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Review Article

DIAGNOSTIC ACCURACY OF CHEST X-RAY AS A FRONTLINE DIAGNOSTIC TOOL FOR DETECTING COVID-19 PNEUMONIA -OUR STUDY IN A TERTIARY LEVEL COVID HOSPITAL

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A B S T R A C T

Introduction: Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is a new virus recently isolated from humans. SARS-CoV-2 was discovered to be the pathogen responsible for a cluster of pneumonia cases associated with severe respiratory disease that occurred in December 2019 in Wuhan, China. Chest Radiography has very limited role in diagnosis of early and mild course of disease but it showed significant role in intermediate to advanced course of disease as well as during follow-up.

Purpose: The purpose of our study is to correlate chest x-ray findings with RT-PCR, describe various chest x-ray findings and monitor patient's disease progression over time.

Materials and Methods: We selected 152 patients from tertiary level COVID hospital from 3rd April to 9th June who had symptoms of COVID-19 (fever, cough, sore throat, dyspnoea). All patients performed RT-PCR nasopharyngeal and throat swab, CXR on admission and during follow-up. RT-PCR results were considered the reference standard. A CXR severity scoring index was determined for each lung. A total severity score was calculated by summing both lung scores.

Results: The study was composed of 152 clinically suspected patients, of which 140 patients were tested positive for COVID-19 RT-PCR. 82 of 140 RT-PCR positive patients at initial scan and 16 patients in follow-up scan showed chest X-ray abnormalities. 12 patients were tested negative for RT-PCR, out of which 4 patients showed chest X-ray abnormalities (false positive). Most common findings of chest X-ray were consolidation (69,67.6%) followed by ground glass opacity (36,35.3%), reticulation and interstitial thickening (34, 33.3%). Pleural effusion was found in 4 patients (3.9%). Chest x-ray of one patient (1,0.9%) revealed cardiomegaly, with smooth cardiac boarders suggestive of pericardial effusion. Most cases showed peripheral predominance (65,63.7%) with Bilateral lung involvement (66, 64.7%) and lower zonal (77, 75.5%) distribution. Total severity scores ranged from 0 to 8 and calculated at baseline, first week and second week of follow-up scan. Peak severity was reached at 12-14 days of disease onset. By using RT-PCR results as standard, overall sensitivity and specificity of chest radiography were 70% and 66.7% respectively in the diagnosis of COVID-19.

Conclusions: Chest radiography can be used as initial diagnostic tool for triaging of COVID-19 in symptomatic patients and useful for monitoring chest manifestations and extent of lung involvement and disease progression over time.

INTRODUCTION

The WHO has declared Coronavirus-19 as one of the deadliest pandemics till date. SARS-CoV-2 was discovered to be the pathogen responsible for a cluster of pneumonia cases associated with severe respiratory disease that occurred in December 2019 in Wuhan, China (16,17). India reported first case of COVID-19 on 30th January in Kerala(18).

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Coronaviruses are a family of enveloped, single-stranded, positive-strand RNA viruses classified within the *Nidovirales* order. This coronavirus family consists of pathogens of many animal species and of humans, including the recently isolated severe acute respiratory syndrome coronavirus (SARS-CoV)(19). They are known to cause diseases including the common cold, Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) in humans(20).

Chest Radiography has very limited role in diagnosis of early and mild course of disease but it showed significant role in

intermediate to advanced course of disease as well as during follow-up.

Chest CT has a potential role in the diagnosis, detection of complications, and predict disease severity. However, this modality created so much burden on the radiology departments and required intense infection control measurement.(1) However, due to infection control issues related to patient transport to CT suites, the inefficiencies introduced in CT room decontamination, and lack of CT availability in parts of the world, portable chest radiography (CXR) will likely be the most commonly utilized modality for identification and follow up of lung abnormalities. In fact, the American College of Radiology (ACR) notes that CT decontamination required after scanning COVID-19 patients may disrupt radiological service availability and suggests that portable chest radiography may be considered to minimize the risk of cross-infection (American College of Radiology). (2)

To better understanding of the role chest radiography in COVID 19 our aim is to correlate chest x-ray findings with RT-PCR, describe various chest x-ray findings and monitor patient's disease progression over time.

MATERIALS AND METHODS

Study Design*:* Retrospective observational study.

Sample selection: We selected 152 patients from Medical

College, Kolkatafrom 3rd April to 9th June who had symptoms of COVID-19 (fever, cough, sore throat, dyspnoea).

Inclusion Criteria

1. Clinically suspected COVID-19 patients admitted in isolation ward
2. Patients who gave consent to take part in the study
3. Patients with contraindications for CT scan

Exclusion Criteria

1. Asymptomatic patients
2. Children less than14 years
3. Pregnant patients

Ethical consideration: The study was conducted after getting approval from Institutional Ethics Committee and other authority. Informed consent was taken from all participants.

Procedure*:* The study was conducted in Medical college, Kolkataon Covid-19 patients admitted at isolation ward of Medical College, Kolkata which has been assigned as dedicated tertiary level COVID-19 hospital by Govt. of West Bengal. Covid-19 infection was confirmed by RT-PCR testing after taking both nasopharyngeal and throat swab. All patients underwent chest radiography by our FUJI computed radiography machine on admission and follow-up chest radiography done by portable X-ray units. PA projection was done initially at the time of admission and AP projection was done during follow-up.

The following information were collected from each patient. Age, sex, H/O diabetes, hypertension, heart disease, smoking, COPD, Chronic kidney disease. Clinical features and examination findings were noted. Age of the patients were ranged from 14years to 85 years and categorized into 5 groups:<15 years, 15-29 years, 30-44 years, 45-59 years and >60 years.

Image Analysis: All chest radiographs were reviewed by experienced radiologist. Radiographic features including consolidation, ground-glass opacities, reticulation and interstitial thickening, pulmonary nodules as well as pleural effusion were diagnosed according to the Fleischner Society glossary of terms **(3).** Distribution of lung changes are classified into peripheral predominance, perihilar predominance or neither: Upper zonal distribution, lower zonal distribution or no zonal predominance: Unilateral (right or left) involvement or B/L involvement, presence or absence of effusion, collapse, pneumothorax. After analysis of images a radiographic scoring was proposed.

Radiographic Scoring: To assess the extent of infection a severity score was proposed by Warren *et al* (4). Each lung was given a score of 0–4 depending on the extent of lung involvement (score 0 = no involvement; 1 ≤ 25%; 2 = 25–50%; 3 = 50–75%; 4 ≥ 75% lung affection). A total severity score was calculated by summing both lung scores (total severity scores ranged from 0 to 8).

Table 1 Radiographic Scoring based on Lung Involvement

Scoring of each Lung	Extent of lung involvement
0	No involvement
1	<=25%
2	25-50%
3	50-75%
4	>=75%

RESULTS

- A total 152 clinically suspected COVID-19 patients selected for our study. Each patient underwent RT-PCR testing and baseline chest radiography at the time of admission. There were 114 males (75%) and 38 females(25%). Age group examined was from 14 years to 85 years with median age 41 years.
- Most common comorbidity was hypertension (24, 15.7%) followed by diabetes (13,8.5%) and coronary heart disease (5, 3.3%).
- Most of the patients were symptomatic at the time of admission. Common symptoms were fever (125, 82.2%), cough (77, 50.7%), dyspnoea (72,47.4%).

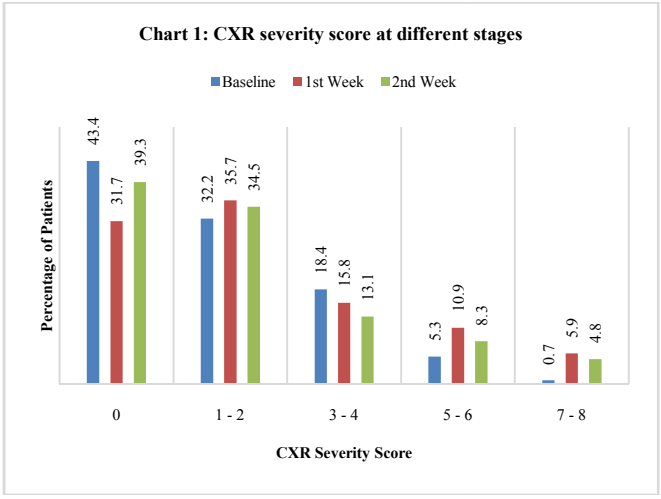
Table 2 Demographic Characteristics of Patients

Study Variable	No. of Patients
Gender	
Male	114
Female	38
Mean Age	40.9
Symptoms	
Fever	125
Cough	77
Dyspnoea	72
Comorbidities	
Hypertension	24
Diabetes	13
Coronary Heart Disease	5

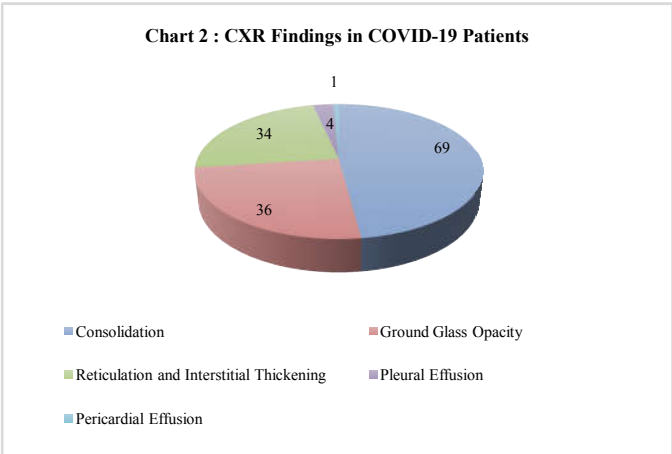
- Baseline chest Xray was performed in all patients at the time of admission. 86 patients (56.6%) had lung involvement on baseline scan and 66 patients (43.4%) had normal CXR. During follow-up scan 16 of 66 normal baseline chest X-ray showed abnormality. So, chest X-ray abnormalities were found in 102 of 152 patients at certain time of disease progression.
- Total severity score was calculated at baseline, first week and second week of follow-up scan. Out of 86 patients who had baseline abnormal chest X-rays, 49

patients (32.2%) had mild symptoms with TSS 1-2. Moderate to severe involvement were found in 28 (18.4) and 8 (5.3) patients with severity score 3-4 and 5-6 respectively. Only one patient (0.7%) had extensive lung involvement with severity score 7-8 at initial scan.

- Follow up scan was done at first and second week after the disease onset. First week follow-up scan was performed in 101 patients, scores of 1-2, 3-4, 5-6, 7-8 were found respectively in 36(35.7%), 16 (15.8%), 11 (10.9%), 6 (5.9%)patients respectively. Second week follow-up scan were done in 84 patients, scores of 1-2, 3-4, 5-6, 7-8 were found respectively in 29 (34.5%), 11(13.1%), 7(8.3%), 4(4.8%). Peak severity was reached at 12-14 days of disease onset.



Most common findings of chest X-ray were consolidation (69,67.6%) followed by ground glass opacity(36,35.3%), reticulation and interstitial thickening (34, 33.3%). Pleural effusion was found in 4patients (3.9%).Chest x-ray of one patient (1,0.9%) revealed cardiomegaly, with smooth cardiac boarders suggestive of pericardial effusion.



- Most cases showed peripheral predominance (65,63.7%) followed by perihilar (9, 8.9%) involvement and neither of mentioned two (28, 27.4%).
- Bilateral lung involvement was found in most of the patients (66, 64.7%) followed by right lung(20, 19.6%) and left lung(16, 15.7%) involvement.
- Most patients showed lower zonal (77, 75.5%) distribution while 19 patients (18.6%) showed upper and 6 patients (5.9%) showed no zonal distribution.
- RT-PCR and chest X-ray correlation- Out of 152 patients 140 patients were tested positive for COVID-19 RT-PCR. 82 of 140 RT-PCR positive patients at initial scan and 16 patients in follow-up scan showed chest X-ray abnormalities. 12 patients were tested negative for RT-PCR, out of which 4 patients showed chest X-ray abnormalities (false positive).
- By using RT-PCR results as standard, overall sensitivity and specificity of chest radiography were 70% and 66.7% respectively in the diagnosis of COVID-19.

Table 3 Correlation between CXR and RT-PCR

	RT-PCR Positive	RTPCR Negative
CXR Positive	98	4 (false positive)
CXR Negative	42	8

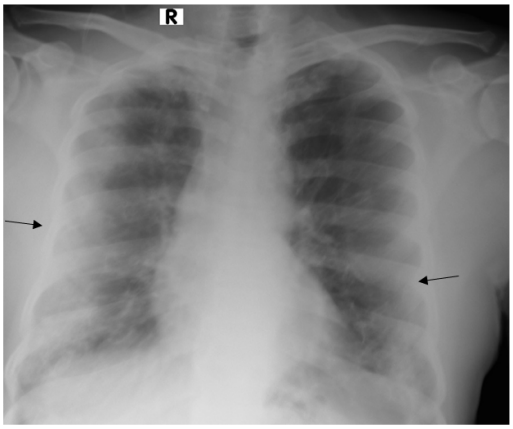


Fig 1 CXR showing bilateral peripheral zonal air space consolidation opacities along the periphery of both lungs (arrows)

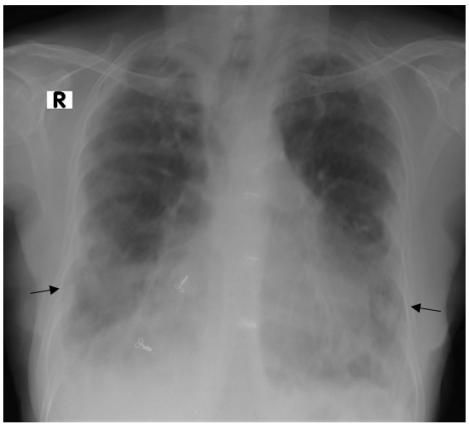


Fig 2 CXR showing bilateral ground glass opacities predominantly in mid and lower zones.

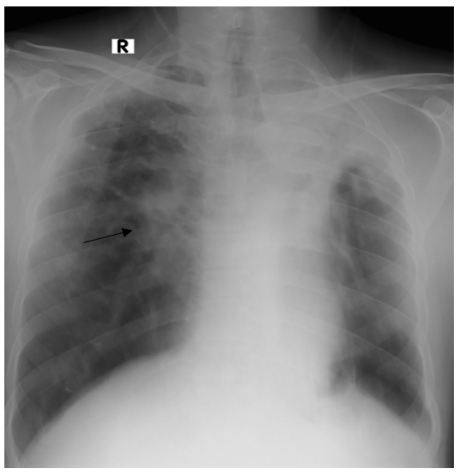


Fig 3 Chest X-ray showing right perihilar air space consolidation opacity extending to the right Para cardiac region

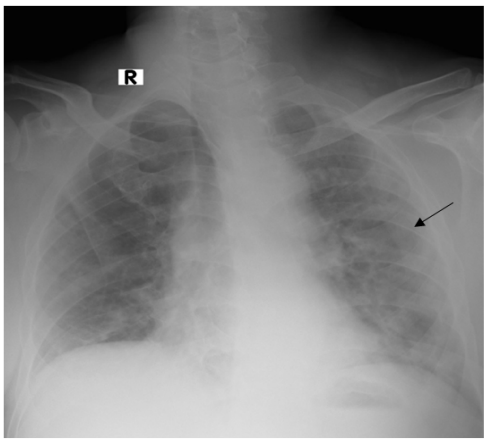


Fig 4 CXR showing reticular in interstitial thickening predominantly in left mid and lower lung zones and right lower zone

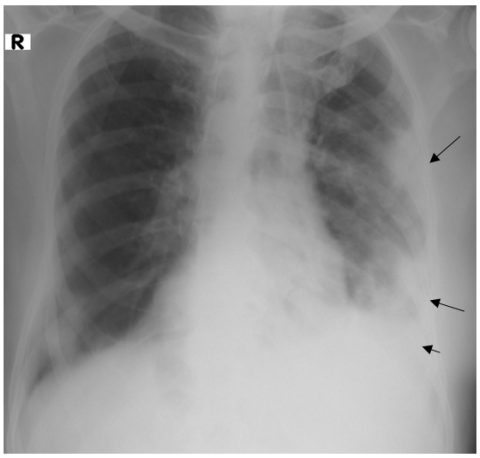


Fig 5 CXR showing peripheral airspace consolidation (long arrows) in left mid and lower zones along with mild left pleural effusion (short arrow)

DISCUSSION

COVID-19 is a highly infectious disease that has been spread widely through the world. The disease management strategies primarily depend upon the early disease diagnosis. (5,6,7). In radiology, much of the literature to date has focused on chest CT manifestations of COVID-19.[7] However, due to infection control issues related to patient transport to CT suites, the inefficiencies introduced in CT room decontamination, and lack of CT availability in parts of the world, portable chest radiography (CXR) will likely be the most commonly utilized modality for identification and follow up of lung abnormalities[8].

Although chest X-ray (CXR) is considered less sensitive for the detection of pulmonary involvement in early-stage disease, it is useful for monitoring the rapid progression of lung abnormalities in COVID-19, especially in critical patients admitted to intensive care units [9].

In our study total severity score (TSS) of lung was calculated based on extent of lung involvement. Each lung was given a score of 0-4 (score 0- no involvement, score 1- <25%, score 2-25-50%, score 3-50-75%, Score 4->75%). Total severity score calculated adding scores of both lung (total severity scores-0 to 8).

The above scoring system of lung involvement was first described by Yasin R, Gouda W. Total severity score, time to reach maximum total severity score, severity score at different stages of illness was estimates using the score. [10]

Borghesi *et al*. made another CXR scoring system for COVID-19 pneumonia (Brixia score) by dividing the lungs to six zones on frontal projection (upper, middle, and lower zones); then, a score (from 0 to 3) is assigned to each zone based on the lung abnormalities detected on frontal chest projection as follows: score 0, no lung abnormalities; score 1, interstitial infiltrates; score 2, interstitial and alveolar infiltrates (interstitial predominance); and score 3, interstitial and alveolar infiltrates (alveolar predominance). The scores of the six lung zones are then added to obtain an overall "CXR SCORE" ranging from 0 to 18. [9]

In our study most common finding was consolidation seen in 69patients (67.6%) followed by ground glass opacity seen in 36 patients (35.3%), and reticular thickening seen in 34 patients (33.3%). Pleural effusion was seen in 4patients (3.9%). Chest x-ray of one patient (1,0.9%) revealed cardiomegaly, with smooth cardiac boarders suggestive of pericardial effusion. Later Echocardiography was done and pericardial effusion was confirmed. Most patients showed peripheral (65,63.7%) and lower zonal distribution (77, 75.5%) and bilateral lung involvement (66, 64.7%).

Wong *et al*. reported that at baseline chest radiography, consolidation was the most common finding (47%), followed by ground-glass opacities (33%). Peripheral distribution (41%) and lower zone distribution (50%) were the more common locations, and most had bilateral involvement (50%). Pleural effusion was found in two patients (3%). [1]

Rousan LA *et al*. found that peripheral ground glass opacities (GGO) were the most common findings affecting the lower lobes. In the course of illness, the GGO progressed into consolidations (GGO 70%, consolidations 30%). The consolidations regressed into GGO towards the later phase of the illness (GGO 80%, consolidations 10%).[11]

Lomoro P *et al*. who did a study on 32 COVID-19 patients, they found of these, five patients exhibited normal CXR despite chest CT scan showed bilateral ground-glass opacities (GGO). In the remaining twenty-seven cases, consolidation was most common findings seen in fifteen patients (46.9%) with bilateral (78.1%) and lower zone involvement (52%) and hazy increased opacity in twelve patients (37.5%),no pleural effusion was identified.[12]

In most studies, it was reported that pleural effusions, pneumothorax, and lung cavitation are rare in COVID-19 infected patients. [8,13]

In our study Total severity score was calculated at baseline, first week and second week of follow-up scan., 49 patients (32.2%) at baseline hadshown mild severity with TSS 1-2. Moderate Severity score ranging between3-4 was found in 28 patients (18.4) and 5-6 score (severe) seen in 8(5.3) patients. Only one patient (0.7%) had extensive lung involvement with severity score 7-8 at initial scan. Peak severity was reached at 13-14 days of disease onset.

Wong *et al* found that Baseline chest radiography was normal in 20 patients (31%). Twenty-six patients (41%) had mild findings with total severity score of 1–2.Moreextensive involvement was observed in 13 (20%) and five (8%) patients, who had severity scores of 3–4 and 5–6, respectively. There was no patient severity score greater than 6 at baseline chest radiography with the severity of CXR findings peaked at 10–15 days from the date of symptom onset. [1]

In our study 140 patients were tested positive and 12 patients tested negative for COVID-19 at initial RT-PCR. 82 RT-PCR positive patients at initial scan and 16RT-PCR positive patients in follow-up scan showed chest X-ray abnormalities. Out of 12 RT-PCR negative patients on repeat scan, 4 patients showed chest Xray abnormalities (false positive).

Cozzi D *et al*. found that patients that had a RT-PCR positive for COVID-19 infection were 234 in total: 153 males (65.4%) and 81 females (34.6%). Thirteen CXRs were negative for radiological thoracic involvement (5.6%).[14]

Wong *et al*. reported that of these, 58 patients had initial positive findings with RT-PCR (91%), 44 patients had abnormal findings at baseline chest radiography (69%). Six patients (9%) showed abnormalities at chest radiography before eventually testing positive for COVID-19 with RT-PCR. [1]

The present study results showed that sensitivity and specificity of chest radiography for detecting COVID-19 infection were 70% and 66.7% respectively by using RT-PCR as standard.

Tsakok M *et al*. also found similar sensitivity of 61% and specificity of 76% in the diagnosis of COVID-19 compared to PCR as reference test. [15]

CONCLUSION

Chest radiography can be used as diagnostic tool with a sensitivity of 70% and specificity of 66.7% for initial triaging of COVID-19 in symptomatic patients. CXR is useful for monitoring COVID-19 chest manifestations and its scoring system provides an accurate method to understand extent of lung involvement and disease progression over time.

LIMITATIONS

- All the patients could not be followed till the final outcome as the course of the disease was truncated in these patients.
- In such an emergency, the completeness of data recorded was less than optimal.
- CT could not be performed in this study, so the correlation between CXR and CT cannot be obtained.
- AP images from portable machines produce a poorer quality image performed in intensive care unit.
- Lack of correlation between the patients' total severity score to the final disease outcome.
- In our study we used FUJI computed radiography machine which requires large number of CR Cassettes, the cassette to be removed each time from the X-ray machine and then placed into a reader. This is a labour-intensive and time-consuming procedure, which can be overcome by using DR Xray machine.
- Imaging of critically ill ICU patients, unconscious, obese patients was difficult with CR cassette with possibility of bending & breakage of cassette. This can be overcome by portable C-arm machine which has ability to move around the patient achieving high quality image without touching the patient.

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