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Radiology of COVID-19 - Imaging the pulmonary damage

Saba Sohail

COMMENTARY

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Abstract

A large part of the world is presently in the grip of the coronavirus disease (COVID-19) by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2 virus), declared a pandemic in March 2020. This document is a brief commentary of the imaging modalities used in the screening, diagnosis and management of COVID-19 pneumonia. Chest x-rays, especially portable, still form a part of majority of official guidelines, with reports of the suggestive radiologic features. The potential of CT scan and ultrasound is also realised, with earlier detection rate. Typical radiologic findings of bilateral, asymmetrical, crazy-paved ground glass opacification, consolidation, reverse halo sign, opacities, progressing to fibrosis are well described for both the X-ray and CT scan. Atypical findings include airway changes, pleural effusion, pulmonary nodules and acute pulmonary embolism. Absence of lymphadenopathy, pleural effusion and pneumothorax is notable. The role of portable lung ultrasound, reported to be useful in emergency, is yet to be established in the guidelines. Disinfection of the equipment is a major concern. Governmental guidelines still advocate X-ray despite professional societies increasingly recommending CT scan.

Keywords: COVID-19, Radiology, Chest X-ray, CT scan, Ultrasound, Artificial intelligence, Sub-pleural consolidation, Ground glass opacification.

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Introduction

Viruses have been known to cause severe respiratory disease. The rise of Coronaviridae, considered a minor pathogen a few decades ago, to a feared name is astounding. Severe acute respiratory syndrome (SARS) epidemic surfaced in the early 2000, followed by Middle East respiratory syndrome (MERS), has now been toppled over by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV- 2). The pandemic which first surfaced in China, spread to Europe, central Asia and the Americas and the rest of the world, mutating along the way becoming deadlier at some places and running relatively less aggressive course at others. The symptoms are non-specific; clinical course is not following any reliably predictable or defined pattern varying from asymptomatic carrier status, to mild flu-like to a severe pneumonia. Nucleic acid testing availability is falling short of the affected numbers. To top it all, the other respiratory pathogens have not declined, producing a dire need to differentiate between the COVID and non-COVID pulmonary disease. Imaging may play a role here.

Reports of radiology features started appearing as early as January 2020, less than a month after disease emergence. Radiologically documented severe pneumonia was described, combined with respiratory distress, cardiac injury and other features of acute systemic injury.[1] Since then, there is a growing body of evidence regarding the imaging of pulmonary damage on chest X-ray, CT scan, and lately ultrasound.[2-8]

Radiologic Signs

The chest X-ray and CT scan signs correspond with each other (Figures 1-4). The signs reported in literature can

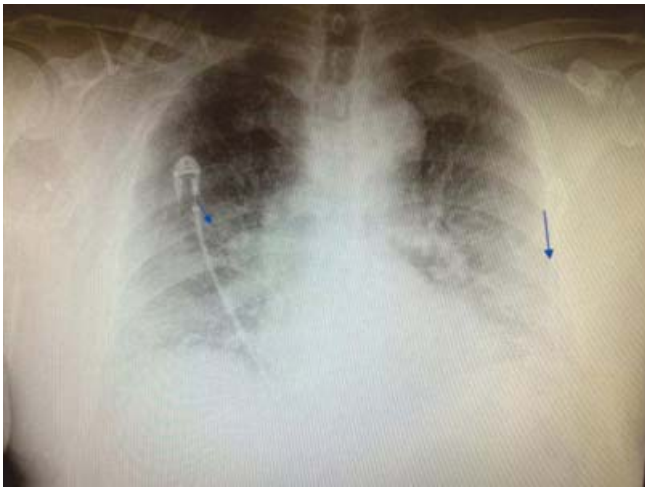

Figure-1: Initial chest X-ray of a polymerase chain reaction coronavirus disease-positive adult showing peripheral ground glass haze (arrows).
(Image courtesy: Dr Imran Sharief, MD, FCCP).

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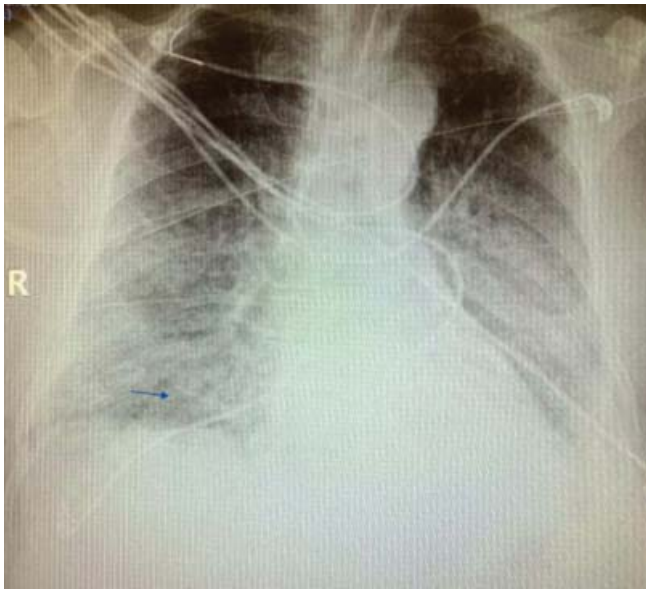

Figure-2: A more advanced pulmonary disease with chest x-ray image with combination of ground glass pattern (arrow), foci of consolidation, interstitial thickening and occasional dilated bronchi. The involvement is bilateral, asymmetrical and more pronounced peripherally.

(Image courtesy: Dr Imran Sharief, MD, FCCP).

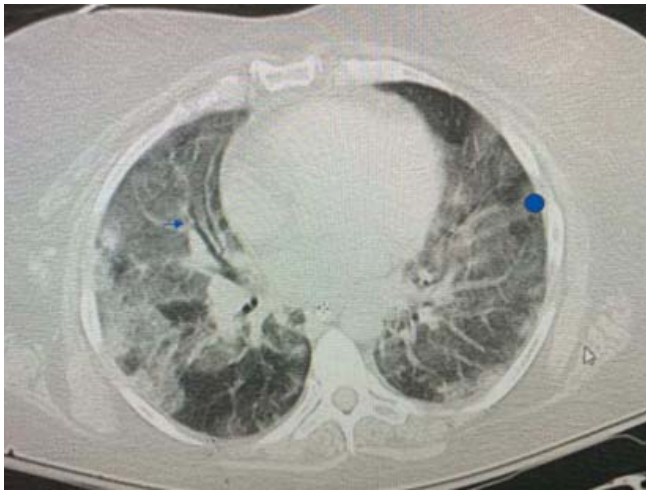

Figure-3: Corresponding CT chest taken at the level of lower lobes, showing the combination of non-dependent ground glass pattern, foci of consolidation with air bronchogram (arrow), interstitial thickening and occasional dilated bronchi (circle). The involvement is bilateral, asymmetrical, with multi-segmental to lobar distribution and the epicenter is sub-pleural.

(Image courtesy: Dr Imran Sharief, MD, FCCP)

now be easily described as typical and atypical.

Typical and common suggestive signs include:[2-7]

◆ Ground glass haze (air-space opacification without obscuring vascular and interstitial markings) progressing to consolidation (air space opacification with air bronchogram, and obscured vascular and interstitial marking)

Figure-4: Early changes of coronavirus disease (COVID-19) pulmonary disease; CT section at the level of carina, showing bilateral sub-pleural ground glass haze, with sub-segmental distribution. There is interstitial thickening with relatively prominent vessels (arrow).

(Image courtesy: Dr Imran Sharief , MD, FCCP)

◆ Reticular pattern with interstitial thickening of interstitial pneumonia

◆ Dilated vessels and bronchi/airway disease within the lesions[6,7]

◆ Reverse halo sign.[4]

Atypical/ uncommon signs include:

◆ Centrilobular nodules[5,6]

◆ Fibrosis[6]

◆ Pleural effusion[3,6]

◆ Acute pulmonary embolism[9]

◆ Lymphadenopathy is typically absent.[2,3,6,7]

Distribution and Evolution of the Signs are the Distinctive Features

It must be remembered that the above stated common or suggestive signs are actually non-specific *per se*, and only indicate acute lung injury as in organising pneumonias of any aetiology. The real distinctive feature is their distribution. The distribution is:

◆ Sub-pleural -often described as peripheral but it can very well be central under mediastinal pleural reflections (Figure-4)

◆ Bilateral but usually asymmetrical involvement,

◆ Subsegmental to begin with, progressing to involve segments and lobes, and sometimes the whole lungs giving a white-washed appearance (Figures-2 and 3)

◆ Lower lobar initially, ascending higher peripherally.

This evolution pattern has been utilised to monitor, gauge the severity, and follow-up on sequential imaging.[10] Using the same evolution pattern, Pan *et al* developed objective criteria for quantitative assessment of the pulmonary involvement.[11] It evaluated serial CT scans to observe the topographic spread from segments to lobes to whole lungs, score staring from 0 (no segmental involvement) to a maximum of 25 (all segments involved).[11] The original version included only segmental and lobar topography, while Huang et al improvised it to include the radiographic patterns as well, to consider the changes in CT appearances from simple ground glass opacification to crazy-paving, and frank consolidation.[12] They also found that serial CT not only monitored the progress, but also noted that all recovered and discharged patients had residual radiologic signs despite clinical recovery, and PCR-negative status.[12]

It was based on these predictive patterns that machine based models were developed and artificial intelligence was employed to differentiate COVID-19 pneumonia from the non- COVID community-acquired pneumonia on chest CT with 90 % sensitivity, and 96% specificity ($p<0.001$).[13]

Role of Ultrasound

Since the beginning of the pandemic, emergency and critical care clinicians, realising the need for urgent decision-making, have been stressing on the need to utilise the ultrasound for evaluation of consolidation and differentiation from pleural effusion based on the development of B-lines in a zone and of air bronchogram.[8,14] Three or more B-lines per zone indicate positive zones and the presence and size of sub-pleural consolidation shows the extent of damage.[8,14] While it makes sense for the sub-pleural and peripheral location of the nature of disease, deep-seated lesions, operator variability, disinfection of the equipment for an appropriate length of time, and physical proximity of the operator with the patient are practical hindrances.

Present Situation and Utility

X-rays are about 69% sensitive for diagnosis compared to > 90 % sensitivity of CT.[3,9] A lot depends upon the interval between the appearance of symptoms and the patient's presentation to the healthcare facility. Early disease may be missed by X-ray but picked by CT; however CT is not available everywhere and is definitely more of a risk for cross-infection compared to a portable X-ray device. Hence governmental guidelines suggest the use of chest X-rays while national and international societies are encouraging the use of CT scan with development of scenario and resource-based protocols for optimum to best practices. Unless there are a greater number of dedicated CT scans, public hospitals in Pakistan are more likely to rely on chest X-ray for differentiation of COVID-19 pneumonia from other causes of pulmonary morbidity. Portable X-ray and ultrasound equipment are to be preferred for early results, limiting the spread of infection and ease of disinfection.

Conclusion

Radiology is helpful in monitoring the progression of COVID-19 pneumonia, with distinctive radiological patterns seen on chest X-ray and CT scan. Use of imaging should be guided by the clinical needs. Disinfection of the contaminated equipment and ease of availability desires the use of portable equipment.

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