Review Article

Emerging Role of Portable X Ray in COVID-19: A Pictorial Review from Pakistan

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Abstract

Outbreak of infection caused by novel coronavirus (COVID-19) has spread across the globe since the beginning of 2020 and healthcare systems world over have struggled to cope with this pandemic. Radiological investigations including radiography, CT scanning and ultrasonography have been used globally to help detect the infection, grade its severity and determine prognosis. However, no perfect diagnostic tool has been developed yet, with the gold standard PCR also having limited sensitivity for detection of the virus. CT scan has been most thoroughly studied among the imaging modalities. However, there are several drawbacks of CT including its availability, lack of portability and risk of cross infection. Chest radiography overcomes these disadvantages. Despite its lack of sensitivity, its availability and portability imply that it is likely to be the most widely used imaging modality for this purpose in our part of the world. Recognition and familiarization with the most common chest radiographic findings in COVID-19 is extremely important for all frontline healthworkers striving to deal with this public health emergency.

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Introduction

Since the first case reported in China on 31 December 2019, the infection caused by novel coronavirus (COVID-19) has now spread to more than 213 countries across the globe.[1] The number of cases and deaths has continued to soar with the global case tally at more than 7 million and death toll more than 0.4 million on 12th June 2020.[2] The first case in Pakistan was officially reported on 26th February 2020.[3] before it was declared by WHO as pandemic on March 11, 2020.[4]

This pandemic has continued to challenge all fields of medicine with newer methods of diagnosis and treatment being tried and tested throughout the world as well as global efforts to invent a vaccine. Radiology has played an important role in its diagnosis and management right from the start when the first cases were reported from China[5] and its reliability versus the gold standard test currently available i.e. PCR continues to be a point of debate.[6] Some studies have reported CT to be much more sensitive than PCR for diagnosis of COVID- 19 reporting sensitivity as high as 98 %.[7] However laboratory diagnosis is still the criteria for labelling a case as definite.

Chest radiography, ultrasound and chest CT have all been employed around the world in different centers for this purpose. Although CT continues to be the most widely used modality for this purpose around the world, chest radiograph is often the first imaging modality of choice for clinicians.[8] Unfortunately, chest radiography is regarded as an insensitive tool for diagnosing COVID-19 infection with a reported sensitivity of only 69%.[9] However this seems like a

generalization, since its ability to pick an abnormality relies on the stage at which it is undertaken.[10] While asymptomatic and mild cases are likely to have no pathological findings on chest radiographs, those having moderate or severe disease are more likely to have abnormal radiographs. As the disease burden in Pakistan is increasing and the guidelines shift from isolating every confirmed patient in isolation centers to encouraging home isolation and taking only patients with moderate or severe disease to healthcare facility[11], more patients are expected to have positive findings when they are first imaged with radiography.

There are a number of advantages of chest radiography over CT scanning in case of COVID-19:

1. The portability possible with performing chest radiograph means that the infection control issues related to transport of patient with such a contagious disease to CT scan suite can be entirely eliminated if the former is used.
2. There is controversy regarding efficacy of even most stringent decontamination measures to disinfect CT scan machinery which will not be required in case of portable radiograph machinery.
3. The risk of cross contamination with CT scanner is theoretically greater than that with radiography and certainly much greater than portable radiography.
4. Even if adequate decontamination is done, this is time consuming in case of CT scan machinery which would disrupt provision of this facility to other patients unless there is a dedicated scanner.
5. There is increased risk of transmission of infection to healthcare professionals and other staff with CT scanning than with portable radiography owing to the number of people involved.
6. The availability of portable radiography is much more widespread than CT scan in third world countries such as Pakistan.
7. Even where CT scanners are available, their limited number implies that it is not possible at least in public sector institutes to dedicate a CT scan machine solely for COVID-19 imaging.
8. With increasing disease burden, serial imaging is likely to become difficult if not impossible with CT scanning, although serial chest radiography is more resource efficient for this purpose[12].

Therefore, while countries like China used dedicated CT scanners to image COVID-19 patients[13] and European countries like UK also tried employing CT scan, ACR tried to discourage the use of CT scanning for COVID-19 as much as possible, stressing to limit its use only for necessary cases.[14]

The second imaging tool that has been employed for COVID-19 is ultrasonography. It offers some of the same advantages as portable radiography. Its potential to be used for this purpose has been reviewed in literature in detail[15], its findings discussed in detail by Italians[16] and even recommendations given on how to standardize it internationally.[17] However its findings are currently regarded non-specific as was the case when it was used for influenza[18]. It is unable to differentiate between bacterial and viral pneumonia nor between pulmonary edema and infection and therefore not recommended by European Society of Radiology (ESR) and European Society of Thoracic Imaging (ETSI).[19] Also it is highly operator dependent and its reliability when used by those other than having vast experience in performing lung ultrasound has been questioned.[20] The local guidelines issued by the Radiological Society of Pakistan (RSP) also do not encourage its use.[21]

Keeping in view all these factors, it is likely that despite its lack of sensitivity and specificity, chest radiography is likely to be used widely in setups across our country for workup of COVID-19. Despite its low sensitivity, as disease prevalence increases, chest radiograph can prove to be a vital tool for diagnosis in appropriate clinical context, increasing the pre test probability.

The objective of this pictorial review is to describe the common patterns of abnormality in chest radiograph in COVID-19 to familiarize the medical community with them and help deal with this pandemic.

1-Ground Glass Opacities

Ground glass opacity is defined as an area of hazy increased lung opacity within which margins of pulmonary vessels may be indistinct[22]. They are the most common finding in COVID-19 on CT scans.[23] They are also thought to be the earliest manifestation.[24] They may be pure ground glass or may be accompanied by consolidation or reticular opacities. The underlying pathology is thought to be partial

replacement of air that normally fills the alveoli. It has been suggested that pulmonary edema and hyaline membrane formation may be responsible for this sign.[25] HRCT with its inherent high resolution is able to delineate it more easily and hence has a greater sensitivity for it. The density of these lesions is very subtle making it difficult to detect by radiography[26] that has a limited resolution and contrast. Yet a careful look at chest radiographs[Fig 1 and 2] can reveal this finding and it has been reported in the limited literature available regarding chest radiography in COVID-19. A study done on ambulatory patients who presented in urgent care center at New York also found that interstitial and ground glass opacities were the also most common finding in chest radiographs of patients with confirmed COVID-19.[27]

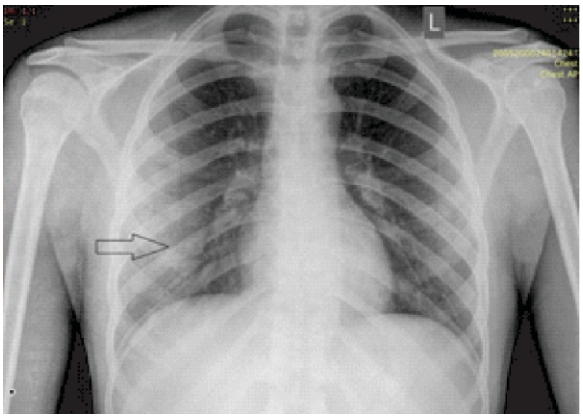

Figure 1: *Area of Ground Glass opacity in Right Mid Zone Appearing as Ill Defined Hazy Area (Indicated by Open Arrow)*

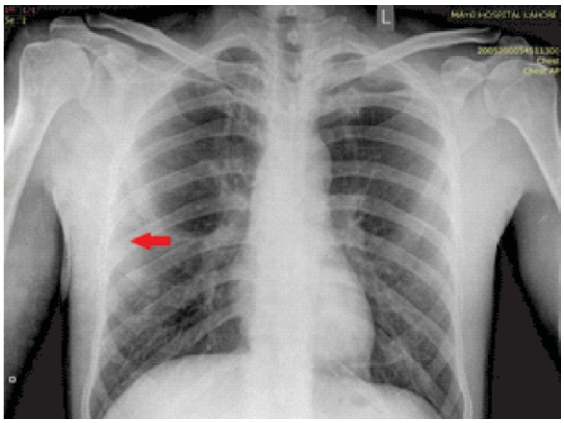

Figure 2: *Red Arrow Indicating an Area of Haziness Located Peripherally in Right Mid Zone*

2. Peripheral Air Space Opacities

Air space is defined as the gas containing part of the lung exclusive of purely conducting airways but including the respiratory bronchioles[22]. The filling of these air spaces with material that may be exudate, pus etc leads to the radiologically seen opacities. Peripheral distribution of findings has been reported most commonly in radiographs in COVID-19. Infact, bilateral peripheral multifocal opacities are considered typical finding for COVID-19 on chest radiograph[8]. Peripheral location of pathology is also one of the reasons chest ultrasonography has been used at experienced centers for evaluation of COVID-19, since it can assess superficial lung regions well.[28] This distribution may be related to the pathophysiology of the disease as peripheral involvement is classically seen in organizing pneumonias. This may also indicate the pattern of spread of the disease along the airways beginning with the bronchioles and alveolar epithelium in the subcortical lung tissue and then spreading inwards[29]. The peripheral air space opacities may be seen unilaterally [Figure 3] or bilaterally [Figure 4].

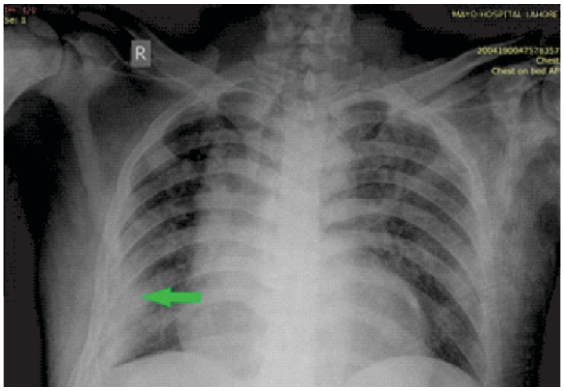

Figure 3: *Area of Air Space Opacification (Green Arrow) that is Obscuring the Underlying Vascular Markings Seen in Right Lower Zone in Peripheral Distribution*

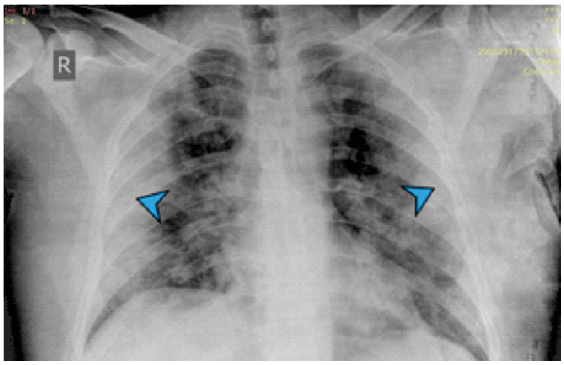

Figure 4: *Air Space Opacification (Blue Arrowheads) Seen Bilaterally in Subpleural Location Spanning all the Zones*

3. Diffuse Air Space Opacities

When there is diffuse opacification of lungs [Figure

5] , it heralds more severe disease.[30] This is also called white lung on chest radiograph and lung whiteout on CT scans.[31] It has been reported to occur first week after symptom onset.[5] This pattern is similar to that seen in processes that cause diffuse widespread lung injury such as in ARDS (acute respiratory distress syndrome). The pathophysiology of this stage is likely to be severe diffuse alveolar and interstitial damage. Understandably, patients with this imaging pattern are severely hypoxic and there-fore this pattern is commonly seen in patients admitted to ICU.[32] In a multicenter study done, diffuse disease was more commonly seen on imaging in patients with severe or fatal disease.[33]

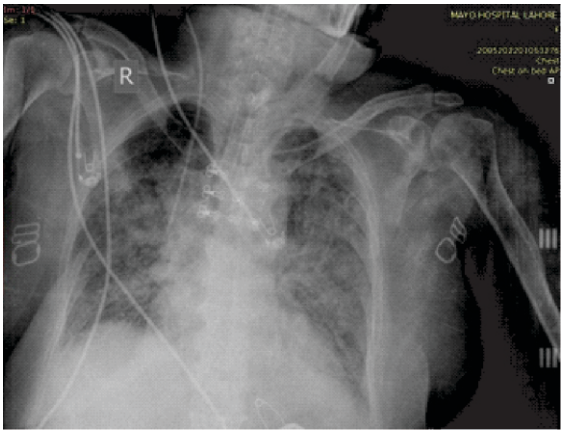

Figure 5: *Air Space Infiltrates Seen Involving Bilateral Lung Fields Diffusely in this Patient Admitted in ICU*

4. Multilobar Consolidations

Consolidation is defined as a homogenous opacity in lung without volume loss, effacement of blood vessel shadows and sometimes an internal air bronchogram[22]. The pathophysiology is similar to air space opacity with the material produced by disease process replacing the air in lung rendering it solid. However, the term air space opacity is classically used for scattered ill defined patchy areas of opacification, while consolidation usually implies a larger coalescent area. Although ground glass opacity has been the most frequent pattern described in most studies done on CT, consolidation has been found to be more frequent finding in study done on chest radiograph[9]. This is understandable given the chest radiograph's lack of sensitivity for ground glassing. However, studies that have serially followed the progression of disease process on imaging have found that consolidation is the predominant pattern later in the course of disease[34] representing evolution of the disease process from the ground glassing seen earlier[35]. Involvement of multiple lobes [Figure 6] is an important clue in differentiating COVID-19 from bacterial pneumonias which tend to unilobar and unifocal[36]. Multifocal involvement has also been classically seen in infections with other coronaviruses such as MERS (Middle East Respiratory Syndrome).[37]

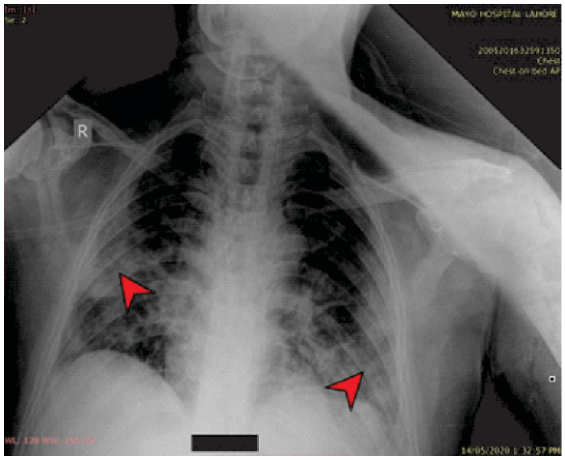

Figure 6: *Areas of Consolidation Indicated by Red Arrowheads Involving Multiple Lobes seen here in Right Midzone and Left Lower Zone*

5. Lower Lobe Consolidations

While the distribution can be multifocal and random, lower lobe distribution [Figure 7] has been found to be a frequent finding. Infact, lower lobe involvement was the most frequent finding reported on chest radiographs[38] as well as CT scans.[23] Lower lobe pattern of involvement is considered to be part of criteria for classic and probable COVID-19 infections by British Society of Thoracic Imaging.[39] Lower zonal predominant distribution is also regarded as typical radiographic appearance of COVID-19 by

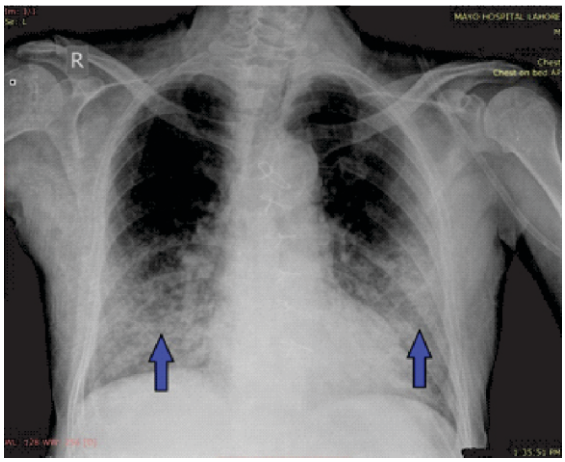

Figure 7: *Consolidations (Blue Arrows) Involving Bilateral Lower Zones with Internal Air Bronchograms*

Canadian Society of Thoracic Radiology.[8]

6. Reticular Shadowing

Although interstitial septal thickening has been described in literature as the third most common finding on CT scans in COVID-19, after ground glass opacity and consolidation,[40] it has not frequently been described in studies on chest radiography in COVID-19 although such studies are very limited in number. Reticular shadowing is its radiograph correlate defined as small linear opacities that together produce an appearance resembling net.[22] This pattern [Figure 8] reflects interstitial involvement by disease process and may be seen on chest radiograph depending on the stage of disease process. The pathophysiology is thickening of the interlobular septa due to infiltration by inflammatory cells.[41] The prevalence of this imaging pattern may increase as disease duration gets longer.[5]

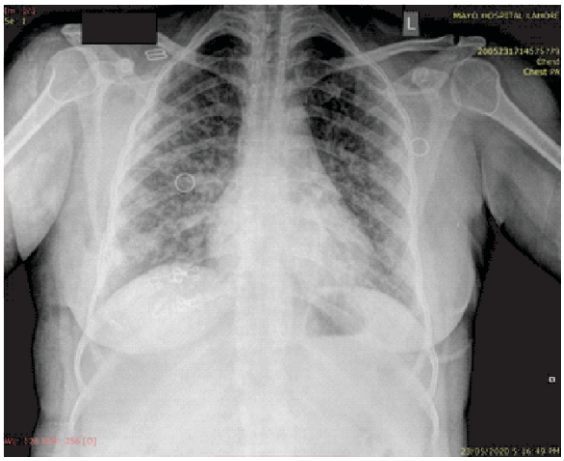

Figure 8: *Fine Linear Opacities Seen Diffusely Throught the Lung giving Appearance of Net*

7. Uncommon Findings

Although reported infrequently, pleural effusions, lymphadenopathy, nodules, cavities and pneumothorax can occur. However, these are not typical imaging findings in COVID-19. These are not seen in early phases of the disease.[42] When present, lymphadenopathy and pleural effusion are usually associated with a poorer prognosis.[43] The presence of these findings may also be suggestive of an alternate diagnosis or superadded bacterial infection.[11] Even when pneumothorax was reported in a study it was not clear whether it was attributable to the disease process itself.[44] Other rare findings such as subcutaneous emphysema, pneumomediastinum and interstitial emphysema have also been reported in COVID-19.[45] Pneumomediastinum has been reported and associated with poor prognosis in infections with other coronaviruses particularly SARS (Severe Acute Respiratory Syndrome).[46] However in case of COVID-19, these findings are atypical and may also be sometimes attributable to consequences of positive pressure ventilation rather than disease process itself.

Conclusion

A variety of common imaging patterns are seen on chest radiographs in COVID-19, which in the appropriate clinical setting, can provide support to the diagnosis. These are also helpful in assessing disease course and progression besides providing clue to the severity of pulmonary involvement. As the disease burden continues to rise, chest radiography is likely to be used more frequently even if as an ancillary tool in COVID-19. The inherent disadvantages of using CT scan for this purpose particularly in a limited resource country such as Pakistan and the unreliability of ultrasound for this purpose at present imply that familiarization with these common imaging patterns is a must in our endeavors to combat this pandemic.

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