Chest Radiograph Findings in Critical and Non-Critical Patients with Covid-19: A Study from Pakistan

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Abstract

Objective: To find out the common patterns of COVID-19 infection manifestations on chest radiographs and to compare the findings between critical and stable admitted patients.

Methods: This retrospective study was conducted in Department of Radiology Mayo Hospital, Lahore from 1st July 2020 to 31st December 2020. PACS database was searched for chest radiographs of patients with confirmed COVID-19 infection. The radiographs which fulfilled the inclusion and exclusion criteria were then analyzed by two qualified and experienced radiologists for presence and type of abnormality, zonal distribution, peripheral verses central distribution, unilaterality or bilaterality of findings and presence of ancillary findings. The findings were then compared between patients admitted in ICU and those in non-ICU settings.

Results: The most common abnormality was consolidation (53.1%) in both critical and non-critical patients, followed by ground glass opacities (32.4%). The findings were seen mostly in lower zone and bilaterally in both subsets. The findings were seen predominantly in peripheral location overall (55.0%) and in non-critical patients (63.3%). However, they were mostly randomly distributed in critical patients (50.9%). Ancillary findings were seen in a minority of patients (4.6%), more so in the critical subgroup. Overall the most common pattern in both critical and non-critical patients was bilateral, peripheral, lower zone consolidations.

Conclusion: Chest radiograph is fairly capable of detecting abnormalities associated with COVID-19 infection in admitted patients particularly critical ones with bilateral, peripheral, lower zone consolidations and ground glassing being the hallmark of COVID-19 infection.

Keywords: COVID-19, chest radiograph, corona virus

How to cite: *Mansoor A, Masood M. Arooj S, Haroon J, Asghar A, Raja R. Chest Radiograph Findings in Critical and Non-Critical Patients with Covid-19: A Study from Pakistan. Esculapio - JSIMS 2021;17(04):326-331.*

DOI:*https://doi.org/10.51273/esc21.251742*

Introduction

The disease caused by novel coronavirus labelled as COVID-19 was declared as pandemic by WHO on 11th March 20201. More than a year later, the global disease burden and mortality due to COVID-19 pandemic continues to rise, with many countries coping with the fourth wave of deadly infection. The fourth wave of COVID-19 infection was officially declared in July 2021.[2] More than one and a half year after the first confirmed case of COVID-19 in the country, the country-wide confirmed case toll reached more than 1,246,000 on 1st October with more than 27,700 confirmed deaths.[3] Although the vaccination drive continues in many countries including Pakistan, it is likely to take some time before target of global vaccination is achieved.

Amidst this ever changing scenario, efforts continue to diagnose those who have contracted the infection as early and reliably as possible and to treat, manage and prognosticate those who have contracted the disease. While the diagnosis is largely based on PCR testing, imaging plays an important role in management and prognostication.[4] It also has an important role in case of false negative PCR.[5]

Ultrasound, radiography, CT scan as well as PET-CT have been employed worldwide for COVID-19 patients. Although most of the literature has focused on the use

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Submission Date: 05-10-2021
1st Revision Date: 15-10-2021
Acceptance Date: 09-12-2021

of CT scan in COVID-19, chest radiograph is often the first imaging modality used in both suspected and confirmed cases of COVID-19.[6] Infact, X ray has a number of advantages over CT – X ray machine is portable, it is more easily available particularly in third world country like Pakistan and lesser radiation dose making it possible to do serial imaging. Furthermore, issues related to transmission of infection make X ray a more feasible and safer option because disinfection is faster and easier - the X-Ray machine is not in direct contact with patient unlike CT scanner. There is also lesser chance of infection transmission to health professionals and between patients with X-Ray because the machine can be transported to patient rather than the other way round in case of CT scanner.[7]

In these circumstances, it is imperative that chest radiograph continues to be the most commonly used radiological investigation in COVID-19 in our country. Therefore, it is important to understand the most common chest radiograph findings associated with it. The aims of this study were to find out the common patterns of pulmonary manifestations of COVID-19 on chest radiographs and to compare the findings between critical and stable admitted patients.

Material & Methods

This retrospective descriptive study was conducted at Department of Diagnostic Radiology, Mayo Hospital, Lahore. After taking permission from Institutional Review Board and Ethical Committee, PACS database was searched for radiographs of PCR confirmed COVID-19 cases performed from 1st July 2020 to 31st December 2020. Patients aged older than 16 years were included in the study to exclude pediatric patients. The search yielded 1256 radiographs. Out of these, patients having known pre-existing pulmonary pathologies such as lung mass, pneumonectomy etc. were excluded by looking at their clinical data in PACS database. Those radiographs which were technically inadequate such as incomplete coverage were excluded. This yielded a study population of 1166.

These radiographs were then analyzed by consensus between two qualified radiologists, one having 10 years and other having 6 years experience in radiology. Gender, age and status of patient critical or not were noted, critical being defined as admitted in ICU department. The radiographs were assessed for presence or absence of

Table 1: *Distribution of findings on chest radiographs*

		CRITICAL (n = 419)	NON-CRITICAL (n = 747)	TOTAL (n = 1166)
ABNORMALITY	Abnormal	412 (98.3 %)	534 (71.5 %)	946 (81.1 %)
	Normal	7 (1.7 %)	213 (28.5 %)	220 (18.9 %)
PARAMETERS IN ABNORMAL RADIOGRAPHS		CRITICAL (n = 412)	NON-CRITICAL (n = 534)	TOTAL (n = 946)
PREDOMINANT ABNORMALITY PATTERN	Consolidation	199 (48.3 %)	303 (56.7 %)	502 (53.1 %)
	Ground glass opacity (GGO)	119 (28.8 %)	188 (35.2 %)	307 (32.4 %)
	Reticulation	14 (3.4 %)	14 (2.6 %)	28 (3.0 %)
	Consolidation + GGO	60 (14.6 %)	20 (3.7 %)	80 (8.4%)
	GGO + Reticulation	13 (3.2 %)	7 (1.3%)	20 (2.1%)
	Consolidation + Reticulation	7 (1.6%)	2 (0.4%)	9 (1.0%)
ZONAL DISTRIBUTION OF FINDINGS	Upper	7 (1.7 %)	16 (3.0 %)	23 (2.4 %)
	Lower	206 (50.0%)	323 (60.5%)	529 (55.9 %)
	Diffuse	120 (29.1 %)	94 (17.6 %)	214 (22.6%)
	No predominance	79 (19.2 %)	101 (18.9%)	180 (19.0 %)
PREDOMINANT LUNG INVOLVEMENT	Peripheral	182 (44.2 %)	338 (63.3%)	520 (55.0 %)
	Central	20 (4.9 %)	15 (2.8%)	35 (3.7 %)
	Random	210 (50.9 %)	181 (33.9%)	391 (41.3 %)
LATERALITY OF FINDINGS	Right	25 (6.1 %)	42 (7.9 %)	67 (7.1 %)
	Left	26 (6.3 %)	75 (14.0 %	101 (10.7%)
	Bilateral	361 (87.6 %)	417 (78.1%)	778 (82.2%)
ANCILLARY FINDINGS		CRITICAL (n = 419)	NON-CRITICAL (n = 747)	TOTAL (n = 1166)
		22 (5.3 %)	32 (4.3 %)	54 (4.6 %)

ground glassing, consolidation and reticular shadowing defined according to glossary of terms by Fleischner society[8]. Zonal distribution whether upper or lower zone involvement (defined as upper and lower halves of lung field), diffuse involvement or no predilection was assessed. Peripheral and central distribution was assessed based on distance halfway between lateral edge of lung field and hilum. Unilateral and bilateral lung involvement was also assessed, whether it was on right or left side in case of former. The presence or absence of ancillary findings such as mediastinal lymphadenopathy, pleural effusions and pneumothorax were also evaluated and all this information recorded on a predesigned proforma.

Collected data was then entered in SPSS version 20 and analyzed for the presence and distribution of findings.

Results

Out of 1166 patients, 808(69.3%) were male and 358 (30.7%) were female. The ages ranged from 20 years to 95 years with mean age 51.5±14.8 years. Out of the 1166 subjects, 36.1% (421) were in ICU and classified as critical and 63.9%(745) were in wards and considered not critical. Out of the 808 male patients, 306(37.9%) were critical while 115(32.1%) out of the 358 female patients were classified as critical. Of the 1166 radiographs studied, 946 radiographs had findings while 220 were negative with respect to COVID-related abnormalities. **Table-1** presents a summary of the radiographs with findings.

The most common pattern of abnormality was consolidation (53.1 %) in both critical as well as non-critical patients, followed by ground glass opacities (32.4 %). Lower zone was predominantly involved in both subsets of patients. The findings were seen predominantly in peripheral location overall (55.0 %) and in non-critical patients (63.3 %). However, they were mostly randomly distributed in critical patients (50.9 %). Bilateral involvement was typically seen in both subsets of patients. Ancillary findings were seen in a minority of patients (4.6 %), more so in the critical subgroup (5.3 %). The most common abnormality was pleural effusion which was mostly bilateral. Other findings included bronchiectasis, cardiomegaly, hyperinflated lungs, pneumothorax, subcutaneous emphysema, lung collapse, miliary nodules and pericardial effusion.

Fig-1 shows some common abnormality patterns seen in critical patients and **Fig-2** shows some abnormal radiographs of non-critical patients.

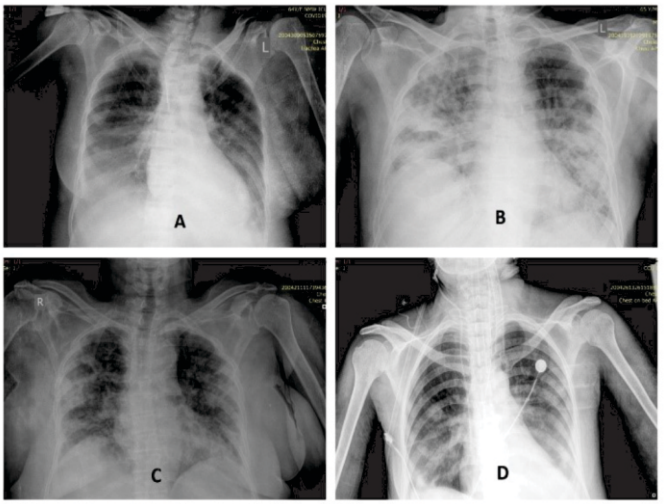

Fig-1: *Chest radiographs of critical patients: a - bilateral lower zone ground glass haze , b - diffuse opacification of bilateral lung fields, c - bilateral peripheral consolidations, d - left lower zone ground glass haze + right random opacities.*

Table 2: *Distribution of ancillary findings on chest radiographs*

	CRITICAL (n = 22)		NON-CRITICAL(n = 32)		TOTAL (n = 54)	
Bilateral pleural effusions	4	(18.2%)	1	(3.1 %)	5	(9.3%)
Right sided pleural effusion	4	(18.2%)	6	(18.8%)	10	(18.6%)
Left sided pleural effusion	7	(31.8 %)	7	(21.9%)	14	(25.9%)
Left lung collapse	0	(0.0%)	1	(3.1 %)	1	(1.9%)
Pericardial effusion	0	(0.0%)	1	(3.1 %)	1	(1.9%)
Bronchiectasis	0	(0.0%)	1	(3.1 %)	1	(1.9%)
Cardiomegaly	2	(9.1%)	11	(34.4%)	13	(24.1%)
Hyperinflated lungs	1	(4.5 %)	3	(9.4%)	4	(7.4%)
Miliary nodules	0	(0.0%)	1	(3.1 %)	1	(1.9%)
Right pneumothorax	2	(9.1%)	0	(0.0%)	2	(3.7%)
Subcutaneous emphysema	1	(4.5 %)	0	(0.0%)	1	(1.9%)

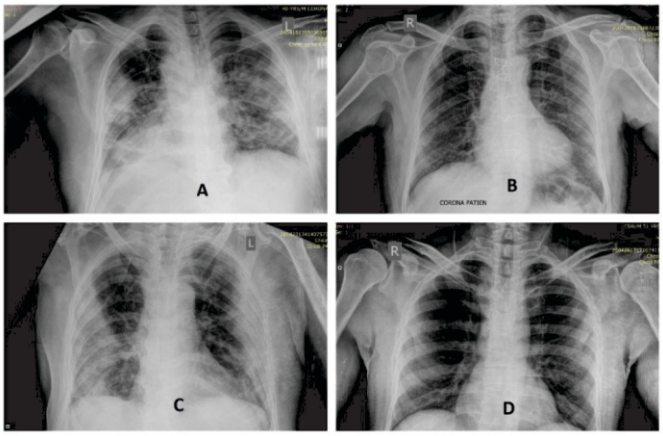

Fig-2: *Chest radiograph findings in non-critical patients : A - right peripheral consolidation and left peripheral ground glass haze, B - left peripheral ground glass haze, C - bilateral peripheral consolidations, D - bilateral peripheral ground glass haze.*

Overall the most common pattern in both critical and non-critical patients was bilateral, peripheral, lower zone consolidations.

Discussion

Worldwide research has focused mainly on CT scan for diagnosis and prognostication of COVID-19 pneumonia[9] owing to its greater sensitivity and specificity than chest X ray.[10] However, in a resource limited country like Pakistan with limited availability of CT scanners, chest radiography is a promising alternative. Numerous studies have been done regarding patterns of abnormalities and its validation for assessment of disease severity in Pakistan.[11,12] However, our study is the largest study to date regarding the patterns of COVID-19 abnormality on chest radiographs. This study showed a high proportion of abnormal chest radiographs (81.1 %), although the ratio was much higher in critical patients admitted in ICU (98.3 %). One of the largest studies done on COVID-19 chest radiographs in New York on 636 patients reported an abnormal radiograph percentage of 41.7 %.[13] However, this study was done on outpatients while our study population comprised patients symptomatic enough to be admitted in hospital. Another large study done in Pakistan comprising a sample of 1000 chest radiographs found 75.9 % radiographs to be normal.[12] However, again this study included outpatient as well as critical patients. The inclusion of relatively homogenous group of patients having disease severe enough to warrant hospital admission might explain the higher percentage of abnormal chest radiographs in our study. An Italian study[14] also reported a high percentage of abnormal chest radiographs (94.4%). This study was performed in emergency department, which supports the notion that chest radiography is likely to be more sensitive in more symptomatic patients requiring emergency management or hospital admission.

Consolidation was the most common pattern of abnormality (53.1 %) seen in both critical and non-critical patients. This is similar to the results of Wong et al.[10] who also reported consolidation as the most common abnormality (47%). However some other studies have reported ground glass density as the most common abnormality.[11,12] The second most common pattern of abnormality was indeed ground glass opacity in our study population as well. However, ground glassing is a subtle finding on chest radiograph due to its limited contrast resolution.[15] Furthermore, it usually corresponds to earlier course of disease likely to be seen in outpatient and ambulatory patients such as those in study done by Weinstock et al.[13] which involved stable outpatients. Our study mainly focused on admitted patients likely to be in later stages of disease which would explain the greater propensity of consolidative rather than ground glassing pattern on chest radiographs.

There was a predilection for involvement of lower zones of lungs in both critical and non-critical patients (50.0 % and 60.5%) respectively, although a significant percentage of critical patients (29.1%) also showed diffuse lung involvement. This latter finding likely correlates with ARDS-like pattern encountered in severe disease[16] and therefore more commonly encountered in ICU patients. Most previous studies have also reported lower zonal involvement as the most frequent abnormality in COVID-19 pneumonia.[10,-12,14] This is infact considered typical of COVID-19 infection by Canadian Society of Thoracic Radiology[6] and included in definition of classic and probable case by British Society of Thoracic Imaging.[17] This study also supports this criterion particularly in non-critical cases where diagnosis is likely not yet definitive.

The results of this study show peripheral lung involvement to be the most common pattern overall (55 %), although the abnormalities seemed to be more commonly having random distribution in critical patients (50.9 %). Previous studies have also shown peripheral lung involvement to be the predominant pattern on chest radiographs[10,12] and CT scans.[18,19] However, in a study which followed temporal progression of disease process, it was found that in the severe stage of disease when the pulmonary lesions were at their peak, diffuse lung involvement could be seen.[20] Understandably, the critical sub group of our study population is likely to have been in this phase of the disease which would explain the random distribution of findings rather than peripheral distribution.

Overwhelming majority of the radiographs showed bilateral lung involvement (82.2% overall). Infact, bilateral involvement is a key differentiating feature of viral pneumonias from bacterial pneumonias[21].

Other coronavirus infections such as MERS (Middle East Respiratory Syndrome) also tend to have multifocal involvement.[22] Many previous studies done on chest radiographs have showed bilateral lung involvement as typical for COVID-19.[10,11] Although early in the course of disease, unilateral involvement can be some-times seen, usually these eventually progress to bilateral multifocal involvement.[20]

Ancillary findings were seen in a minority of our study group (4.6%), the most common abnormality being pleural effusion. These findings have been uncommonly reported in COVID-19 pneumonia and when seen they usually occur later in course of disease[23] and are associated with poor prognosis[24]. Unsurprisingly therefore, these ancillary findings were more commonly seen in critical subgroup of patients. Other findings such as pneumothorax, subcutaneous emphysema have also been previously reported in COVID-19[25] albeit rarely. Bronchiectasis and cardiomegaly seen in a few cases likely represent manifestations of comorbidities.

Overall, the findings of this study support those of earlier studies. However, certain differences particularly in critical subgroup of patients can likely be explained by the relatively homogenous study population of our study which was done on patients admitted in hospital unlike other studies which have included outdoor patients, many of which are likely to have asymptomatic or mild form of disease.

Our study was limited by the fact that PCR and chest radiograph were invariably performed at different times, therefore exact correlation was not possible whether the patient had active infection at the time the radiograph was performed. Similarly, the exact time course of disease at the time radiograph was performed, in relation to development of symptoms, was not available. Also, the criteria of critical vs non critical was based on setting of patient rather than objective assessment like oxygen saturation etc. at the time of radiograph. Improvements in the form of correlating radiograph findings with HRCT findings and assessment of serial radiographs in relation to disease course could be done.

Conclusion

This study showed a high proportion of abnormal radiographs in admitted patients particularly critical patients, suggesting that chest radiograph could have a greater sensitivity in detecting COVID-19 associated abnormalities in appropriate clinical settings, than usually expected. It is the largest study done to date on chest radiographs in COVID-19 and confirms the results of earlier studies that bilateral, peripheral, lower zone predominant consolidations and ground glassing are the hallmark of COVID-19 infection.

Conflict of Interest *None*

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Authors Contribution

MA: Conceptualization of Project
MM: Data Collection
AS: Literature Search
JH: Statistical Analysis
AA: Drafting, Revision
RR: Writing of Manuscript