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Spectrum of Chest Radiographic Findings in Indian Patients Admitted with COVID-19 Infection

Dr Mridula M Muthe, Dr Anagha R Joshi, Dr Vikrant P Firke, Dr Ankita U Shah, Dr Amith K Gaitonde, Dr Kushal M Bidichandani

Abstract: ***Context**: Even though there are many studies describing the chest radiographic features of COVID-19 pneumonia from many countries, a study describing the portable chest radiographic features of COVID-19 in Indian population is lacking. **Aims**: To describe the portable chest radiographic imaging spectrum in admitted Indian patients with COVID-19 infection, confirmed with reverse transcription polymerase chain reaction (RT-PCR) test. **Methods**: This is a retrospective observational study conducted in a tertiary care hospital in India. The portable radiographs of 511 patients were analysed for the presence or absence of lung opacities, characterisation of the opacities when present with regards to the type, location and other findings such as pleural effusion. **Results**: Out of the 511 chest x-rays analysed, 11 were excluded due to non-reportability. Consolidation was the most common finding seen in 268/500 patients (53.6%), followed by ground glass haziness which were seen in 198/500 patients (39.6%). We found bilateral and multifocal involvement in 310/500 patients (62%) which was more common than unilateral involvement 105/500 (20.8%). There was significantly higher frequency of involvement of the lower zones as compared to the upper zones. **Conclusions**: Our study confirms the previously reported findings from other countries that the pulmonary involvement of COVID-19 is in predominantly peripheral and lower zone distribution with consolidation or ground glass haziness being the main lung findings. Hence in the current scenario, such abnormalities found on chest radiographs of symptomatic as well as asymptomatic patients should prompt the radiologists or the treating physicians to consider the differential of COVID-19 pneumonia.*

Keywords: chest, radiograph, X- ray, COVID-19, portable

Key message: Pulmonary involvement of COVID-19 is in predominantly peripheral and lower zone distribution with consolidation or ground glass haziness being the main lung findings seen on portable chest radiographs.

1. Introduction

Corona virus disease 2019 (COVID – 19) is a highly infectious communicable disease which has been labelled a pandemic. [1]It is caused by severe acute respiratory syndrome coronavirus-2 (sars-cov-2) which is a novel beta coronavirus.[2]This pandemic has its origins from Wuhan, China from where it has been spreading rapidly throughout the world, including in Indiawith 2.46 million cases diagnosed in India and 48,040 deaths at the time of writing this article.COVID-19 is diagnosed by reverse transcription polymerase chain reaction (RT–PCR) test using a nasopharyngeal or oropharyngeal swab. However in this unprecedented pandemic, shortage of RT-PCR kits may lead to delayed diagnosis causing delay in treatment as well as may accelerate further spread of infection due to lack of quarantine. In comparison imaging modalities such as chest x-ray provide for an early diagnosis, is easily available as well as cost effective. According to the Fleischer society recommendations, chest radiography is indicated for patients in resource constrained environment, where access to CT is limited.[3] American college of Radiology recommends the use of portable radiography in ambulatory care facilities when clinically indicated. [4]Hence it is important for all the radiologists as well as the treating physicians to be aware of the chest radiographic findings of COVID-19. Even though there are many studies describing the chest radiographic features of COVID-19 pneumonia from many countries, a study describing the portable chest radiographic features of COVID-19 in Indian population is lacking.

This study aims at describing the portable chest radiography findings of patients with confirmed COVID 19 RT-PCR positive test who have been admitted in a tertiary care hospital in India.

2. Methods

This is a retrospective observational study conducted in a tertiary care hospital in India from 1st June to 30th June. The age, sex of the patients, time between the symptom onset and obtaining the chest radiograph was noted. This was a retrospective study done with de-identified data base, hence institutional ethical approval was not needed. The consent of the patients was taken at the time of obtaining their radiograph.

Inclusion Criteria
Patients, with symptoms of COVID-19 such as fever, sore throat, myalgia, headache, diarrhoea and breathlessness who were tested for COVID-19 using real-time reverse transcriptase polymerase chain reaction (RT-PCR) test and underwent chest radiography on clinical demand.

Exclusion criteria
Patients with non-reportable radiographs.

Image acquisition
A portable digital anteroposterior chest radiograph was acquired at full inspiration whenever possible, using Allengers MARS 15 mobiledigital radiography system. The CT chest studies were obtained on 64 slice Philips machine.

Image analysis-
The radiographs were analysed by two junior radiologists with seven years of experience and in case of any disagreement in the findings, a senior radiologist with 20 years of experience confirmed the findings. The presence or absence of lung opacities was analysed. In case of visualisation of lung opacities, they were characterized into ground glass haziness (GGO), consolidation or reticular

opacities which were defined as per the Fleischner society glossary of terms for thoracic imaging. An area of extensive hazy opacity with indistinct margins of the underlying pulmonary vessels was characterized as ground glass haziness whereas a homogeneous pulmonary parenchymal opacity that obscured the margins of the underlying airway walls and vessels was characterised as consolidation and linear opacities were characterised as reticular opacities.[5]The location of these opacities was noted with regards to laterality and zone involved. Each lung was divided into 3 zones. The upper zone extended from the lung apex to the lower border of the anterior end of second rib. The mid zone extended from the lower border of the second rib to the lower border of the anterior end of fourth rib and the lower zone extended from the lower border of the anterior end of fourth rib to the costophrenic angles. The opacities were also classified as central and peripheral with central being inner two third of the lung field and peripheral being outer one third. Presence of lobar consolidation, nodular opacities, cavities, pleural effusion and other findings if present were noted.

Statistical Analysis-

Complete concordance and Cohen's kappa coefficient was used to assess agreement in CXR interpretation between the two radiologists. Data was entered into Microsoft Excel (Windows 7; Version 2007) and analysis was done using the Statistical Package for Social Sciences (SPSS) for Windows software (version 22.0; SPSS Inc, Chicago). Descriptive statistics such as percentages were calculated for categorical variables. Association between Variables was analyzed by using Chi-Square test for categorical variables. Level of significance was set at 0.05.

3. Results

The portable radiographs of 511admitted patients were analysed. The study population included 340 males and 171females with age ranging from 18 to 72 years. Eleven patients were excluded from the study due to severe motion artefacts leading to non-reportable radiographs.

Out of the 500 radiographs studied 86 (17.2%) were normal. GO were seen in198/500 patients (39.6%) and consolidation was seen in 268/500 patients (53.6%) (Figures 1 and 2). Reticular opacities were present in 150/500 patients (32%) (Figure 3). Solitary GGO were seen in 126/500 patients (25.2%) and solitary consolidation was seen in 199/500 patients (39.8%).

The right upper zone was involved in 87/500 patients (17.4%), left upper zone was involved in 69/500 patients (13.8%), right mid zone was involved in 241/5100 patients (48.2%), left mid zone was involved in 274/500 patients (54.8%), right lower zone was involved in 277/500 patients (55.4%) and the left lower zone was involved in 351/500 patients (70.2%).

There was significantly higher frequency of involvement of the lower zones as compared to the upper zone, P value<0.01. The left lower zone was the commonest zone involved (Figure 4).

The peripheral zones were involved in 386/500 patients (77.2%) and the central zones were involved in 123/500 patients (24.6%). Selective involvement of the peripheral zones was seen in 276/500 patients (55.2%), selective involvement of the central zones was seen in 34/500 patients (6.8%) and involvement of both the peripheral and central zones was seen in 110/500 patients (22%) (Figure 5). There was statistically higher involvement of the peripheral zones as compared to the central zones, P value <0.01.

Bilateral involvement was found in 310/500 patients (62%) and unilateral involvement was found in 105/500 (20.8%). Thus bilateral involvement was more common than unilateral involvement, P value <0.01.

Round opacities were found in seven patients and nodular opacities were found in six patients.

Fibrotic and fibrocalcific changes were found in four patients, which could have been due to sequlae to old healed infection.

Pleural effusion was found in 61 of 500 patients (12.2%). Right sided pleural effusion was more common than left sided or bilateral effusion.

One patient had left sided moderate pneumothorax and passive atelectasis of the ipsilateral lung.

One patient had diffuse chest wall subcutaneous, intramuscular emphysema and pneumomediastinum. (figure 7).

The CXR were obtained between 2 to 30 days from symptom onset (median-9 days). The main CXR findings with relation to the duration of symptom onset are summarised in table 1.

Out of the 86 patients who had normal radiographs, 37 patients underwent CT chest study, 14 patients (37.83%) of which had abnormal pulmonary parenchymal findings in the form of mild ground glass opacities (Figure 6).

We found there was no significant difference between the sensitivity of CXR for the diagnosis of COVID-19 which was 82.8% (95% confidence interval: 80%, 99%) versus that of RT-PCR which was 78%, (95% confidence interval: 70%, 99%), P >.001.

Images

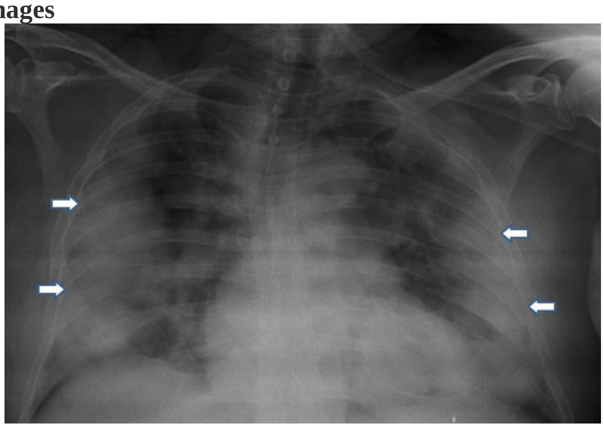

Figure 1: AP chest radiograph reveals areas of consolidations involving bilateral mid and lower zones in a predominantly peripheral distribution (arrows)

Figure 2: AP chest radiograph reveals ground glass densities in bilateral upper and mid zones (thin arrows) and areas of consolidations involving left bilateral lower zones (thick arrows) in central as well as peripheral distribution.

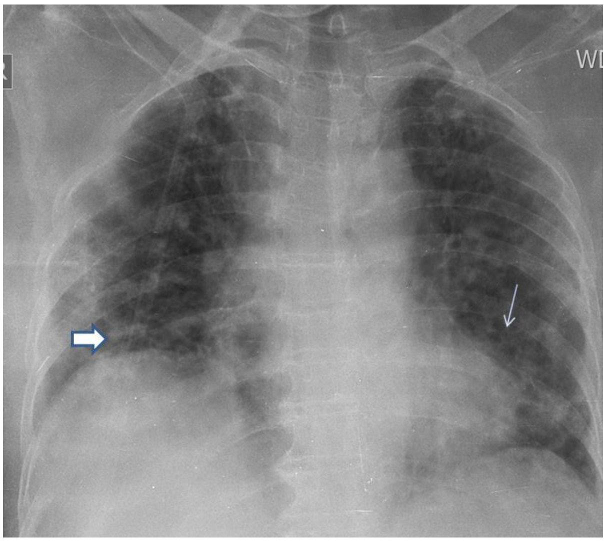

Figure 3: AP chest radiograph reveals multiple reticular opacities (thin arrow) and ground glass opacities (thick arrow) in central and peripheral distribution of both lungs.

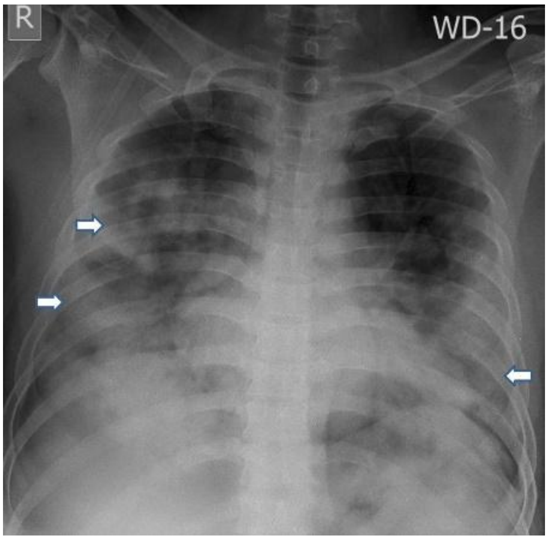

Figure 4: AP chest radiograph reveals areas of consolidations involving right mid and bilateral lower zones in a predominantly peripheral distribution (arrows)

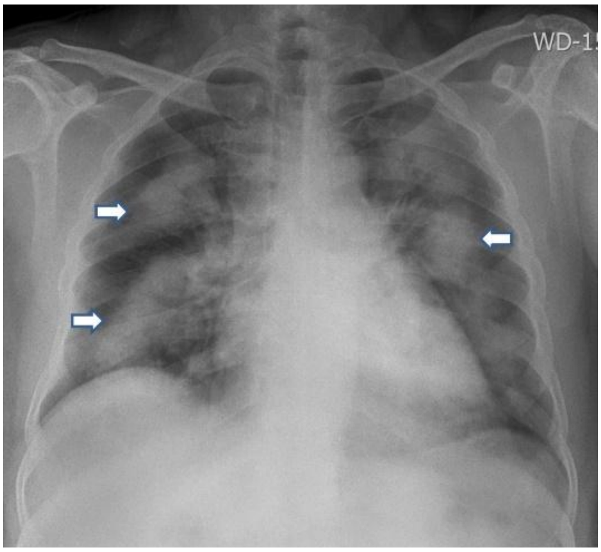

Figure 5: AP chest radiograph reveals patchy areas of consolidations (arrows) in predominantly central distribution

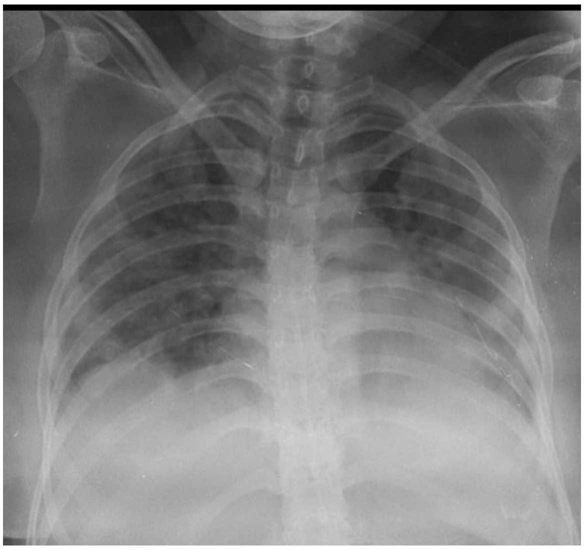

Figure 6: AP chest radiograph reveals multiple ground glass opacities in central and peripheral distribution of both lungs

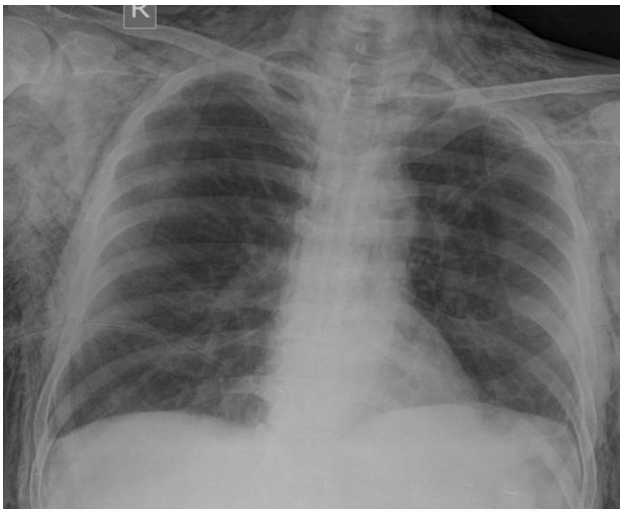

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Figure 7: AP chest radiograph reveals multiple ground glass opacities in central and peripheral distribution of both lungs (thick arrows)

4. Discussion

Consolidation was the most common finding (53.6%), followed by ground-glass opacities (39.6%). Wong et al found consolidation to be the most common finding (47% of patients), followed by ground-glass opacities (33% of patients).[6]Ng MY et al studied 21 patients from Shenzen and Hongkong and found ground glass opacities to be more common than consolidation.[7]Alfonso et al performed a metanalysis with many studies from China and one study from Australia which included 2874 patients. They found ground glass opacities to be the predominant abnormality in 68.5% patients.[8]Consolidation was found in 70% of the patients in a case series from Korea.[9]

We found bilateral and multifocal involvement was more common than unilateral involvement. Numerous studies have shown bilateral involvement to be the most common distribution.[6],[8],[10], [11]

We found the pulmonary opacities predominantly involved the peripheral location in the lung fields. Peripheral distribution was the most common pattern of lung involvement found in many studies.[6],[7],[12],[13],[14]

The radiographs of COVID-19 patients in our study showed predominantly lower zone involvement which corresponded with the findings from other studies. [6], [11],[14]

Pleural effusion was an uncommon finding in our study.Pleural effusion and lymphadenopathy were absent in all cases studied by Ng MY et al.[7] Wong et al found pleural effusion in just 3% of the patients studied.[6]

We found diffuse chest wall subcutaneous and intramuscular emphysema in one patient with pneumomediastinum. Ruihong et al reported a case of COVID-19 pneumonia with gradual development of mediastinal emphysema, lung bulla and pneumothorax.[17]It has been postulated that pneumomediastinum can result due to alveolar rupture in patients who have received ventilation with positive end expiratory pressure.[17]We also found one patient with moderate left pneumothorax and collapse of the ipsilateral lung. In patients with severe COVID-19 pneumonia, the alveoli may rupture in patients with excessive coughing due to severe alveolar injury, resulting in pneumothorax. Lung nodules, cavities and pneumothorax are rare features seen in patients with COVID-19 but can occur.[18]

Even though RT-PCR is the gold standard test for detecting COVID-19, Tao et al have reported a higher sensitivity of CT of 88% as compared to RT PCR which had a sensitivity of 59%. [19] Several studies have reported high sensitivities of CT up to 94 - 100%.[19,20,21] Despite a higher sensitivity, CT lacks specificity since the CT imaging features of COVID-19 overlap with other viral pneumonias. The reported specificity of CT for diagnosing COVID-19 pneumonia is as low as 25%.[19] With combined use of RT PCR and CT for the diagnosis of COVID-19, the specificity of CT reaches upto 100%. CT has been extensively discussed as the primary imaging modality for COVID-19, however CXR is also being increasingly used due to its various advantages. The CXR imaging features as well as the temporal evolution of COVID-19 pneumonia are similar to the findings on CT. The sensitivity and specificity of CXR as well as CT are variable depending on the stage of the disease. Initially the reported sensitivity of CXR was 59%[22] however as the pandemic progressed, the sensitivity as well as specificity of CXR increased due to increasing experience of the radiologists. The sensitivity of CXR was reported as 68.1% and 69% by Cozzi et al. [23]and Wong et al. [6]respectively. In a study from Italy significantly higher sensitivity as well as specificity of CXR was reported. Real time CXR reports showed a sensitivity of 89.0%, specificity of 60.6%, positive predictive value of 87.9% and negative predictive value of 63.1%.[24] Cozzi et. Al. reported a sensitivity of 89 %, specificity of 66 % and accuracy of 76 %–86 % with a lower specificity of 41 %for less experienced radiologists. [25] In a metaanalysis by Salameh et. al. the CXR pooled sensitivity was 82.1% (95%CI: 62.5 to 92.7) whereas the pooled sensitivity of CT was 93.1% (95%CI: 90.2 - 95.0). [26]

Covid-19 is a highly infectious disease and is rapidly spreading throughout the world. It presents with pneumonia in many patients, thus making imaging essential in the diagnosis as well as monitoring of the disease. Many radiological societies have recommended the use of imaging in the course of management of this disease. Even though, radiography is less sensitive than CT in mild or early disease[6], portable radiography may be the preferred modality in view of easy availability and concerns related to cross infections in CT suite. Furthermore in resource limited environments with unavailability of CT and shortage of reverse transcription polymerase chain reaction (RT-PCR) COVID testing kits, radiography may be used for establishing the diagnosis. Hence it is essential for the treating physicians as well as the radiologists to acquaint themselves with the radiographic features of COVID-19 pneumonia.

Our study had few limitations. The portable nature of the radiographs posed a limitation in interpreting the mediastinum. Suboptimal patient positioning and lack of breath hold in some patients might have limited the visualisation of subtle opacities.

5. Conclusion

Our study confirms the previously reported findings from other countries that the pulmonary involvement of COVID-19 is in predominantly peripheral and lower zone distribution with consolidation or ground glass opacities being the main lung findings. Hence in the current scenario, such abnormalities found on chest radiographs of symptomatic as well as asymptomatic patients should prompt the radiologists or the treating physicians to consider the differential of COVID-19 pneumonia.

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