Original article

Chest Radiograph appearance of SARS-CoV-2 Infection: A Prospective Observational Study of Ambulatory Patients from a Field Hospital in a Middle-Income Country

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ABSTRACT

Background: The ongoing COVID-19 pandemic has had a profound impact on both individuals and society, resulting in widespread illness and death, as well as a global economic downturn. In order to examine chest X-rays (CXRs) of ambulatory patients diagnosed with COVID-19 in a field isolation center, our aim is to determine the proportion of patients with normal versus abnormal chest radiographs. Moreover, in cases where abnormal findings are present on the CXR, our goal is to document the distribution and patterns of these abnormalities.

Methodology: This prospective observational study was conducted on a cohort of 510 consecutive COVID-19 patients who tested positive for the virus and presented at the field isolation center between March 15th and May 15th, 2020. The study encompassed patients of all ages and both genders, with the exclusion criteria being patients requiring intensive care and those with unreadable CXRs due to technical limitations. The review of CXRs was performed by two certified radiologists, ensuring reliable and accurate assessments. Age, gender, and X-ray findings were noted, and the data were analyzed using SPSS version 21.

Results: Among the total of 510 patients included in the study, 463 (90.8%) were male, while 47 (9.2%) were female. The age range of the study population spanned from 12 to 64 years, with the majority falling within the 23-33 year age group. During the review of CXRs, 433 (84.90%) were classified as normal, while 77 (15.10%) were deemed abnormal. The most frequently observed abnormal pattern was ground glass opacification, accounting for 54.5% of the cases, followed by the reticular pattern at 45.5%. Regarding the distribution of abnormalities, 48.10% exhibited a multifocal pattern, 32.5% were bilateral, and 37.3% involved more than one zone.

Conclusion: CXRs obtained from confirmed COVID-19 patients were normal in 85% of the patients. The most common abnormality seen in our study population was involvement of the lower lobes with patchy peripheral ground glass opacities or reticular shadowing, which was focal or multifocal in location.

Keywords: Chest X-ray; CXR; COVID-19; Ground glass opacities; Lung

INTRODUCTION

The ongoing COVID-19 pandemic has had a profound impact on both individual and social aspects of human life, resulting in a substantial toll of illness, loss of life, and global economic slowdown. The repercussions of this unprecedented crisis have been far-reaching, encompassing health, socioeconomic dimensions. Despite the implementation of various measures such as lockdowns, travel restrictions, and isolation protocols, the pandemic continues to unfold and evolve on a daily basis. Vaccination efforts have played a crucial role in curbing the spread and severity of the disease, but achieving global immunization coverage remains a complex task.[1, 2] Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a highly contagious virus responsible for the current COVID-19 pandemic. The virus transmits through close contact and respiratory droplets. Fever is the most common symptom of the COVID-19 infection, followed by cough, anosmia, fatigue, shortness of breath, and myalgia.[3,4] Currently, the diagnosis of COVID-19 infection is made by taking a swab either from the nasopharynx or oropharynx with reverse-transcription polymerase chain reaction (RT-PCR) or real-time RT-PCR (rRT-PCR). This method is limited by.[5,6] While this method has been widely used and is considered the gold standard for diagnosis, it does have certain limitations such as time delay, a high false negative rate and availability of diagnostic kits that necessitate further

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investigations, including radiological examinations. Given these limitations, there is a growing recognition of the value of radiological examinations as supplementary diagnostic tools for COVID-19. Imaging techniques such as chest X-rays and computed tomography (CT) scans can provide valuable insights into the presence and characteristics of lung abnormalities associated with the disease. These imaging modalities can help identify typical patterns, such as ground glass opacities and consolidations, which are indicative of COVID-19 pneumonia.

By integrating radiological examinations into the diagnostic algorithm, healthcare professionals can enhance the accuracy and efficiency of COVID-19 detection, facilitating prompt decision-making regarding patient management, isolation measures, and appropriate treatment strategies. Evidence has established the diagnostic utility of chest computed tomography (CT) in COVID-19 because of its high sensitivity (up to 98 %). The typical findings commonly reported in COVID-19 are bilateral pulmonary ground-glass opacities involving the lower lobes, peripheral in distribution.[7-9] While chest CT has excellent sensitivity for lung pathologic findings related to COVID-19, its cost, availability, and sterilization after use limit its use on a large scale.

On the other hand, although plain film radiography has lower sensitivity, it is inexpensive and available everywhere, which makes it an excellent choice in field hospitals and poor resource health settings. Considering the rising disease burden and imaging follow-up demands, portable imaging with X-rays is the need of the hour.

Typical radiographic features of COVID-19 are similar to those described for CT: bilateral, peripheral, ground glass opacities and/or consolidation.[10] As compared to CT there are not that many large studies on CXR for COVID-19. This study is aimed at describing the number of abnormal CXR findings and the frequency of specific type of abnormal findings on CXR in asymptomatic or mildly symptomatic confirmed COVID-19 patients. The various distinctive radiographic patterns observed in COVID-19 are crucial indicators that can play a significant role in both the diagnosis and prognosis of the disease.

MATERIALS AND METHODS

This prospective observational study was carried out at the Field Isolation Center of Karachi (FIC-K), Pakistan. Karachi is the largest city in Pakistan. This field hospital is jointly run by the provincial government, i.e., Sindh government, and the Pakistan Army. The formula for estimating sample size for proportions was used with the following assumptions: a confidence level of 95% (α = 0.05), expected prevalence of abnormal chest radiographs which was assumed to be around 33%[10] and the acceptable margin of error of 4.03% which yields the minimum sample size of (n=510) required for your study.

The study screened a total of 600 RT-PCR-positive COVID-19 patients in a consecutive manner whose chest x-rays (CXRs) were available. After applying the exclusion criteria, 510 patients were included in the final study. The study encompassed patients of all ages and both genders, with the exclusion criteria being patients requiring intensive care and those with unreadable CXRs due to technical limitations. The data was collected over a period of 2 months, i.e., March 15th to May 15th 2020.

A structured format was devised, including the patient's age and gender as well as the X-ray findings. Two CPSP (College of Physicians and Surgeons of Pakistan)-certified radiologists were involved in the reading and reporting of these CXRs. One radiologist had reviewed 300 CXRs, while the other had reviewed 210 CXRs. They knew about the COVID-19 positive RT-PCR status of the patients at the time of reporting. CXRs were classified as normal or abnormal. Findings in those classified as abnormal were described in detail.

The interpreting radiologists were given thirty CXRs initially as a pre-test to review together to establish inter-observer agreement in reporting. Percentage agreement was used to calculate the proportion of agreement between observers. This measure is typically used for categorical data and provides a straightforward understanding of the level of agreement. Ethical approval was granted by the authorized body (Senior Board Member/Focal Person, Field Isolation Center, dated: 29/06/2020). Statistical Package for Social Science Version 21® (SPSS) was used for data analysis. Descriptive statistics were used to express categorical variables in terms of frequency and percentage. The association between categorical variables was determined using the Chi square test or Fisher exact test, where appropriate. The significance level was set at $p<0.05$.

RESULTS

Out of the total 510 patients, 463 (90.8%) were male and 47 (9.2%) were female. Patient ages ranged from 12 to 64 years, with a mean age of 33.78±11.24 years. The majority of the patients were in the age group 23–33

years followed by 34-44 years. The gender and age distribution is depicted in Figure 1.

Background characteristics such as age and gender were cross tabulated with the x-rays findings. The Chi square independence test showed no significant difference between different age groups and findings on CXR (p=0.625). However, Fisher exact test showed that gender proportions differed significantly between findings on CXRs such as normal and abnormal (p=0.018) as shown in Table 1.

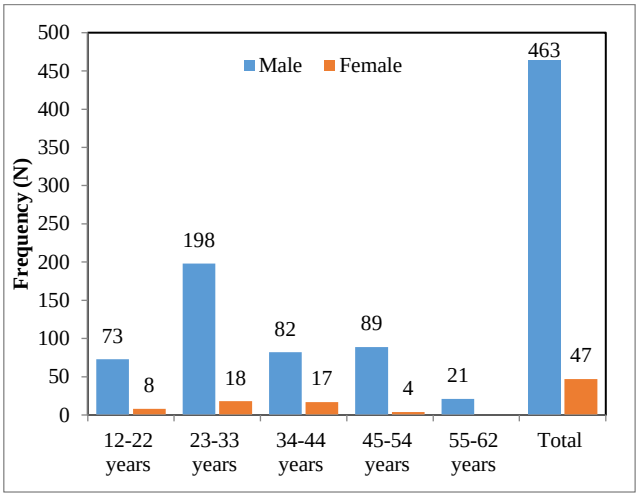

Figure 1: Age and gender distribution of the study patients (n = 510).

Table 1: Cross-tabulation of background characteristics with CXR findings

Characteristics		CXR findings		P-value
		Normal N=433	Abnormal N=77	
		n(%)	n(%)	
Age groups	12-22years	69(15.94)	12(15.58)	0.625
	23-33years	179(41.34)	37(48.05)	
	34-44years	85(19.63)	14(18.18)	
	45-54years	80(18.48)	13(16.88)	
	55-62years	20(4.62)	1(1.30)	
Gender	Male	399(92.15)	64(83.12)	0.018
	Female	34(7.85)	13(16.88)	

Table 2: Description of radiographic findings (n=77).

Radiological properties	Categories	n (%)
Abnormal finding	Reticular pattern	35(45.50%)
	Ground glass opacities (GGO)	42(54.50%)
Multiplicity	Single	40(51.90%)
	Multiple	37(48.10%)
Central/Peripheral	Central	17(22.10%)
	Peripheral	60(77.90%)
Location	Mid zone	5(6.50 %)
	Lower zone	37(48.10 %)
	More than one zone	29(37.70%)
	Peri-hilar	6(7.80%)
Laterality	Unilateral	52(67.53%)
	Bilateral	25(32.47%)
Other findings	Effusion	12(85.70%)
	Lymphadenopathy	2(14.30%)

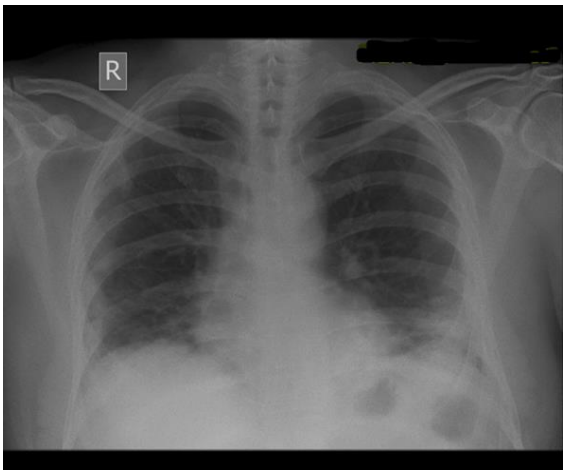

Figure 2: Patchy, peripheral ground glass opacities seen in left lower zone.

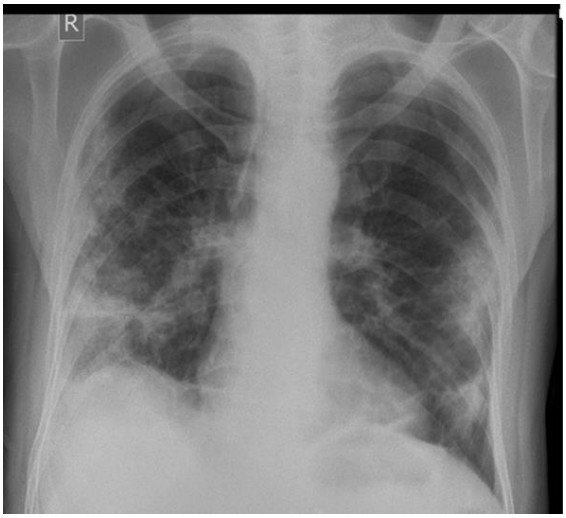

Figure 3: Patchy ground glass opacities in bilateral mid and lower zones predominantly peripheral in location.

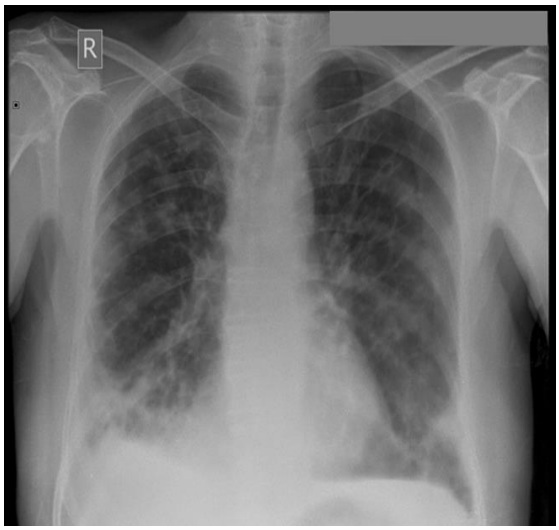

Figure 4: Patchy ground glass opacities in bilateral lower zones with reticulations in bilateral mid and upper zones.

Of the 510 CXRs, 433 (85%) were termed normal, and 77 (15%) were labeled abnormal with respect to the findings. The findings in these abnormal CXRs were documented for every patient. The most commonly observed abnormal findings on these radiographs were ground glass opacification (54.5%) and reticular pattern (45.5%). The most common location of these findings was the lower zones (48.10%) predominantly peripheral. The findings were multifocal in 48.10%, bilateral in 32.50% and involved more than one zone in 37.70%. Furthermore, other rare radiological findings in the study patients were pericardial effusion (n = 12, 14.30%) and mediastinal or hilar lymphadenopathy (n = 2, 85.70%). as shown in table 1 and figures 2-4.

DISCUSSION

Radiology, including CXR and CT scans, has played a very important role in identifying and characterizing COVID-19 patients. A CT scan has proven to be more reliable due to its better contrast resolution in identifying suspected COVID-19 patients. But the availability, decontamination limitations, and danger associated with the spread of infection while transferring patients to the CT scanner room limit its wide use. Chest radiography, on the other hand, is widely available, and its portable form is in excellent use. [11] Many studies have reported the frequency and distribution of abnormal findings on CXR. This study is unique because of the setting (a field isolation center) and the utilization of portable CXR in a large set of ambulatory patients.

Comparing results from our study with other studies, it was found that 84.90 % of the CXRs done on the COVID-19 positive patients were normal. Wong et al analyzed 255 CXRs from 64 positive COVID-19 patients and found that 31% of baseline CXRs were normal.[10] Vancheri et al studied the CXRs of 240 patients, of whom 25% were normal with no abnormal findings.[12] In another study, Weinstock et al analyzed CXRs of 636 ambulatory patients in a single encounter. They found that CXRs were normal in about 58 % patients.[13] The reasons for the high number of normal CXRs in our study might be the ambulatory patients and the failure to obtain serial CXRs.

Regarding the type of abnormal lung findings on CXRs, our study findings were almost consistent with the published literature. Ground glass opacities (GGO) were the most commonly observed abnormal lung findings. Following in frequency, the next commonly observed abnormal lung finding was a reticular pattern. Multiple studies analysing the radiological findings in COVID-19 have also reported similar findings, with ground glass opacifications being the most common finding.[10, 12, 13] Most studies done so far have reported the distribution of abnormal findings as peripheral, multifocal, and lower lobe involvement, with interstitial or ground glass appearance being the most common.[10, 12-14] It can be observed in our study results that only 32.47 % patients had bilateral involvement if there were abnormal findings. This number is low when compared with studies on CT chest findings in COVID-19.[15], but consistent with findings on CXR in ambulatory patients.[13] The presence of lymphadenopathy and pleural effusion were reported to be very rare findings.[10, 12, 13]

This study has certain limitations. Worth mentioning is the study design, which was cross-sectional observational, and such types of studies are always associated with some limitations. Serial CXRs were not obtained; rather, a single x-ray was taken of each patient. Serial CXRs would have definitely given much information, i.e., whether the abnormal findings progressed or resolved with time. Similarly, the investigators had no access to patients' previous records or CXRs, so it is possible that some of the abnormal findings on CXRs could represent chronic illnesses. However, most patients (95.88 %) were <55 years of age and, therefore, were assumed to be normal before this presentation. Furthermore, the radiologist knew that all the CXRs that they were reporting were from confirmed COVID-19 patients. There was selection bias as most patients were male and needed isolation, and females needed less isolation due to cultural issues.

CONCLUSION

Our study concludes that most patients who are asymptomatic or have mild symptoms do well and recover completely. Patients who have abnormalities on CXR have a lower lobe preponderance seen as ground glass or reticular shadowing with patchy, peripheral, focal, or multifocal distribution.

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