Research Article

Different Radiological Patterns on Plain Chest X-Ray in COVID-19 Patients

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Abstract

Objective: The purpose of this study was to describe the radiological findings on radiograph chest in patients with 2019 Novel Corona virus disease (COVID-19).

Methods: This is a retrospective study which was conducted at Radiology Department, Mayo Hospital, Lahore, Pakistan. Study was done on only those patients who were tested positive by RT-PCR method for Covid-19 infection. 350 patients were selected for the study and out of them 266 tested positive for Covid-19 by RT-PCR therefore radiographs of those 266 patients were included in the study. The radiographs were reported by two consultant radiologists.

Results: Total 350 patients were selected for retrospective study. Out of these 350 patients, 266 tested positive for COVID-19 by RT-PCR method. The radiological findings were assessed in radiograph chest of these 266 patients. Out of 266 patients, 202(75.9%) were males and 64(24%) females. 62% (n=165) had bilateral lung involvement, 19.5% unilateral lung involvement and 18.4% (n=49) had normal radiographs. Majority of the patients had involvement of all zones of the lungs i.e. upper middle and lower zones at the time of study comprising of 69.12% (n=150). Middle and lower zones were simultaneously affected 22% (n=48). Interestingly only 2 patients (0.9%) had involvement of upper and middle zones. Surprisingly 7% (n=15) patients had involvement of only lower zone with normal upper and middle zones.

Conclusion: Chest radiograph is an effective tool in early detection and characterization of the lesions in suspected or diagnosed cases of COVID-19 infection. It is also useful in follow up and prognosis of the patients suffering or recovered from COVID-19.

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Introduction

In February 2020 population of Pakistan started suffering from a lung infection of unknown cause at a faster spread rate in each province of the country[1].The infection later was identified through genomic sequencing as corona virus.[2] The viral gene having a homology of up to 85% with bat SARS-like viruses.[3] The National Health Commission of China named this new coronavirus-infected pneumonia "new coronavirus pneumonia" (COVID-19) on February 7, 2020[4] and on February 11th the World Health Organization designated the disease caused by corona virus as COVID-19 (corona virus disease 2019).[5] Transmission of COVID-19 from person to

person is by contact transmission or droplet transmission, with an incubation period of 1 to 24 days, most of which is 5 to 7 days.[6]

Ongoing COVID-19 radiological study is basically centered around CT scan detections because of their higher sensitivity than chest X-ray (CXR).[7-11] In first world countries like China, CT is being frequently used as first-line radiological examination for COVID-19.[12,13] This practice, however, put an enormous workload on CT units because it demands infection control measures to a greater extent. A few medical clinics in China managed exclusive CT scanners only for suspected COVID-19 patients[14], a practice which is quite difficult to implement in Pakistan.[15] Provision of radiological services can be compromised during CT decontamination after scanning COVID-19 patients hence making portable chest X-ray a better option to minimize cross infectivity as indicated by The American College of Radiology.[16] Italian and British emergency clinics are preferring CXR as a first-line diagnostic tool over reverse transcriptase polymerase chain reaction (RT-PCR) because the latter one is considerably time consuming.[17,18] Italian and British hospitals are employing CXR as a first-line tool due to long reverse transcription polymerase chain reaction (RT-PCR) turnaround times.[17,18]

It is evident that CT scan in our country is not readily available everywhere however X-ray chest is available even at primary healthcare level. This study will help the clinician in prompt assessment of the disease regarding diagnosis and thus provision of early treatment.

Methods

Total 350 patients were selected and out of them 266 tested positive by RT-PCR method for Covid-19 infection. True positive cases were 266.True negative were 84. 266 chest radiographs were analyzed of diagnosed patients of COVID-19 infection through RT-PCR method during a period of one month (30th May 2020 to 30th June 2020) out of which 202 were males (75.9%) and 64 females (24%) (age 20-70 years).These patients were admitted in the corona ward with complaints of fever, dry cough, myalgia and dyspnea. Patients with positive pharyngeal swabs tests for COVID-19 nucleic acid and with symptoms of COVID-19 infections were included in the study. Patients having clinical symptoms of non COVID-19 infections or other viral infections, known cases of pulmonary TB, trauma and thoracic surgical intervenetions were excluded from the study.

The chest radiographs were done in either anteroposterior or posterior anterior positions depending on the clinical condition of the patient undergoing imaging. Dedicated portable machine “Perlove PLX 5100 high frequency mobile Digital X-Ray Equipment” was used with settings of 70kv and 30m as digital radiographs under local safety protocols of the hospital. However depending upon the weight of the patient, settings were changed accordingly. The chest radiographs were reviewed by two senior radiologists of Mayo hospital on digital CR system. One of them has experience of 20 years in diagnostic radiology and the other one with 7 years of expertise.

Results

The radiographic features diagnosed in accordance with the Fleischner Society glossary of terms.[19] Distribution of the lung changes was categorized into peripheral predominance, central predominance or both; unilateral or bilateral lung involvement; and upper zone, mid zone or lower zone.

Out of the total number of patients 49(18%) had normal chest radiographs despite of having symptoms of COVID-19.

Out of 266 patients, 202(75.9%) were males and 64(24%) females. 62% (n = 165) had bilateral lung involvement, 19.5% unilateral lung involvement and 18.4% (n = 49) had normal radiographs. Majority of the patients had involvement of all zones of the lungs i.e. upper middle and lower zones at the time of study comprising of 69.12% (n = 150). Middle and lower zones were simultaneously affected in 22% (n = 48) of chest films. Only 2 patients (0.9%) had involvement of upper and middle zones. Similarly only 2

patients (0.9%) had upper and lower zones affected. One patient (0.4%) had consolidation patches in upper zone only. One patient had involvement of only middle zone. Surprisingly 7% (n = 15) patients had involvement of only lower zone with normal upper and middle zones.

In 19.8% (n = 43) of the total patients the radiographic changes were prominent in the central half, 2.7% (n = 6) in peripheral half whereas both portions were involved in 77.4 % (n = 168) of the patients. Regarding radiological pattern of the disease, 94.4% (n = 205) of the patients had patchy air space pacifications/consolidation pattern, 3.2% (n = 7) had nodular and 2.3% (n = 5) had reticular pattern on chest radiographs. Only one patient (0.4%) had ground glass pacification on chest film.

Table 1: *Chest X-Ray (CXR) findings. (No. of Patients: 266) Normal CXR (No. of patients: 49) 18%*

Distribution of the lesions	No. of patients	% age
Laterality		
Bilateral	165	76
Unilateral	52	23
Area		
Central	43	19.8
Peripheral	6	2.7
Both	168	77.4
Zones		
Upper	1	0.4
Middle	1	0.4
Lower	15	6.9
Both upper and middle	2	0.9
Both middle and lower	48	22.1
Both Upper and lower	2	0.9
All zones	148	68.2
Consolidation Pattern		
Hazy increased opacity	205	94.4
Reticular	5	2.3
Nodular	7	3.2
Ground glass opacities	1	0.4
Pleural effusion	2	0.9

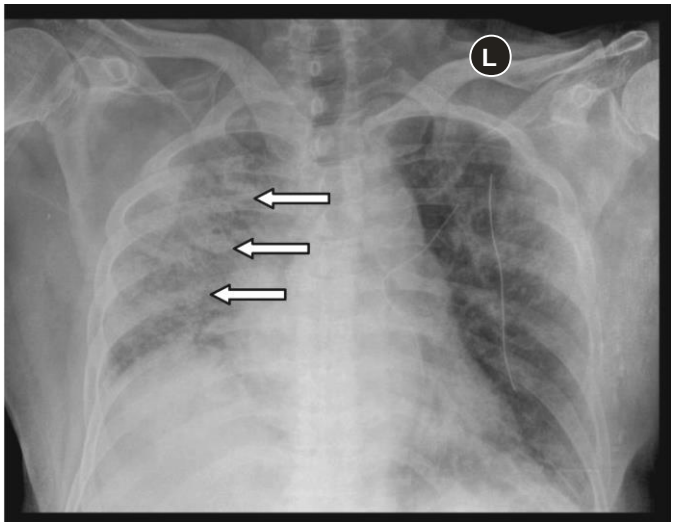

Figure 1: *Unilateral (right side) involvement of lung in a COVID-19 patient.*

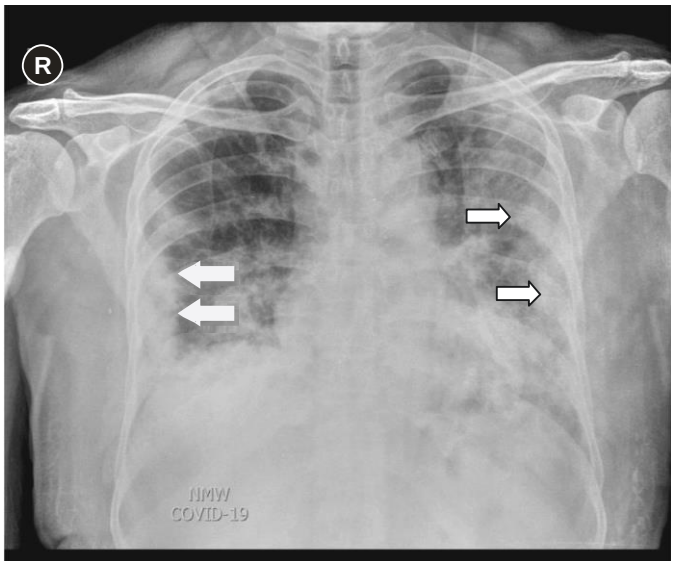

Figure 2: *Bilateral peripheral shadowing in a COVID-19 patient*

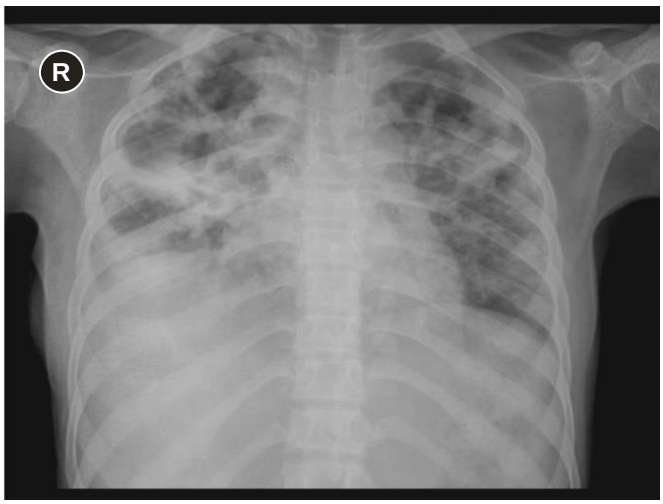

Figure 3: *Bilateral consolidation pattern*

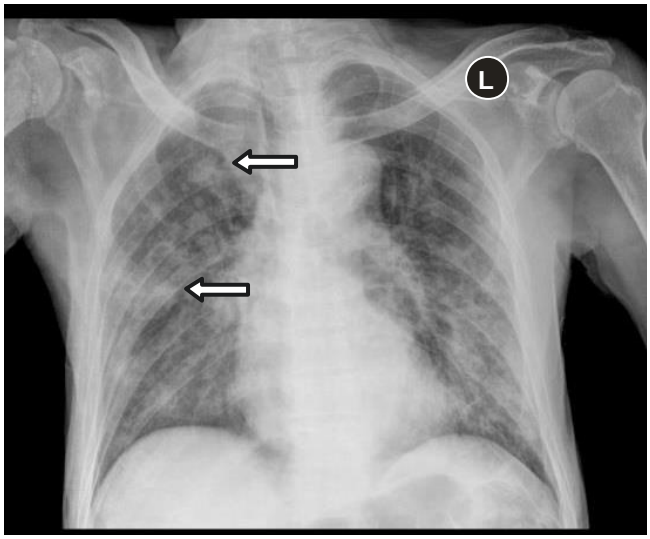

Figure 4: *Unilateral nodular pattern*

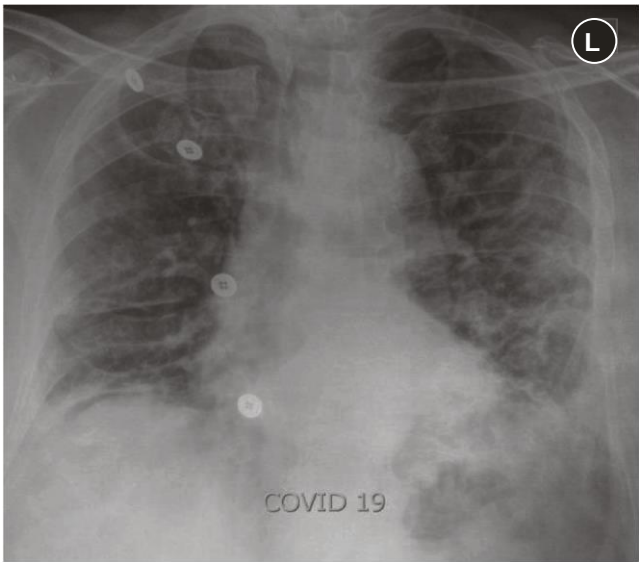

Figure 5: *Reticular pattern*

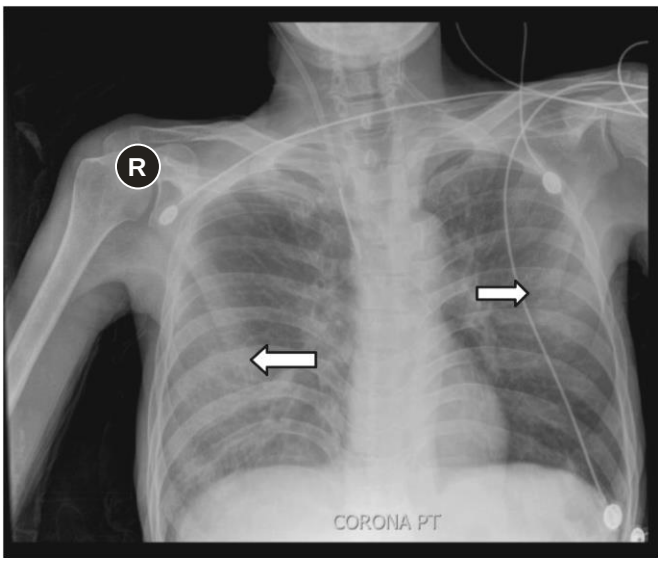

Figure 6: *Subtle ground glass pattern*

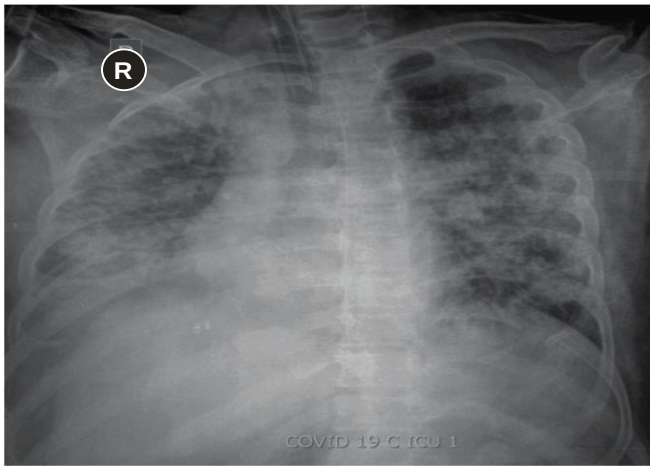

Figure 7: *Right sided pleural effusion with patchy consolidation in both lungs.*

Discussion

The COVID-19 virus enters the bronchial epithelial cells through the alveolar type II epithelial cell angiotensin-converting enzyme 2 as a receptor to replicate[20], causing multi-organ injury. Because the population generally lacks immunity to this virus, it is highly contagious and spreads quickly. According to the latest diagnosis and treatment plan issued by the National Health Pakistan, the final diagnosis of COVID-19 requires comprehensive consideration of epidemiology, clinical manifestations, X-ray chest, CT chest characteristics and nucleic acid test results[21]. Although nucleic acid testing is regarded as the gold standard for the diagnosis of COVID-19[22], in practice, due to many factors, such as insufficient short-term supply of kits, delayed test results, and limitations of sampling and testing techniques, false negative results have caused many drawbacks. Diagnosis of the patient is either delayed or misinterpreted, which delays treatment. The symptoms of different clinical classifications of COVID-19 are variable. It has been reported that patients usually have fever, cough, and fatigue as the initial symptoms, and some patients also have symptoms such as diarrhea, myalgia, headache, and sore throat.[23]

The older patients or those with underlying diseases are more prone to get severe and critically ill. Low body's immunity leads to a large-scale inflammatory infiltrating injury of the alveoli, reducing the lung

ventilation function, which eventually leads to respiratory failure.

The latest report shows that the mortality rate of severe COVID-19 patients in Wuhan, a city of China, is as high as 60% [2].Therefore, accurate judgment and even early evaluation of the severity of the patient's disease is very important for the graded treatment of COVID-19.

Our study exhibits higher proportion of abnormal radiographic findings (217 patients, 81%) as compared to the case series of 9 patients published by Yoon *et al.* (5/9, 56%) [23]

Although lower than the reported 97-98% sensitivity of CT,[7-24] results of our study show that CXR can play a vital role in the initial screening of COVID-19 patients at primary, secondary or tertiary care level. X-ray chest is an excellent and highly convenient modality in rapid and gross assessment of the COVID-19 patients with certain limitations. Further studies are required in the scenario where there is high clinical suspicion of COVID-19 and it is conceivable that a positive CXR may obviate the need for a CT, thus reducing burden on CT units during this pandemic. Similarly in far flung areas of Pakis-tan where the access to CT chest is hard or even unavailable, X-ray chest is by far the most common investigation in government as well as private setups.

In our studies it was evident that the features of COVID-19 pneumonia were very much similar to previously published cases.[10-23] However, there is no specific radiographic pattern for diagnosis of COVID-19 and a normal chest radiograph does not exclude COVID-19 infection.[25]

In our study 94.4% (n=205) of the patients had consolidation pattern similar to the study conducted by Zhou S. in 62 patients suffering from COVID-19 pneumonia in Wuhan.[26] The 3.2% (n = 7) of the reviewed X-rays showed nodular pattern and 2.3% (n = 5) had reticular pattern which are comparable with the results of study done by Adam J.[29] Only one patient (0.4%) had ground glass opacifications on chest film. Ground glass densities observed on CT may often have a correlate that is extremely difficult to detect on CXR[29], however, reticular opacities accompanying regions of ground glass attenuation are more easily identified on standard CXR.[29]

2(0.9%) patients had pleural effusion on chest radiographs. Pleural effusions have been reported as exceedingly rare on CXR and CT in COVID-19 infected patients, and when present are most often identified late in the disease course.[27]

Community acquired bacterial pneumonia has tendency to be unilateral and involving a single lobe[28] however, COVID-19 and other viral pneumonias typically produce lung opacities in more than one lobe as comparable with our study too (see Table 1).

Peripheral lung involvement is one of the most unique and somewhat specific features of COVID-19 pneumonia[29], often mirroring other inflammatory processes such as organizing pneumonia. Such peripheral lung opacities also tend to be multifocal, either patchy or confluent, and can be readily identified on CXR.[29]

In summary, through the analysis of these 266 confirmed cases of COVID-19, we can see that the imaging manifestations of patients are much variable and especially the number of lesions involved in the lung zones and whether these are diffusely distributed or focal.

Conclusion

Chest radiograph is an effective tool in early detection and characterization of the lesions in suspected or diagnosed cases of COVID-19 infection. It is also useful in follow up and prognosis of the patients suffering or recovered from COVID-19.

Limitations

Apparently normal AP view chest radiograph might be having subtle findings which can only be seen on HRCT. Small nodules, ground glass opacities and peripheral opacities can be missed on chest radiographs. Follow up of the patients was not possible because of large number of patients and short duration of study. Some of the radiographs were subtle in

findings due to improper position of the critically ill patients in the critical care unit of the hospital.

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