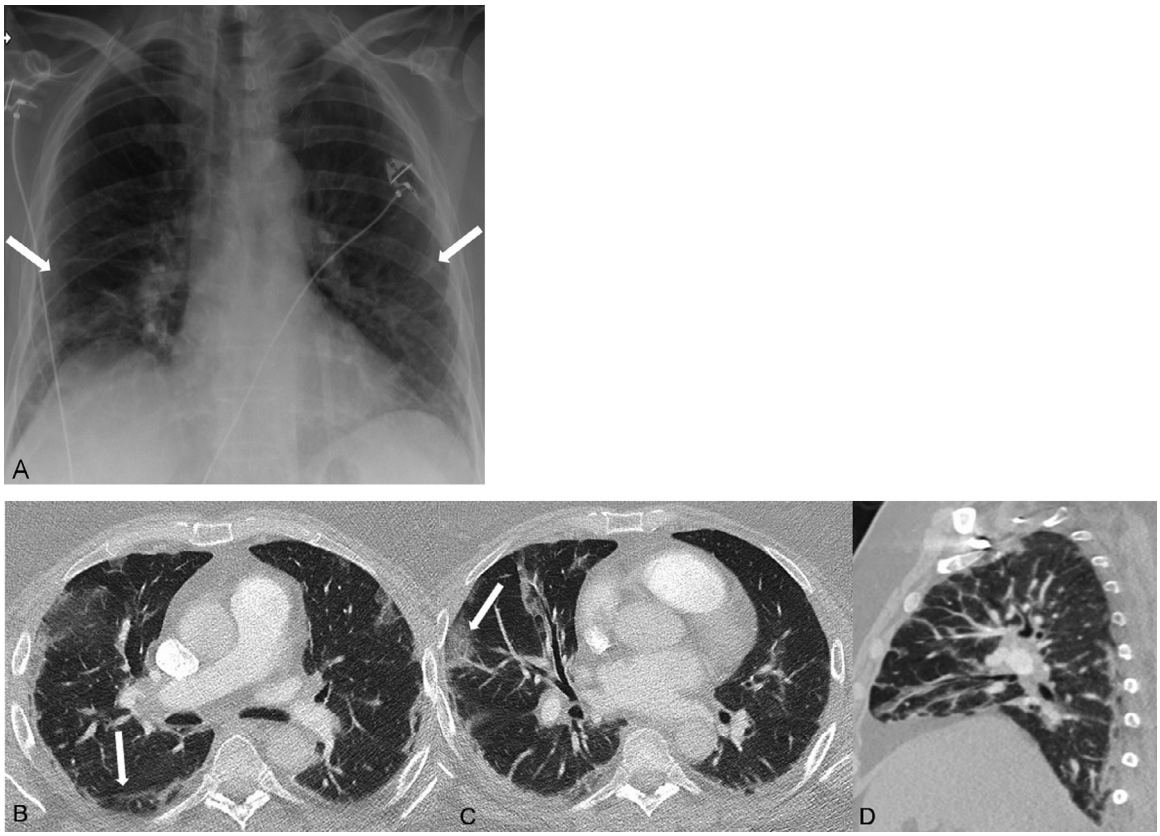


**FIG 1.** (A) CXR with nonspecific peripheral and bilateral lower lung opacities (arrows). (B-D): Axial (B, C) and Sagittal (D) CT chest show bilateral lower lung predominant subpleural linear opacities (B) and scattered peripheral ground glass opacities (C). CXR, Chest radiograph.

CXR showed worsening of bilateral peripheral patchy pulmonary opacities (Fig 2 B). He was treated in the intensive care unit (ICU) with empiric antibiotics, hydroxychloroquine, and tocilizumab while intubated. Follow-up CXR in 2 days showed progression to consolidations (Fig 2C). COVID-19 tested positive on the eighth day of admission. The patient was started on Remdesivir on day 10 after which liver function tests improved. Follow-up radiograph obtained on day 10 revealed improving pulmonary opacities (Fig 2D).

## Case 3

Fifty-six-year-old male health care worker recently tested positive for COVID-19 presented to the ED with worsening cough, fever, SOB, rhinorrhea, nausea, and vomiting. Frontal CXR revealed right mid and left lower lobe airspace opacities (Fig 3A). The patient was admitted to the isolation floor and started on ceftriaxone, hydroxychloroquine, and Remdesivir. CXR on the second day showed mild worsening of bilateral airspace opacities (Fig 3B). By day 5, patient was afebrile with SpO2 97% on 2 L nasal cannula. CXR revealed stable pulmonary opacities (Fig 3C).

## Case 4

Sixty-nine-year-old male presented to the ED with 3 days of increasing cough, fever, shortness of breath, and an episode of hemoptysis. Recently traveled within the US without any known COVID-19 positive contact. Comorbidities include type II diabetes mellitus (DM) and emphysema. Worsening hypoxia in the ED prompted intubation and ICU admission. CXR showed bilateral mid and lower lung predominant hazy opacities (Fig 4A) with rapid worsening in 3 hours (Fig 4B). A CT scan showed bilateral predominantly dependent consolidations without lymphadenopathy, effusion, or cavitation (Fig 4C, D). Patient tested positive for COVID-19. A clinical diagnosis of ARDS with septic shock secondary to COVID-19 infection was made. Patient developed acute renal failure and a left-sided tension pneumothorax while in ICU (Fig 4E), treated with chest tube placement. As patient's condition worsened with right heart failure, extracorporeal membrane oxygenation was initiated on day 6; subsequently, the patient expired on day 7.

## Case 5

Forty-five-year-old male with known history of hypothyroidism, hypertension, hereditary hemochromatosis, and obstructive sleep apnea presented to the ED with worsening fever, cough, SOB, and chest tightness. Patient had recent history of multiple air travel within the US. No known direct sick contact. COVID-19 reverse transcription polymerase chain reaction was positive. Initial CXR showed ill-defined right perihilar airspace opacity (Fig 5A). A CT chest showed patchy, somewhat rounded GGO in the right lower lobe with a few bilateral scattered smaller GGOs. (Fig 5 B-D). On day 6, CXR showed worsening of parenchymal opacities (Fig 5E). Medications during hospitalization included hydroxychloroquine, azithromycin, and other supportive drug treatments with symptomatic improvement and gradual clearing of parenchymal opacities on day 9 (Fig 5F).

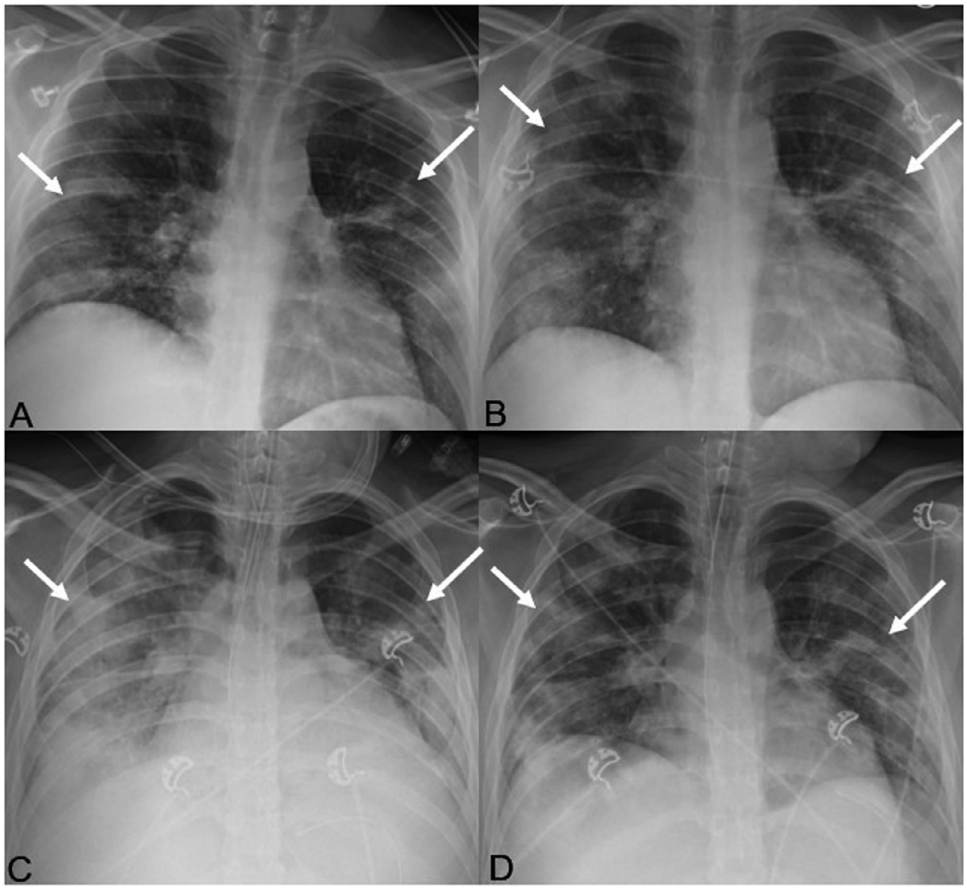


**FIG 2.** (A-D) Serial CXRs: Day 1 (A) showing ill-defined focal patchy airspace opacities in the bilateral middle and lower lung zones (arrows). Three days later (B) the CXR shows worsening of lung disease (arrows). Day 5 CXR (C) shows progression of opacities with features of ARDS (arrows). Improving opacities day 10 of treatment (D). ARDS, acute respiratory distress syndrome; CXR, Chest radiograph.

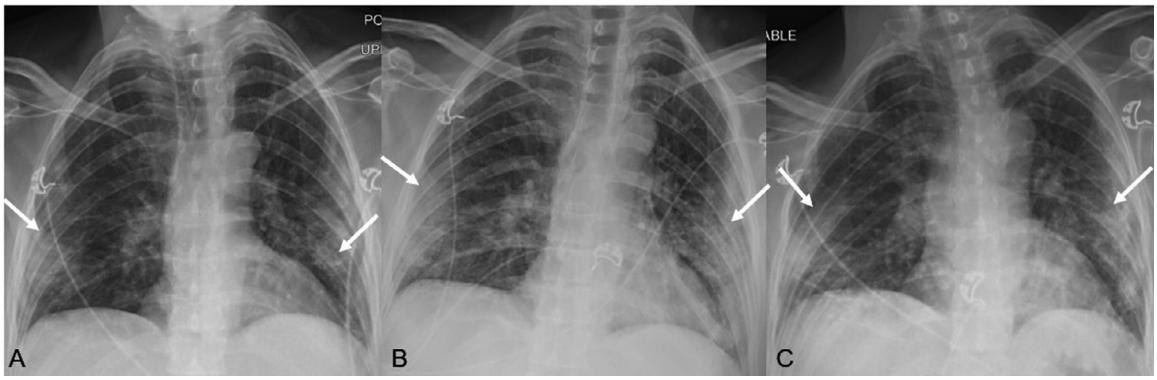


**FIG 3.** (A-C) Serial CXRs: CXR at presentation (A) shows opacities in the right lower and left mid-lung zones (arrows). CXR (B) on the second day of admission shows mild worsening of bilateral pulmonary opacities (arrows). Day 5 (C) of admission shows stable bilateral pulmonary opacities (arrows). CXR, Chest radiograph.

## Case 6

Forty-three-year-old man with history of uncontrolled type 2 diabetes mellitus presented to ED with fever, sore throat, dry cough, runny nose, and mild SOB. The patient reported contact with a coworker who had recently traveled to Germany. His wife and child presented with similar symptoms. He was initially admitted to the ICU for cardiac monitoring and for worsening shortness of breath, where he tested positive for COVID-19. The initial CXR (Fig 6A) showed ill-defined patchy airspace opacities in both lower lungs. On fourth day of admission, his symptoms and pulmonary opacities worsened (Fig 6B) and hence he was intubated. On the ninth day, oral Remdesivir was initiated. A follow-up radiograph was obtained after extubation on day 16 of his visit (Fig 6C). CT scan obtained during his hospitalization showed progressively worsened peripheral and lower lobe predominant GGOs and consolidation with few interlobular septal thickening (Fig 6 D-F).

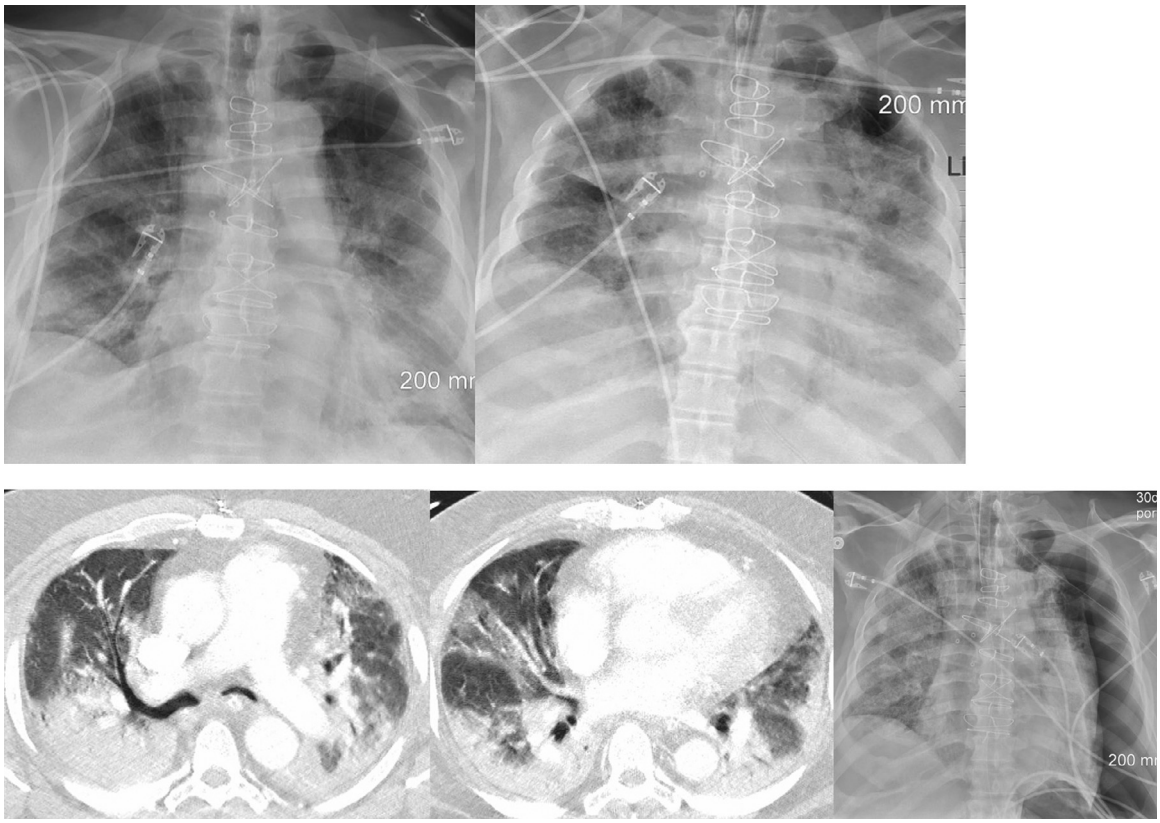

**FIG 4.** (A-E) CXR Day 1 (A) shows bilateral mid and lower lung hazy opacities (arrows). CXR 3 hours later (B) shows worsened hazy and consolidative opacities bilateral mid and lower lung (arrows). Initial CT (C, D): Bilateral predominantly dependent consolidative opacities (asterisks). No effusions or cavitation. Follow-up CXR (E) day 6 shows a left-sided tension pneumothorax (arrows). CXR, Chest radiograph.

## Case 7

Fifty-nine-year-old woman with history of hypertension presented to the ED with worsening cough. She complained of mild shortness of breath while coughing, mid-sternal chest pain, and absent sense of smell and taste for 5 days. She tested positive for COVID-19 virus and is currently under treatment. Positive contact history with her mother who tested positive for COVID-19 and hospitalized with worsening respiratory symptoms. Initial CXR (Fig 7A) and Chest CT (Fig 7 B-D) revealed asymmetric patchy peripheral GGOs intermixed with intralobular septal thickening, most prominent in the subpleural regions of the right lower lobe.

## Case 8

Seventy-nine-year-old man presented to ED with “flu-like symptoms” including productive cough with yellow sputum, SOB, body aches, and subjective fevers. At admission, he was found to be COVID-19 positive with active tuberculosis. Infectious work-up notable for positive mycobacterium TB PCR and COVID-19 tests. CXR shows biapical fibronodular mass-like densities and subtle patchy basilar hazy opacities (Fig 8A). Chest CT showed multifocal peripheral patchy GGOs in right upper lobe and basal segments of both lower lobes (Fig 8B-D). Patient was started on antitubercular treatment along with doxycycline, hydroxychloroquine, and vancomycin which lead to improvement in his symptoms 2-weeks later. A follow-up chest CT is scheduled in 2 months to follow up the upper lobe masses.

## Discussion

COVID-19, a member of the Betacoronavirus Genus, is an enveloped, single stranded RNA virus. It is the seventh member of the family of coronaviruses infecting humans, along with the zoonoses middle east respiratory syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV).[1] The COVID-19 outbreak has resulted in a global health emergency, with morbidity and mortality exceeding the outbreaks of SARS in 2003 and MERS in 2012. Despite radiologic similarities to SARS and MERS pneumonia, significantly fewer number of patients with COVID-19 infection have abnormalities on the initial CXR.[7-9] CXRs remain the initial imaging tool of choice but have a limited role in the diagnosis of disease. Wong et al found that consolidation was the most common finding on CXRs in COVID-19 patients with a peripheral, lower zone predominance.[10] The variety of the findings in COVID-19 have been categorized in the consensus documents from American College of Radiology/Society of Thoracic Radiology /Radiological Society of North America Radiology as typical, indeterminate and atypical features, and negative for pneumonia.[11] The typical features are peripheral bilateral GGOs, rounded GGOs, and reverse halo sign of organizing pneumonia. Indeterminate features include multifocal,

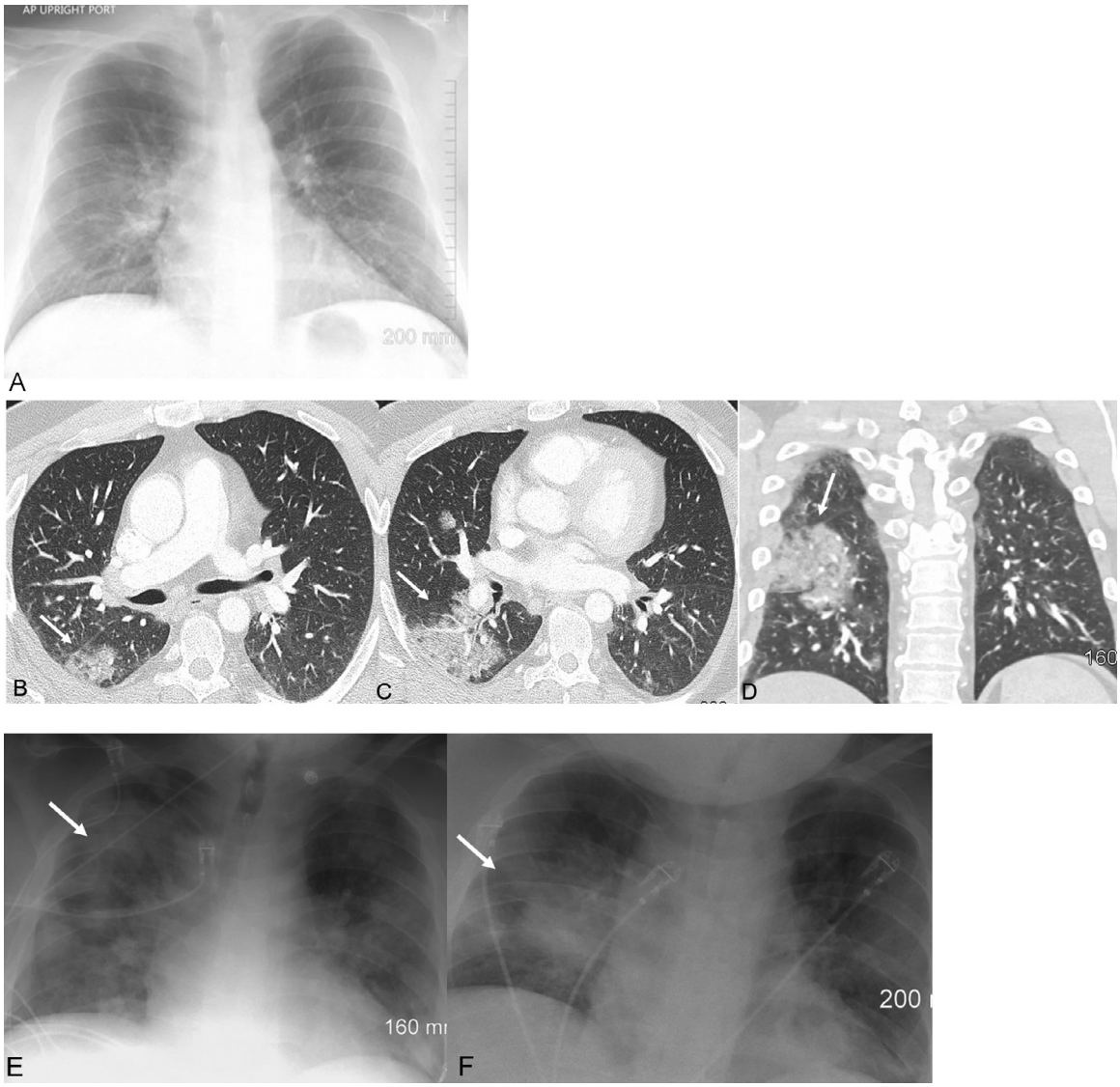


**FIG 5.** (A) Day 1 CXR – Right perihilar ill-defined opacities (arrow). (B-D) Day 1 CT Axial (B, C) and coronal (D) CT shows rounded GGO in the right lower lobe (arrows) with hazy opacities in the left lower lobe. (E-F) Serial CXRs. Day 6 (E) CXR worsening of multifocal opacities in both lungs suggestive of ARDS (white arrow). Day 9 of treatment with improvement in lung opacities (F). ARDS, acute respiratory distress syndrome; CXR, Chest radiograph; GGO, ground glass opacities.

diffuse, perihilar, or unilateral GGOs with nonrounded, nonperipheral distribution. Atypical features include isolated consolidations, tree-in-bud opacities, cavitation, and smooth interlobular septal thickening with pleural effusion. CT can be used to better assess the extent of disease, identify complications and monitor treatment response.[12] In the early stages of the disease, the abnormalities on CT are localized to the subpleural or peribronchovascular regions of one or both lungs, and manifest as pure GGOs with or without vascular enlargement.[13] Disease progression is associated with increasing GGOs, and multilobar involvement.[14] Progression to bilateral consolidations is often seen in hospitalized patients,[15] due to the development of ARDS. Interlobular septal thickening, crazy-paving pattern, and air bronchograms are common. Pleural effusion and mediastinal lymphadenopathy are rarely seen and most likely favor alternative etiologies.

Our 8 patient case series (Table 1) (2 females, 6 males) included patients who acquired the infection from travel and community spread. Two of the 8 patients expired from respiratory issues, and the remaining individuals are responding to treatment. Associated comorbidities were present in more than half of the patients. Leukocytosis was seen in only 1 of the 8 patients in our series. One of the 8 patients experienced a loss of sense of smell and taste, which has been anecdotally reported in literature with COVID-19 infection worldwide. In addition to the commonly reported imaging manifestations (Table 2), which include patchy peripheral GGOs with lower lobe predominance, we encountered one patient with a pneumothorax, and asymmetric involvement at initial presentation. Pattern of GGOs and consolidative opacities seen in COVID-19 patients can mimic those of other viral pneumonias, particularly influenza, and organizing pneumonia due to other causes such as bacterial infection, drug toxicity, inhalation injury, connective tissue disease, and idiopathic. Imaging features can also be seen synchronously with chronic abnormalities like granulomatous disease or malignancies.[16] This case series hopefully adds to the knowledge base that is evolving and helps in the understanding of this relatively new and unknown viral pandemic.

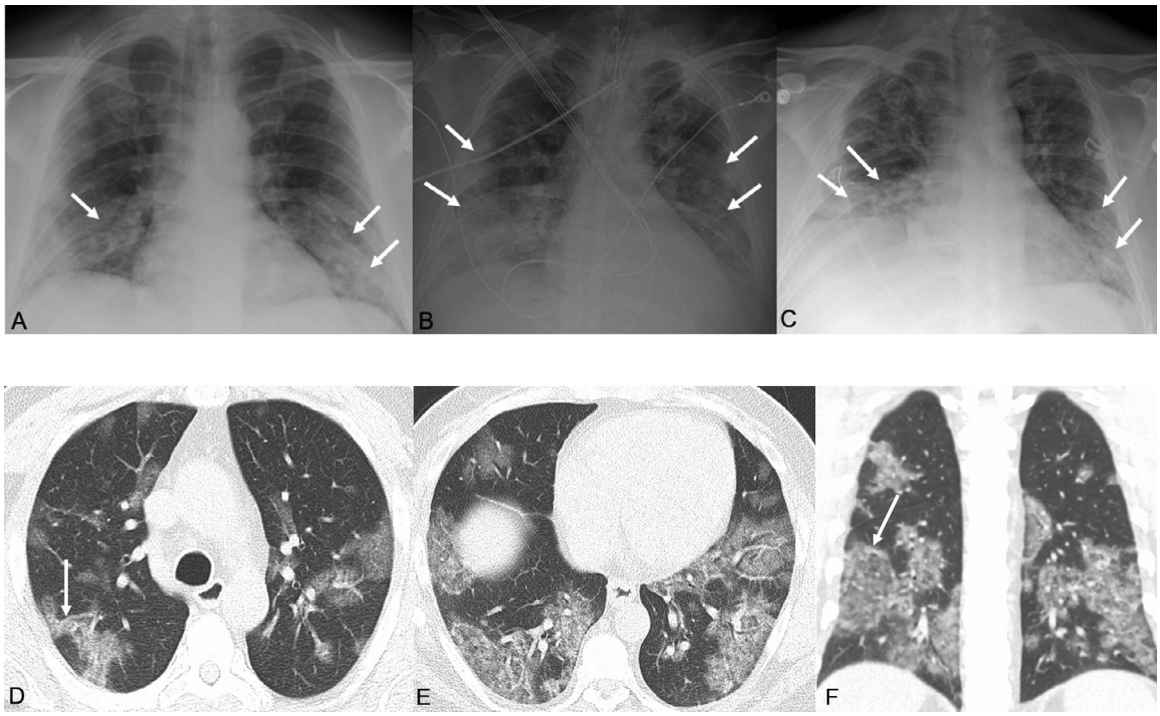


**FIG 6.** (A-C) Serial CXRs: Day 1 (A) showing ill-defined patchy airspace opacities in the bilateral lower lungs (white arrows). Nine days later (B) the CXR shows worsening of lung disease (white arrows) in the mid and lower lung zones and progression of opacities with features of ARDS (white arrows). Interval extubation with improving opacities at the right lung base with new small right pleural effusion on day 16th of treatment (C). (D-F) Axial (D, E) and Coronal (F) CT chest with multifocal patches of mainly peripheral GGOs and mild septal thickening, predominantly within bilateral lower lobes with regions of peripheral consolidation. Reversed halo sign (arrow in F) is present in the lower lobes. Perilobular thickening (arrow in D) evident in the right upper lobe. ARDS, acute respiratory distress syndrome; CXR, Chest radiograph; GGO, ground glass opacities.

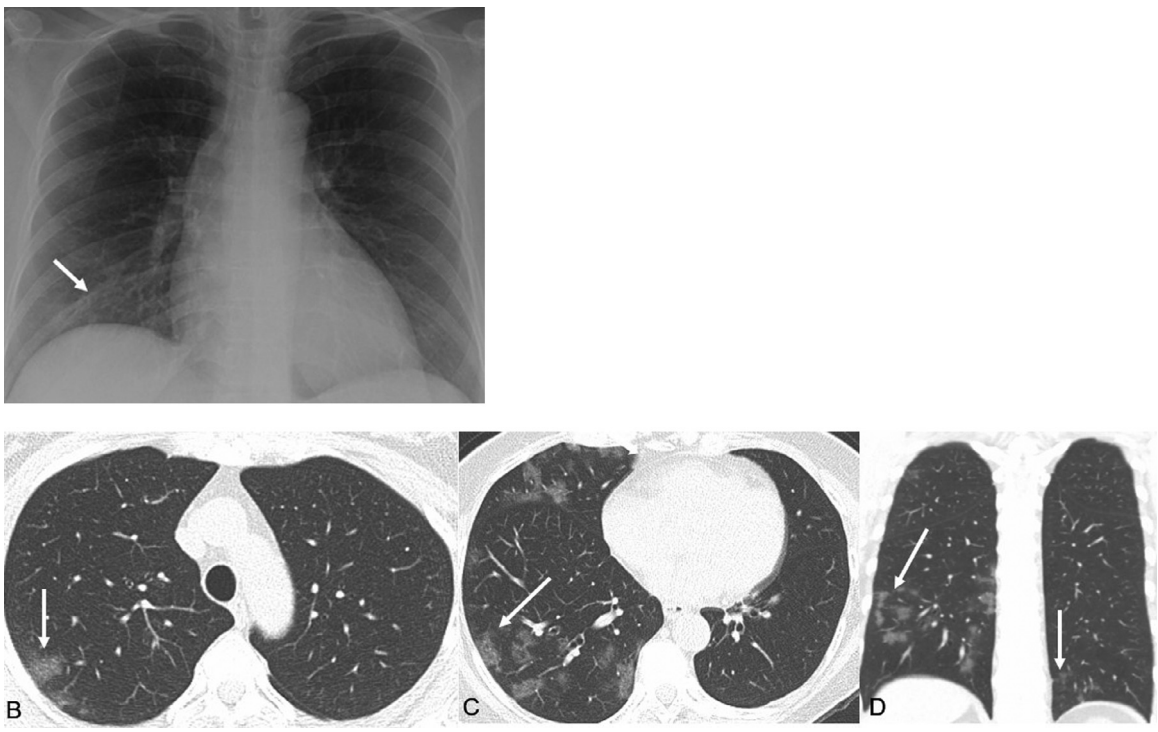


**FIG 7.** (A) CXR shows a vague ill-defined hazy opacity in the right lower lobe in a COVID positive patient. B-D Axial (B, C) and Coronal (D) CT chest show right lung multifocal mainly peripheral GGOS (arrows) and mild intralobularseptal thickening, most prominent in the subpleural distribution in the right lower lobe. Subtle left lower lobe GGOs are also noted (D). CXR, Chest radiograph; GGO, ground glass opacities.

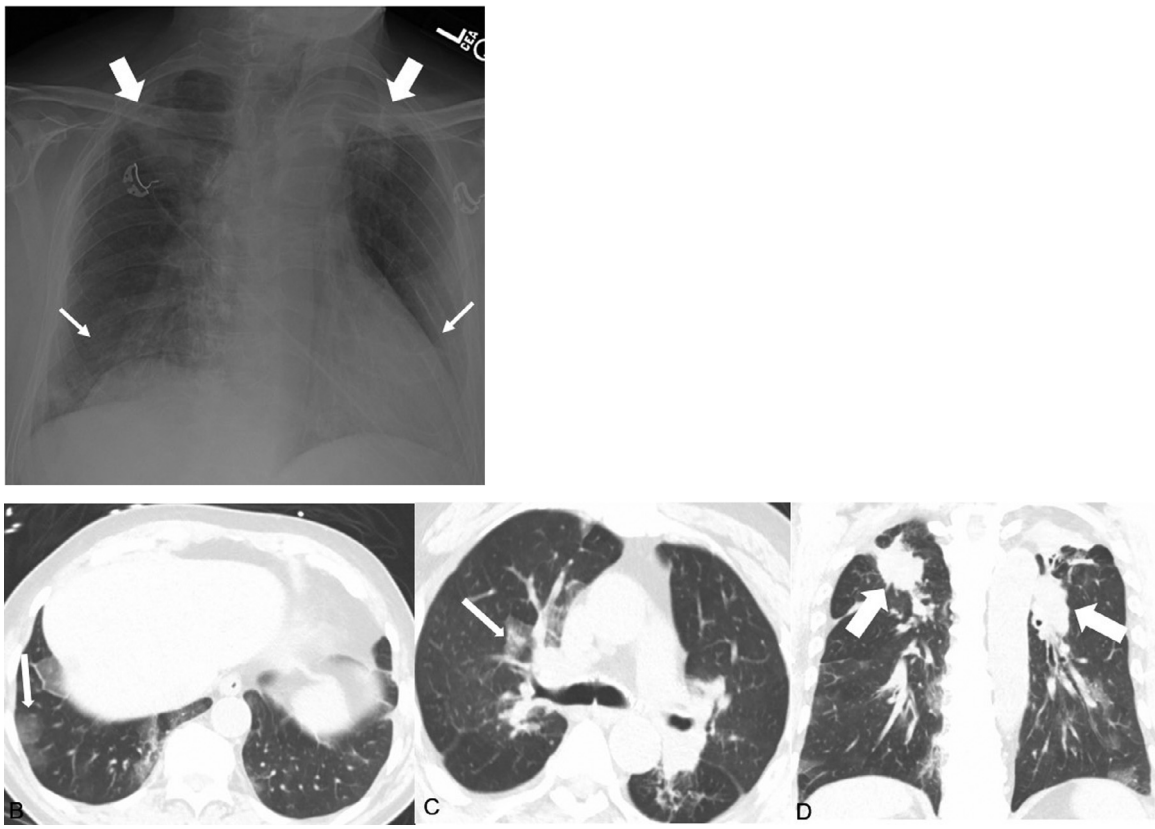


**FIG 8.** (A) CXR shows biapical mass like densities with fibrosis (block arrows) from ongoing and sequelae of prior mycobacterial infection. An underlying neoplastic mass in the right upper lobe was in the differential. In addition, there are patchy bibasilar subtle opacities (white arrows). A CT chest was subsequently performed. (B-D): Axial (B, C) and Coronal (D) CT chest show multifocal peripheral patchy GGOs in right upper lobe and basal segments of both lower lobes. These findings of organizing pneumonia pattern are nonspecific and may be seen with atypical infection such as viral pneumonia among other etiologies. Note the right apical mass and bi-apical fibrosis from old and ongoing Mycobacterial infection in the coronal CT image (Block arrows on D). CXR, Chest radiograph; GGO, ground glass opacities.

**TABLE 1**
Baseline demographic and clinical characteristics of patients in the case series

| Characteristics | Patients with COVID-19 (n = 8) |
|---|---|
| Age (Y), *mean +/- SD* | 54.5 ± 11.5 |
| Male | 6 (80%) |
| Female | 2 (20%) |
| Comorbidities | 6 (80%) |
| Cough | 8 (100%) |
| SOB | 8 (100%) |
| GI symptoms | 1 (12%) |
| Sore throat | 2 (25%) |
| Loss of sense of smell, taste | 1 (12%) |
| Peak body temperature (F), *mean +/− SD* | 101.8 ± 1.1 |
| Interval from symptom onset to admission, (days) *mean +/− SD* | 7 ± 2.4 |
| Leukocyte count, *mean +/− SD* | 7.45 ± 3.366 |
| Hydroxychloroquine | 4 (50%) |
| Remdesivir | 3 (37%) |
| Death | 2 (25%) |

**TABLE 2**
Imaging findings in patients with COVID pneumonia

| Patient | Location of abnormality on initial presentation | Consolidation | Pneum othorax | Pleural effusion | Cavitation | Lymphadeno-pathy |
|---|---|---|---|---|---|---|
| 1 | B/L, LL, P | N | N | N | N | N |
| 2 | B/L, LL, P | Y | N | N | N | N/A |
| 3 | B/L, LL, P | N | N | N | N | N/A |
| 4 | B/L, LL, P | Y | Y | N | N | N |
| 5 | R, LL, P | Y | N | N | N | N |
| 6 | B/L, LL, P | Y | N | N | N | N |
| 7 | R, LL, P | N | N | N | N | N |
| 8 | B/L, LL, P | N | N | N | N | N |

B/L, BILATERAL; LL, LOWER LOBES; N, NO; P, PERIPHERAL; R, RIGHT; Y, YES.

## Conclusion

This is the third corona virus pandemic in recent years with tremendous impact on the global health and economy. At the time of writing (March 29, 2020), the American College of Radiology recommends CT use only in specific clinical indications, and not for screening COVID-19 patients due to low specificity and problems with infection control.[17] Nevertheless, the global implications of the pandemic make it important for radiologists, trainees, and clinicians to be familiar with the varying radiographic features of coronavirus lung disease to assist in difficult clinical decisions and manage the care of their patients.

## References

1. Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 2020;382(8):727–33, https://doi.org/10.1056/NEJMoa2001017.
2. Hui DS, I Azhar E, Madani TA, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health — The latest 2019 novel coronavirus outbreak in Wuhan, China. Int J Infect Dis 2020;91:264–6, https://doi.org/10.1016/j.ijid.2020.01.009.
3. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020. Accessed March 29, 2020.

4. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. https://doi/org/10.1016/S1473-3099(20)30120-1.
5. Wu J, Wu X, Zeng W, et al. Chest CT findings in patients with corona virus disease 2019 and its relationship with clinical features. Invest Radiol. February 2020:1. https://doi/org/10.1097/rli.0000000000000670.
6. Cheng Z, Lu Y, Cao Q, et al. Clinical features and chest CT manifestations of coronavirus disease 2019 (COVID-19) in a single-center study in Shanghai, China. Am J Roentgenol 2020:1–6, https://doi.org/10.2214/ajr.20.22959.
7. Ajlan AM, Ahyad RA, Jamjoom LG, Alharthy A, Madani TA. Middle East respiratory syndrome coronavirus (MERS-CoV) infection: Chest CT findings. Am J Roentgenol 2014;203(4):782–7, https://doi.org/10.2214/AJR.14.13021.
8. Das KM, Lee EY, Enani MA, et al. CT correlation with outcomes in 15 patients with acute middle east respiratory syndrome coronavirus. AJR Am J Roentgenol 2015;204(4):736–42, https://doi.org/10.2214/AJR.14.13671.
9. Wan YL, Tsay PK, Cheung YC, et al. A correlation between the severity of lung lesions on radiographs and clinical findings in patients with severe acute respiratory syndrome. Korean J Radiol 2007;8(6):466–74, https://doi.org/10.3348/kjr.2007.8.6.466.
10. Wong HYF, Lam HYS, Fong AH-T, et al. Frequency and distribution of chest radiographic findings in COVID-19 positive patients. Radiology 2019:201160, https://doi.org/10.1148/radiol.2020201160.
11. Simpson S, Kay FU, Abbara S, et al. Radiological Society of North America expert consensus statement on reporting chest CT findings related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA. Radiol Cardiothorac Imaging 2020;2(2):e200152, https://doi.org/10.1148/ryct.2020200152.
12. Bernheim A, Mei X, Huang M, et al. Chest CT findings in coronavirus disease-19 (COVID-19): Relationship to duration of infection. Radiology 2020:200463, https://doi.org/10.1148/radiol.2020200463.
13. Li Y, Xia L. Coronavirus disease 2019 (COVID-19): Role of chest CT in diagnosis and management. Am J Roentgenol 2020:1–7, https://doi.org/10.2214/AJR.20.22954.
14. Dai WC, Zhang HW, Yu J, et al. CT Imaging and Differential Diagnosis of COVID-19. Thorac Cardiac Imaging2091. doi:10.1177/0846537120913033
15. Bassetti M, Vena A, Giacobbe DR. The novel Chinese coronavirus (2019−nCoV) infections: Challenges for fighting the storm. Eur J Clin Invest 2020;50(3), https://doi.org/10.1111/eci.13209.
16. Torrealba JR, Fisher S, Kanne JP, et al. Pathology-radiology correlation of common and uncommon computed tomographic patterns of organizing pneumonia. Hum Pathol 2018;71:30–40, https://doi.org/10.1016/j.humpath.2017.10.028.
17. ACR Recommendations for the use of Chest Radiography and Computed Tomography (CT) for Suspected COVID-19 InfectionAmerican College of Radiology. Available at: https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection. Accessed April 1, 2020.