Review of Chest Radiograph Findings of COVID-19 Pneumonia and Suggested Reporting Language

Diana E. Litmanovich, MD, Michael Chung, MD,† Rachael R. Kirkbride, MBChB,* Gregory Kicska, MD, PhD,‡ and Jeffrey P. Kanne, MD§*

Abstract: The diagnosis of coronavirus disease 2019 (COVID-19) is confirmed by reverse transcription polymerase chain reaction. The utility of chest radiography (CXR) remains an evolving topic of discussion. Current reports of CXR findings related to COVID-19 contain varied terminology as well as various assessments of its sensitivity and specificity. This can lead to a misunderstanding of CXR reports and makes comparison between examinations and research studies challenging. With this need for consistency, we propose language for standardized CXR reporting and severity assessment of persons under investigation for having COVID-19, patients with a confirmed diagnosis of COVID-19, and patients who may have radiographic findings typical or suggestive of COVID-19 when the diagnosis is not suspected clinically. We recommend contacting the referring providers to discuss the likelihood of viral infection when typical or indeterminate features of COVID-19 pneumonia on CXR are present as an incidental finding. In addition, we summarize the currently available literature related to the use of CXR for COVID-19 and discuss the evolving techniques of obtaining CXR in COVID-19-positive patients. The recently published expert consensus statement on reporting chest computed tomography findings related to COVID-19, endorsed by the Radiological Society of North American (RSNA), the Society of Thoracic Radiology (STR), and American College of Radiology (ACR), serves as the framework for our proposal.

Key Words: coronavirus disease 2019, chest radiograph, standardized reporting language, severity assessment, pneumonia

(*J Thorac Imaging* 2020;00:000–000)

Since its onset in late 2019 and labeling as a pandemic by the World Health Organization on March 11, 2020,[1] the coronavirus disease 2019 (COVID-19) outbreak continues to put immense stress on hospital systems, emergency departments, and intensive care units. COVID-19, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is a highly transmissible disease with a predilection for causing potentially fatal pneumonia.[2]

From the *Department of Cardiothoracic Radiology, Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, MA; †Department of Diagnostic, Molecular and Interventional Radiology, Icahn School of Medicine at Mount Sinai, New York, NY; ‡Department of Radiology, University of Washington Medical Center, Seattle, WA; and §Department of Radiology, University of Wisconsin School of Medicine and Public Health, Madison, WI.
The authors declare no conflicts of interest.
Correspondence to: Diana E. Litmanovich, MD, Department of Cardiothoracic Radiology, Beth Israel Deaconess Medical Center and Harvard Medical School, 330 Brookline Avenue, Boston, MA 02215 (e-mail: dlitmano@bidmc.harvard.edu).
Supplemental Digital Content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website, www.thoracicimaging.com.

DOI: 10.1097/RTI.0000000000000541

The diagnosis of COVID-19 is confirmed by reverse transcription polymerase chain reaction (RT-PCR).[3] Many radiology professional organizations and societies, including the American College of Radiology (ACR), the Society of Thoracic Radiology (STR), and the American Society of Emergency Radiology (ASER), currently recommend against performing computed tomography (CT) for the diagnosis of COVID-19.[4,5]

Although chest CT is more sensitive than chest radiography (CXR) for detecting parenchymal abnormalities, there is evidence, albeit limited and reflective of overall small studies, supporting concordance between the 2 modalities.[6–8] CXR is still a useful tool in identifying COVID-19 pneumonia in suspected patients, particularly given that performing chest CT as a first-line imaging test would be very challenging given the large numbers of patients and long equipment cleaning time, along with the potential for increased staff exposure and transmission compared with CXR. One must consider the 2013 review from the Cochrane Database of Systematic Reviews, which concluded that CXR did not improve clinical outcomes (duration of illness) for patients with lower respiratory tract infection.[9] Despite this, CXR, particularly portable radiography, continues to be performed in emergency and critical care settings to assist with individual patient management, to identify complications of pneumonias, and to assess for alternative diagnoses. At the current stage of the COVID-19 pandemic, CXR, especially portable CXR, is being used in multiple countries as a first-line triage tool not only for diagnosis, but also for assessing the severity of the COVID-19 infection.[6,10–12] Furthermore, as the prevalence of COVID-19 is increasing globally, it is important for radiologists and clinicians to recognize COVID-19 features on CXR, especially as CXR is often performed for other purposes. Thus, as recommended by the ACR, portable radiography should be used initially, when medically necessary, given that the surfaces of these machines can be cleaned easily and that those machines could be deployed in designated COVID-19-patient facilities and emergency departments.

Current reports of CXR findings related to COVID-19 contain varied descriptions and terminology[13–16] (Appendix 1, Supplemental Digital Content 1, http://links.lww.com/JTI/A172). This variance can lead to misunderstanding of CXR reports and makes comparison between examinations and research studies challenging. With this need for consistency, we propose language for standardized CXR reporting and severity assessment of persons under investigation for having COVID-19, patients with a confirmed diagnosis of COVID-19, and patients who may have radiographic findings typical or suggestive of COVID-19 when the diagnosis is not suspected clinically. In addition, we summarize the currently available literature related to the use of CXR for COVID-19. The recently published expert consensus statement on reporting chest CT findings related to COVID-19,

TABLE 1. Proposed Reporting Language for CXR Findings Related to COVID-19*

Radiographic Classification	CXR Findings	Suggested Reporting Language
Typical appearance	Multifocal bilateral, peripheral opacities Opacities with rounded morphology Lower lung–predominant distribution	"Findings typical of COVID-19 pneumonia are present. However, these can overlap with other infections, drug reactions, and other causes of acute lung injury"
Indeterminate appearance	Absence of typical findings AND Unilateral, central or upper lung predominant distribution	"Findings indeterminate for COVID-19 pneumonia and which can occur with a variety of infections and noninfectious conditions"
Atypical appearance	Pneumothorax or pleural effusion Pulmonary edema Lobar consolidation Solitary lung nodule or mass Diffuse tiny nodules Cavity	"Findings atypical or uncommonly reported for COVID-19 pneumonia. Consider alternative diagnoses"
Negative for pneumonia	No lung opacities	"No findings of pneumonia. However, chest radiographic findings can be absent early in the course of COVID-19 pneumonia"

Reporting language might be used for the following indications (but are not limited to): patients with suspected COVID-19 pneumonia; assessment or reassessment of patients with COVID-19 pneumonia; and indications other than suspected viral pneumonia or specifically COVID-19.

*CXR is not a substitute for RT-PCR, consider PCR testing according to local procedures or guidelines.

endorsed by the Radiological Society of North American (RSNA), the STR, and (ACR), serves as the framework for our proposal.[17]

PERFORMING CXR DURING THE COVID-19 PANDEMIC

CXR is currently used as a low-cost and widely available diagnostic imaging examination for detecting lung involvement in patients with known or suspected COVID-19 pneumonia.[6,13] However, its true sensitivity and specificity are unclear.[18,19] Portable CXR is particularly appealing for initial assessment of patients presenting with fever or respiratory complaints, including those with suspected COVID-19 pneumonia. Portable CXR can be performed in or near the Emergency Department or hospital unit, reducing the need to transport potentially infected patients around the hospital and decreasing the use of personal protective equipment. Some institutions have developed a protocol by which portable CXR units from the hallway are used to image patients while they remain in their isolation room. The technologist passes the cassette, encapsulated in 2 bags, to a nurse or staff member inside the isolation room, who is wearing appropriate personal protective equipment. The patient, seated in a wheelchair or in bed, faces the x-ray source through a glass door/window while the nurse positions the cassette behind the patient's back. After the radiograph is acquired, the staff member passes the cassette across the doorway, to the technologist, who retrieves only the cassette and inner bag, but not the outer bag. The outside of the inner bag is disinfected, and then the cassette is removed and disinfected[20] (Jeffrey Kanne from J. David Godwin, MD, University of Washington on March 29, 2020, personal written communication).

CXR: SPECTRUM OF IMAGING FINDING AND PROGRESSION OVER TIME

Descriptions of radiographic findings of patients with COVID-19 are limited by inconsistency and nonstandard terminology in reporting and because most published studies are focused on CT. Terminology such as "consolidation," "opacities," "shadowing," and "alterations" are used, presumably interchangeably.[13–16] Summarizing the available literature, the predominant CXR findings of COVID-19 pneumonia are bilateral, peripheral, lower lung predominant opacities, which are described as "hazy," "ground-glass opacity (GGO)," and "consolidation."[6,7,13–15,21–29] In a retrospective analysis study of 64 patients with RT-PCR-confirmed COVID-19 in 4 hospitals in Hong Kong, 44 patients (69%) had abnormal initial CXRs, with 68% having consolidation and 48% having GGO. These findings were most commonly bilateral (73%), with a lower lung distribution (73%) and peripheral predominance (59%).[6] Another study of 162 patients with COVID-19 reports bilateral patchy "shadowing" (62%) and GGO (34%) on CXR.[14] Pleural effusion is reported in 3% of patients on initial CXR.[6]

Normal CXRs are not uncommon for symptomatic patients presenting early in the disease course.[6,14,16,22,23,30] In one cohort of 64 COVID-19-positive patients, 31% had a normal CXR at presentation.[6] Importantly, a small number of patients with clinically severe disease can have a normal initial CXR. Furthermore, of 39 patients who met a primary composite endpoint (ICU admission, ventilation, or death), 9 (23%) had a normal initial CXR.[14] On the contrary, CXRs can have abnormalities typical of COVID-19 pneumonia in asymptomatic patients[18] or with initially negative RT-PCR.[6] Less typical CXR findings in patients with COVID-19 are also reported, with Yoon et al[13] showing a CXR example, with CT correlation, of a patient with a 2.3 cm solitary nodular focus of consolidation, and multiple case reports describing a unilateral opacity on initial CXR.[23,30–32]

From the limited available literature, CXR abnormalities often progress over time[24,30,33] and correlate with clinical

TABLE 2. Proposed Reporting Language for Grading Lung Disease Related to COVID-19 on Frontal CXR

Grading of Lung Disease	Rationale
Mild	Opacities in 1-2 lung zones
Moderate	Opacities in 3-4 lung zones
Severe	Opacities in >4 lung zones

A frontal chest radiograph can be divided into 3 zones per lung, for a total of 6 zones (Fig. 8).[34]

Upper zone: apices to the superior portion of the hilum.

Mid zone: between the superior and inferior hilar margins.

Lower zone: between the inferior hilar margins to the costophrenic sulci.

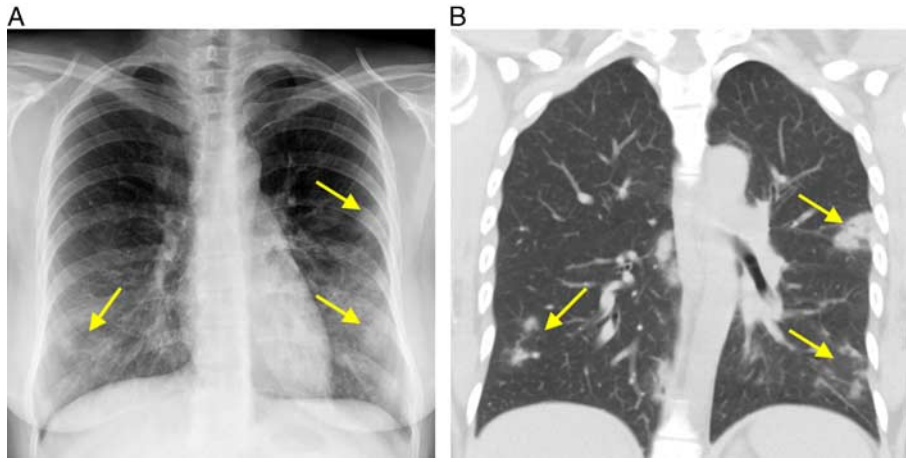

FIGURE 1. Typical CXR features: posteroanterior CXR (A) of a 29-year-old woman with COVID-19 presenting with 2 days of cough and diarrhea shows moderate (3 lung zones) multifocal rounded opacities in the mid to lower lungs with a peripheral distribution (arrows). Coronal CT (B) shows corresponding ground-glass opacity/opacities and consolidation (arrows). full color online

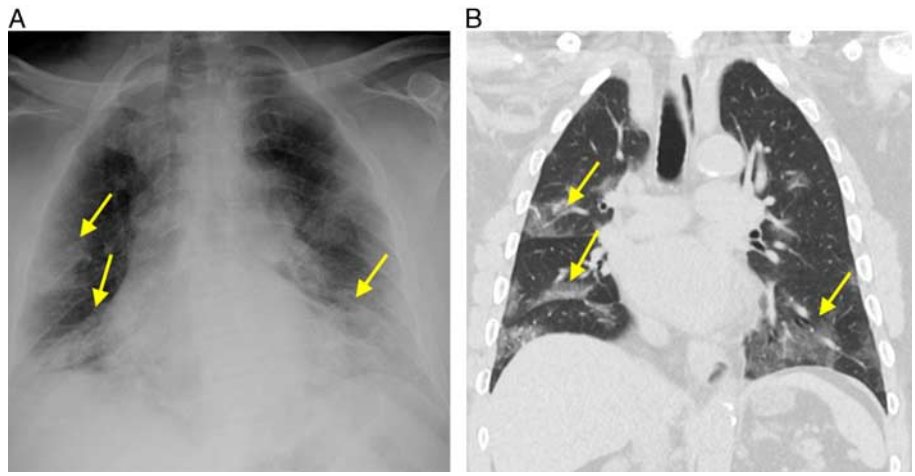

FIGURE 2. Typical CXR features: anteroposterior CXR (A) of a 77-year-old man with COVID-19 presenting with 1 day of fever shows moderate (4 lung zones) multifocal hazy opacities with a lower lung predominant distribution (arrows). Coronal CT (B) shows corresponding bilateral ground-glass opacities (arrows). full color online

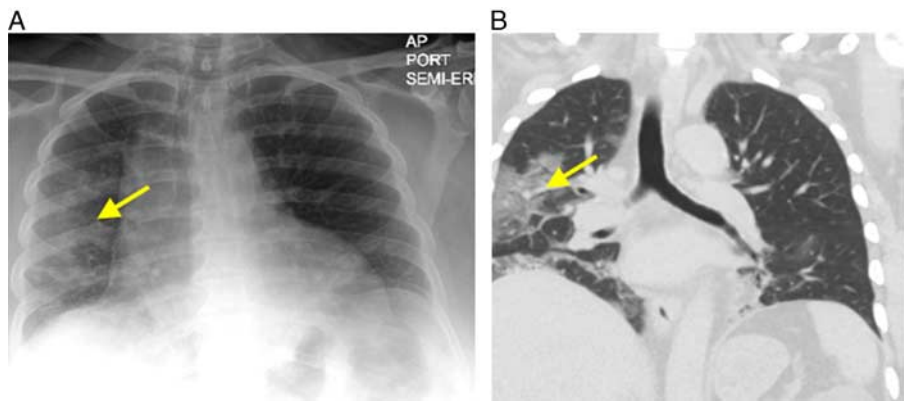

FIGURE 3. Indeterminate CXR features: bedside anteroposterior CXR (A) of a 60-year-old woman with COVID-19 presenting with 2 days of cough shows mild (2 lung zones) hazy opacity in the right mid lung (arrow). Coronal CT (B) shows corresponding unilateral ground-glass opacities (arrow). full color online

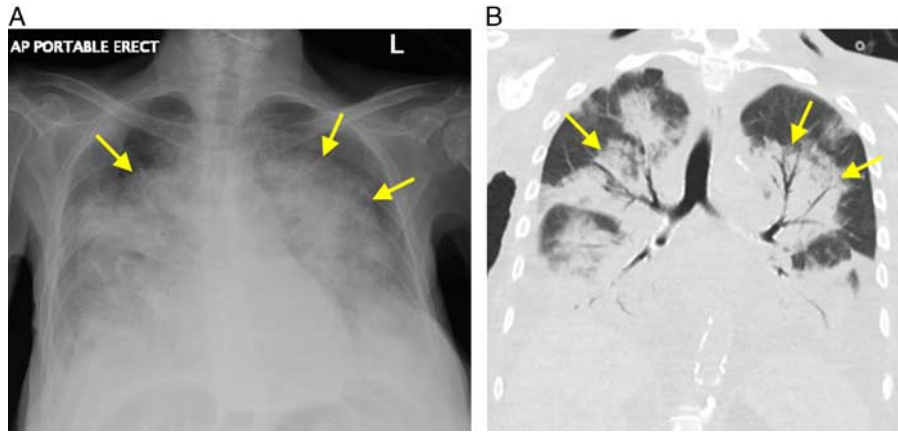

FIGURE 4. Indeterminate CXR features: bedside anteroposterior CXR (A) of a 72-year-old woman with COVID-19 presenting with lethargy and altered mental status shows severe (6 lung zones) bilateral, upper lobe–predominant central opacities (arrows). Coronal CT (B) shows corresponding consolidation with associated air bronchograms (arrows). full color online

severity.[7,23,25,26,34] Wong et al[6] showed worsening CXR "severity score" (calculated from the percentage of affected lung) over time, with a peak at 10 to 12 days after presentation and slow resolution of abnormalities over weeks. Another study showed a 72-hour progression of bilateral "reticulonodular" opacities from 52% to 86%, and GGO from 48% to 67%.[15]

Although chest CT is more sensitive than CXR for detecting parenchymal abnormalities, there is evidence, even though limited and reflective of overall small studies, supporting concordance between the 2 modalities.[6–8,35]

STRUCTURED REPORTING

Rationale for Introducing Suggested CXR Reporting Language

Despite the known limitations of CXR compared with chest CT in assessing patients with known or suspected COVID-19 infection, radiography, like CT, may guide individual patient management decisions, identify complications (iatrogenic or secondary to the pneumonia), or suggest an alternative diagnosis. While CXR is being performed commonly during this pandemic, we do not currently recommend the use of radiography in screening for COVID-19 pneumonia. However, standardized language can be helpful in improving reporting consistency and decreasing the use of vague, nebulous terminology.

Our proposed reporting language (Table 1) for categorizing CXR findings is based on our current knowledge of the typical radiographic manifestations of COVID-19. We also suggest terminology for qualifying the degree of lung disease in COVID-19 pneumonia using a modified version of a scoring system used in studies that quantified severity of severe acute respiratory syndrome on CXR (Table 2).[36] It is important to note that our proposed reporting language does not suggest likelihood of COVID-19 diagnosis, which will depend on the prevalence in one's local community and a patient's risk factors (eg, exposure history).

Radiographic Classification of Findings Potentially Related to COVID-19

Typical features on CXR are those that have been commonly reported in the COVID-19 literature (Figs. 1, 2). The primary differential considerations include other infections or organizing pneumonia, which can be idiopathic or a result of

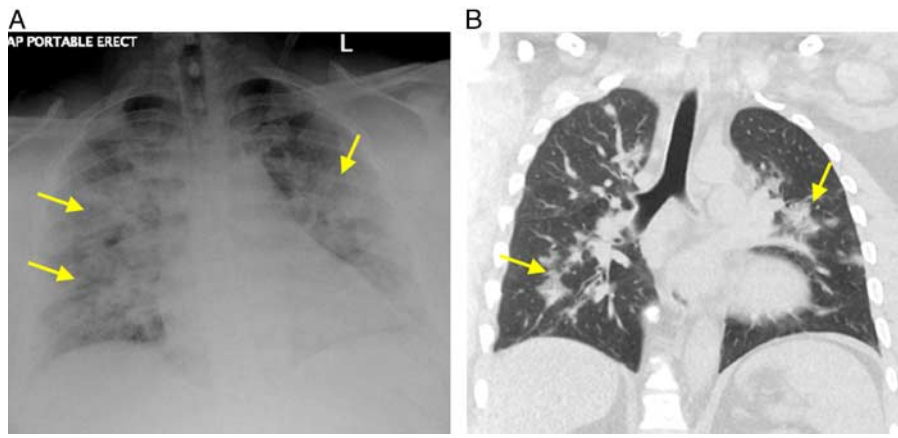

FIGURE 5. Indeterminate CXR features: Bedside AP CXR (A) of a 41-year-old man with COVID-19 presenting with worsening shortness of breath over 7 days shows severe (5 lung zones) bilateral perihilar opacities (arrows). Coronal CT (B) shows corresponding ground-glass opacities and consolidation (arrows). full color online

lung insult from various etiologies such as medications or recreational drugs.

Indeterminate features on CXR are those that have been reported in COVID-19 pneumonia but overlap significantly with other etiologies. An example would be a CXR with upper lung predominant and perihilar (central) disease (Figs. 3–5). On radiography, alveolar edema, or other infections (eg, *Pneumocystis*), can lead to similar appearances. Unilateral disease has also been reported in COVID-19 pneumonia but is less common and less specific for this disease.[37]

Atypical features on CXR are those that are uncommon or have not been reported in the COVID-19 literature. Examples include pulmonary edema, pneumothorax, pleural effusion, lobar consolidation, discrete nodules (solitary nodules or masses or diffuse tiny nodules), and cavitation (Fig. 6). There are a variety of other disease processes that would more likely result in these imaging features including *Streptococcus pneumoniae* pneumonia, which can result in lobar consolidation.

Negative features refer to the absence of lung opacities on CXR. However, it is important to note that chest radiographic findings can be absent early in the course of COVID-19 pneumonia.[6]

Appropriate Clinical Setting to Apply COVID-19-based Structured Reporting Language

There can be considerable overlap between the typical and indeterminate appearance of COVID-19 pneumonia and multiple other infectious and noninfectious diagnoses. The local prevalence of disease at the time CXR was performed must be considered during imaging findings' interpretation. At times of high prevalence, almost any lung opacity can be suspected to correspond to COVID-19 pneumonia. When the prevalence of disease drops, offering COVID-19 as a diagnostic possibility in a patient with very low pretest probability may cause unnecessary and inappropriate diversion of clinical resources to care for what is highly likely to be a COVID-19-negative patient. Negative RT-PCR results should not dissuade a radiologist from suggesting COVID-19 if the appearance is typical and other clinical information indicates a sufficient pretest probability. The primers used for RT-PCR tests vary by locality. The test results of the different primer sets do not always agree in terms of identifying a positive control or cross-reacting with a non-COVID viral panel. This is consistent with the 30% false-negative rate reported in samples acquired with a nasopharyngeal swab.[38]

Quantifying and Qualifying Lung Disease in COVID-19 Pneumonia

Despite variability in CXR reporting and potential wide interobserver agreement among radiologists, grading

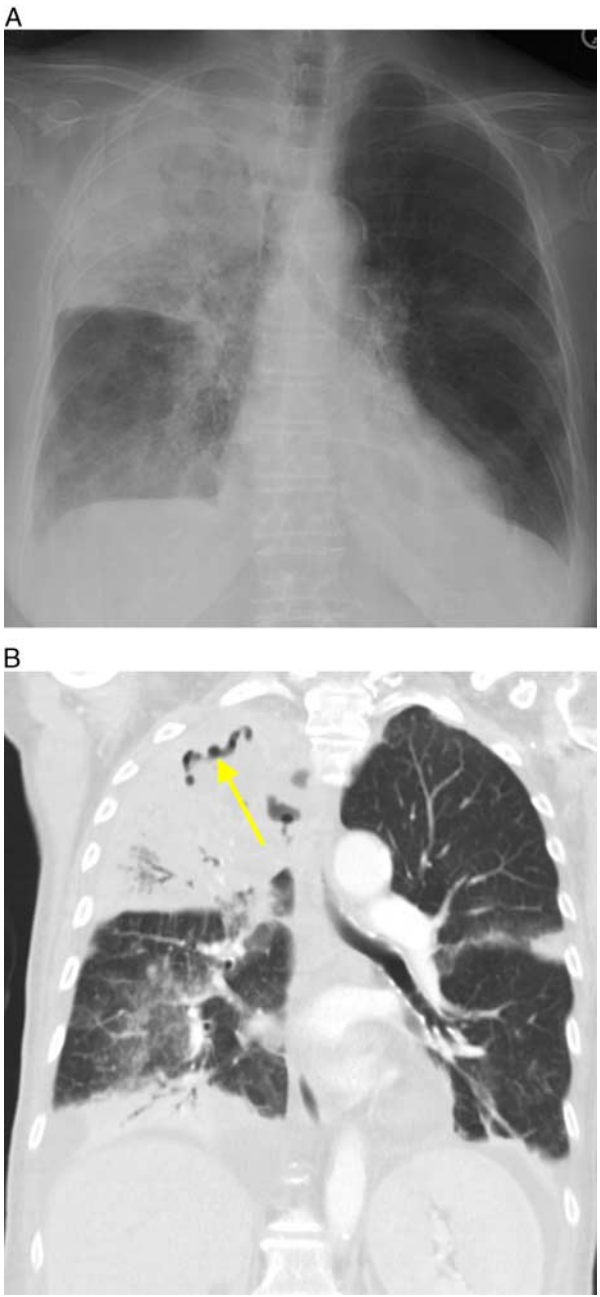

FIGURE 6. Atypical CXR features: a 67-year-old man with a clinically suspected pneumonia, results of RT-PCR pending, presents with 8 days of fever and cough. Posteroanterior CXR (A) shows right upper lobe consolidation. Coronal CT (B) shows corresponding lobar consolidation with developing cavitation (arrow). A bacterial pneumonia is the primary diagnostic consideration. full color online

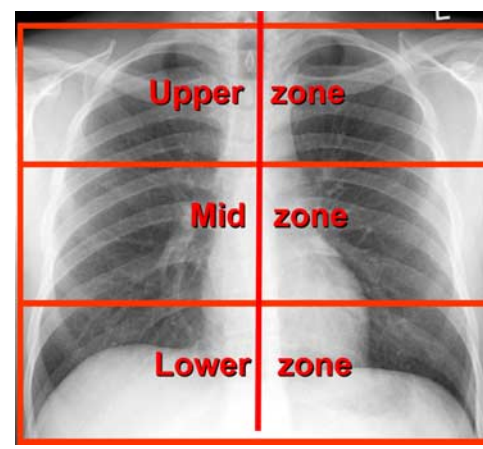

FIGURE 7. Lung zones: proposed methodology for dividing a frontal CXR into 3 zones per lung (total of 6 zones). The upper zone extends from the apices to the superior portion of the hilum. The mid zone spans the space between the superior and inferior hilar margins. The lower zone extends from the inferior hilar margins to the costophrenic sulci. full color online

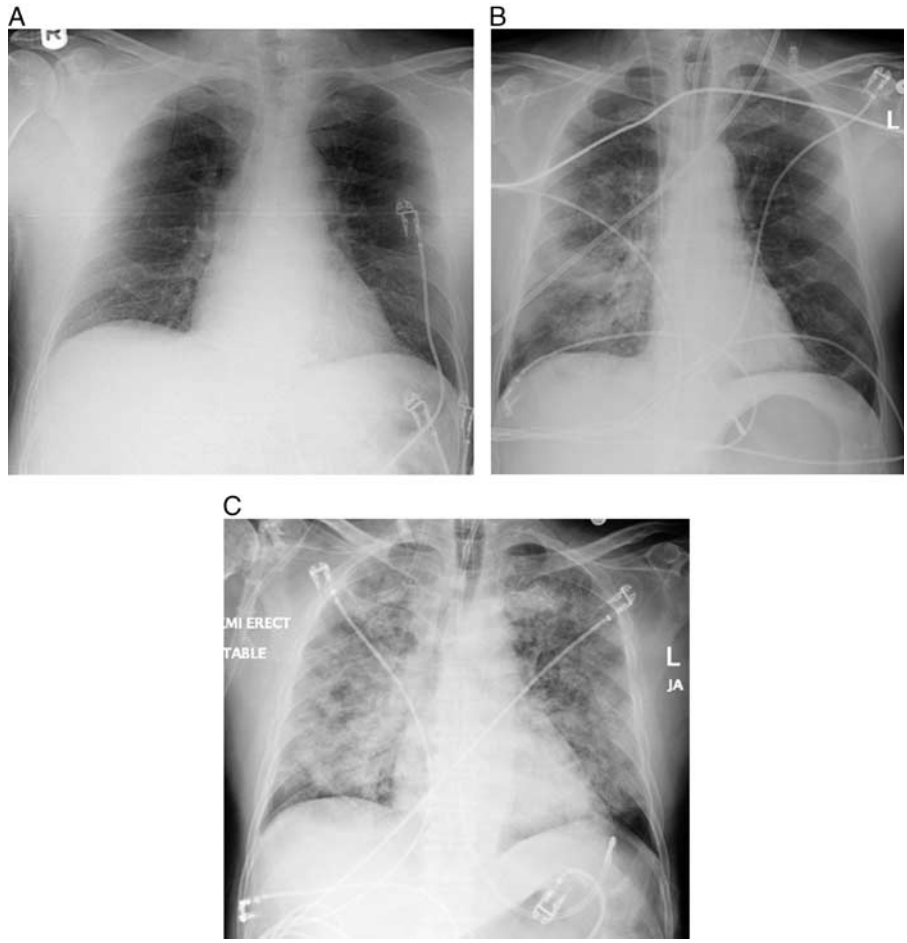

FIGURE 8. Grading lung disease on successive CXR: a 63 year-old man with COVID-19 presents with 1 day of fever and myalgias and normal CXR (A). He returns 2 days later with worsening symptoms and requires ICU admission. Bedside anteroposterior CXR (B) shows moderate (3 lung zones) bilateral opacities. The patient subsequently developed ARDS, and bedside anteroposterior CXR on day 6 (C) shows increased, now severe, diffuse lung opacities.

or quantifying the severity of lung disease in COVID-19 pneumonia on CXR has potential utility, especially with the emergence of CXR as a frontline diagnostic imaging test.[10]

Semiquantitative techniques can be used to further qualify the lung disease on CXR as mild, moderate, or severe, with proposed straightforward reporting language based on lung zone involvement (Table 2, Fig. 7). On follow-up radiographs, the grade of lung disease can be further detailed as being stable, increased, or decreased in severity (Fig. 8).

Communication With Referring Providers

Effective and consistent communication between radiologists and clinicians is critical during this pandemic. It starts with a clear and concise report that allows the referring provider to easily see and comprehend our assessment of the patient. When typical or indeterminate findings of COVID-19 pneumonia are initially found on chest radiographs in persons under investigation or as an incidental finding in an endemic area, we advise prompt communication with referring clinicians to discuss the likelihood of COVID-19 infection. On subsequent radiographs, dynamic assessment of any changes is of paramount importance: stability, improvement, or worsening of the disease should be addressed.

Radiologists should reference the ACR Practice Parameter for Communication of Diagnostic Imaging Findings.[39] In the setting of incidentally found features of COVID-19 pneumonia, radiology and clinic staff (eg, nurses, technologists, clerks, etc.) should also be notified to initiate appropriate infection control measures for potential exposure.

Pros and Cons of Standardized Reporting

Standardized reporting for a variety of indications has increased over the past years.[40] Advantages include providing radiologists with tools needed to confidently report findings suggesting COVID-19, especially when RT-PCR results are not available, or the diagnosis is unexpected, and increased report clarity with reduced variability. Disadvantages of standardized reporting for COVID-19 include inciting unanticipated patient or physician alarm and conflict between local testing guidelines and chest radiography reports.[17]

CONCLUSIONS

The role of radiologists in this pandemic is evolving, as more patients are diagnosed via RT-PCR and as more patients require ICU admission. CXR will continue to play an important, complementary role in the evaluation and management of patients diagnosed with COVID-19. We propose four

categories of suggested CXR reporting language for COVID-19. We also propose a semiquantitative scoring system for assessing the severity of findings on radiography, which can be applied to initial and subsequent radiographs.

This suggested approach can be incorporated into local practice parameters and procedures.

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