Original research article

Evaluation of chest x-ray findings in patients having atypical pneumonia with CO-RADS 4 or above on their high-resolution CT chest scans

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Abstract
More than 6 million people died due to COVID-19 (coronavirus disease-19) with more than 4.5 billion people infected worldwide, while the pandemic continues. The significance of prompt, accurate and readily available diagnostic tools that can be used for early diagnosis and subsequent management evoked the need for analyzing performance of an easily accessible modality of CXR (Chest X-Ray) with respect to resource intensive High Resolution Computed Tomography (HRCT) scans of thorax. This observational, cross-sectional study analyzed imaging data of 200 patients clinically suspected to have atypical pneumonia and who were categorized as CO-RADS 4 or above on their HRCT chest scans and had CXR, HRCT scan done on the same day from April 2020 to May 2021 in Department of Radio-diagnosis, Dr. S. N. Medical College, Mahatma Gandhi Hospital, Jodhpur. In our study, the 200 patients having mean age of 47 years, median of 45 years (65% males and 35% females) showed predominantly ground glass opacity (GGO) as sole finding in 129 patients (64.5%); GGO with consolidation in 45 patients (22.5%); GGO with reticulation in 15 patients (7.5%); GGO with consolidation and reticulation in 5 patients (2.5%); exhibiting no significant difference in pattern based on age and gender. The distribution of ground glass opacity or consolidation was predominantly in the lower and mid- peripheral lung zones. Pleural effusion, lymphadenopathy are uncommon and atypical findings. On comparing HRCT severity score and CXR severity scores for Cohen- kappa inter- rater agreement, the value of 'k' (k= kappa coefficient) came as 0.27558 (linear weights) for CXR score and CT score, which falls under "fair agreement" category. For the grading of severity, it came as 0.72772 and 0.65083 on linear and quadratic weights respectively, effectively meaning "good" agreement between the two modalities.
Keywords: COVID-19, corona virus, SARS CoV-2, atypical pneumonia, imaging, chest x ray, high resolution computed tomography

Introduction

The atypical pneumonia caused by Corona virus-'SARS-CoV-2', isolated from Wuhan, Hubei province, China in early January 2020, the seventh corona virus recognized to infect humans[1], has wreaked havoc to the scale of a pandemic declared on 11th of March 2020 by W.H.O.

The disease can progress to severe pneumonia and may confer morbid sequalae or even death to the affected. For the novel agent's rapid spread, mutations, severe disease, sequalae and lethality, early identification and management of its infection has become critical.

The myriad of radiological means employed for its diagnosis ranging from CXR, USG to CT have left overbearing impact, especially on the resource-constrained regions of the world. The confirmatory test for diagnosing the disease remains the RT-PCR identification of the agent [2].

Among the radiological investigations, while Lung ultrasound is a non-invasive, rapid, repeatableand sensitive bedside method to detect a range of pulmonary pathologies, yet the ultrasound-based effort requires not only a close proximity, mandating expensive precautionary measures but also renders employing highly skilled worker obligatory, with little scope of cross-verification or a 'second opinion'[3].

The CT scan has emerged as one of the desired radiological modalities for its high resolution, threedimensional, stored image-set that can later be compared and analyzed providing ample reference [4]. Despite its coveted advantages, the modality suffers from availability and cost- constraints compounded by greater radiation exposure, added maintenance- burden and trained staff-requirements mandated for the overwhelming quantity of investigations and associated additional preventative measures.

On the other hand, the good old chest X-Ray has been a workhorse in identifying and managing lung-infections for decades[5]. The modality is laden with benefits of ease of use, cheaper maintenance, lower radiation, and even portable commissioning to point of care. With modern digital systems, the images can be stored and processed for supplementary assessment, demanding lesser resources and providing with proven value, making it a 'feasible' choice, particularly for places marred by resource-limitations.

However, the CXR has inherent drawbacks, especially when compared with CT scan. The images obtained are essentially two-dimensional representation of a complex anatomy thus introducing overlapping of features as well as lack of a clear volumetric understanding. The sensitivity of CXR in recognizing earlier appearing ground glass opacities fall behind to that of CT scan's, thus CXR is known to become apparently abnormal in later part of the disease, usually about 4-5 days after the symptom onset compared to high resolution CT scan that may depict typical presentation of ground glass opacities earlier [6]. Certain anatomical peculiarities, such as breast shadows, scapular profile etc. preclude definitive determination of findings on a two-dimensional, single-plane image obtained with CXR imaging.

Computed tomography has substantially improved diagnostic performance over CXR in COVID-19 and CT should be considered in the initial assessment for suspected COVID-19 instead of CXR if capacity allows and balanced against radiation exposure risk. The CO-RADS categories from CO-RADS 4 or above has a high positive predictive value given the high prior chance in this pandemic. The CO-RADS classification is a standardized reporting system for patients with suspected COVID-19 infection developed for a moderate to high prevalence setting[4], yet CXR may provide effective assessment particularly if patient is immovable or facility for CT scan is unavailable, especially in the context of mass screening in a pandemic scenario. In this study, a Chest X-Ray scoring system that is a modified form of Radiographic Assessment of Lung Edema (RALE) score [5, 6]is employed to compare the assessment of severity of the lung-involvement in COVID-19 as ascertained by high resolutionchest computed tomography-scan (HRCT Thorax) and Chest X-Ray (Postero-Anterior and/or Antero-Posterior views). This approach may facilitate non-radiologist clinicians to assess patients with acute respiratory diseases. The system used relies more on volume involvement rather than morphological patterns, since the former is proven to be more relevant regarding the clinical outcomes [6].

This study is an effort to provide with an evidence-based ground for deciding upon the future employment of the highly feasible modality of Chest X-Ray in screening, identification and management of atypical pneumonia caused by coronavirus. The study is centered on comparative analysis of radiological findings obtained with CXR and benchmarked with the CO-RADS 4 or above class assessed on CT scans, indicating probable, highly likely or RT- PCR proven SARS-CoV-2 infected patients who came up with symptoms of atypical pneumonia from May 2020 to April 2021 in Mahatma Gandhi Hospital, attached to Dr. S. N. Medical College, Jodhpur, Rajasthan.

Material and methods: The Observational, cross-sectional study analyzed the HRCT and CXR imaging data of 200 patients, who were suspected to have atypical pneumonia with no other lung pathology, were assessed as CO-RADS 4 or above on their HRCT thorax scans and had their CXR done on the same day, from April 2020 to May 2021, in the Dept. of Radio-diagnosis, Mahatma Gandhi Hospital, Dr. S. N. Medical College, Jodhpur, Rajasthan. Being observational, cross-sectional study with anonymized data set, the consent was waived off by the Institutional Ethical Committee.

Data collection: After attaining Ethical approval, collection of Chest HRCT and Chest X-Ray data for analysis, derived from electronic medical record systems, from April 2020 to May 2021, of patients, visiting M.G. Hospital, Dr. S.N. Medical College Jodhpur, who were suspected to have COVID- pneumonia with CO-RADS of 4 or above on their CT scans and had CXR and CT scan done on the same day, is done. The data has been interpreted and then analyzed by appropriate software (Microsoft ™ Excel and SPSS- Statistical Package for the Social Sciences).

HRCT procedure: All initial chest HRCT scans were performed on the day of patients' presentation using a Philips Ingenuity Core (64 Slice) scanner. Patients were placed in a supine position with single breath hold. Scanning parameters were as follows:

Scan direction (cranio-caudally), tube voltage (100 kV), tube current (100-600 mA)-smart mA dose

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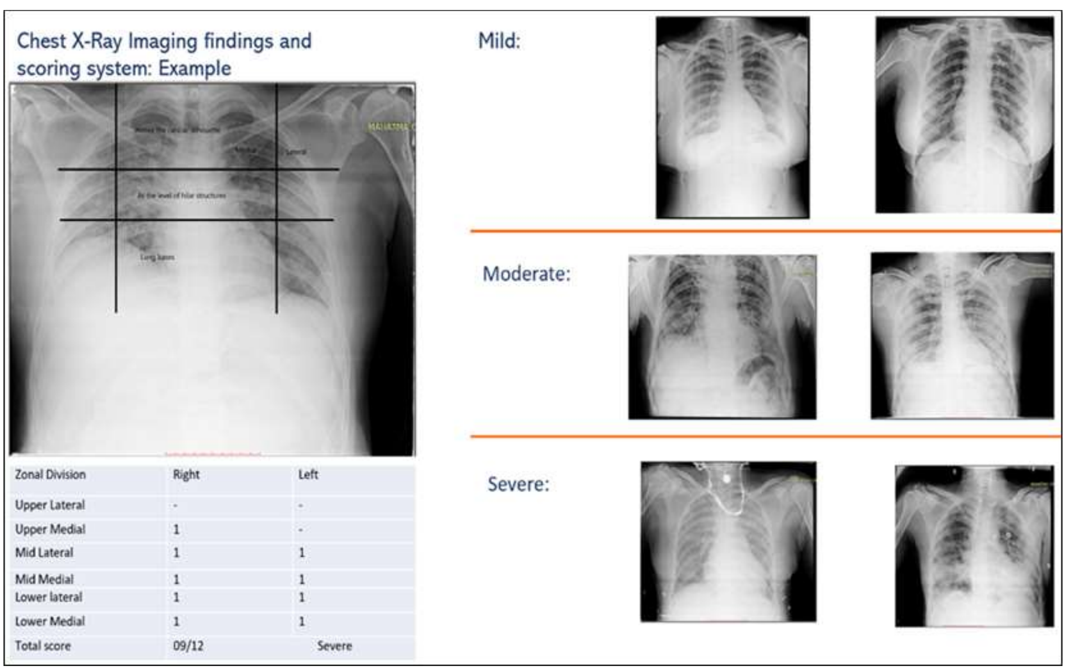
modulation, slice collimation (64 × 0.67 mm), width (0.67 × 0.67 mm), rotation time (0.5 s), pitch and scan length (60.00-300.00s).
Chest X-Rays were taken in the Postero-anterior and/or Antero-posterior projections with the help of FUJI FCR PRIMA™, AGFA Digital CR 30, Allenger MARS-6R systems. The postero-anterior views were taken with the patient in standing position and in full inspiration hugging the detector to pull the scapulae laterally. The antero-posterior views were taken with the patient sitting up on the bed.

CXR and HRCT Image Analysis: Two radiologists with more than 8 years of experience evaluated the images to determine the disease severity score in each patient with consensus. The scans were first assessed whether negative or positive for typical findings of COVID-19 pneumonia (bilateral, multilobe, posterior peripheral ground-glass opacities) as defined by the RSNA Consensus statement (7). Severity then was assessed using the following scoring systems:-

CT severity score: The percentages of each of the five lobes that is involved (having ground glass opacity):
1. < 5% involvement.
2. 5%-25% involvement.
3. 26%-49% involvement.
4. 50%-75% involvement.
5. > 75% involvement.

The total CT score is the sum of the individual lobar scores and can range from 0 (no involvement) to 25 (maximum involvement), when all the five lobes show more than 75% involvement.
Mild: 1 to 8; Moderate: 9 to 15; Severe: 16 to 25[7, 8].

CXR-severity score: The Chest X-Ray scoring system that is a modified form of Radiographic Assessment of Lung Edema (RALE) score [5, 6]is employed. This simplified approach may facilitate non-radiologist clinicians to assess patients with acute respiratory diseases [5,6].
Each lung is divided into 6 zones, namely-upper lateral, upper medial, mid lateral, mid medial, lower lateral and lower medial zones. Involvement with ground glass opacities of each zone is allotted 1 point and total score is calculated that is out of 12. The score of 1 to 4 is considered as "mild", 5 to 8 as "moderate" and 9 to 12 as "severe".



Assessment of severity of atypical pneumonia by CXR in relation to CT: Comparison between CXR scores

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and CT severity scores was made. Then calculation was derived on the ratio scale so as to know what proportion of the “mild, moderate and severe” cases could be identified by CXR, when compared with the “mild, moderate and severe cases” identified by CT scan. The inter-rater agreement using Cohen’s kappa coefficient was calculated with linear regression analysis and correlation matrix derivation while considering HRCT as the benchmark standard. Derivation and evaluation of the findings were done using appropriate statistical tool.

With the help of this data, determination of the comparative effectiveness of the CXR in identifying “degree” of severity of the disease was ascertained.

Observations & Results

Data of 200 patients mean age of 46.94±16.48 yr., ~65% males (n=130, from age 16 yr. to 88 yr., mean age of 46.56± 14.90yr.); 35% females (n=70, from age 16 yr. to 92 yr., mean age of 47.64±19.17 yr.), who came with symptoms of atypical pneumonia and were clinically suspected to have COVID- 19 pneumonia, subsequently had their chest X- Ray and HRCT scans done on same day is analyzed.

Table A: Age distribution of cases

Age (in years)	Number of cases	Percentage of cases
≤20	11	5.50
20 - 30	23	11.50
30 - 40	39	19.50
40 - 50	49	24.50
50 - 60	40	20.00
60 - 70	24	12.00
>70	14	7.00
Mean	46.94±16.48	
Median [range]	45.00 [16.00-92.00]	

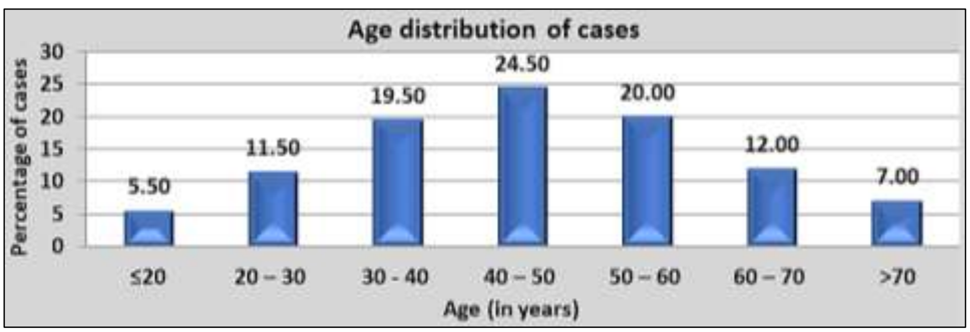

Chart A: Age distribution of cases

Table B: Age and gender distribution of cases

Age (in years)	Number of cases	Male	Female
≤20	11 (5.50)	04 (3.08%)	07 (10.00%)
20 - 30	23 (11.50%)	16 (12.31%)	07 (10.00%)
30 - 40	39 (19.50%)	24 (18.46%)	15 (21.43%)
40 - 50	49 (24.50%)	37 (28.46%)	12 (17.14%)
50 - 60	40 (20.0%)	26 (20.00%)	14 (20.00%)
60 - 70	24 (12.0%)	17 (13.08%)	07 (10.00%)
>70	14 (12.00%)	06 (4.62%)	08 (11.43%)
Mean	46.94±16.48	46.56± 14.90	47.64±19.17
Median [range]	45.00 [16.00-92.00	45.0 [16.0-88.00]	45.0 [16.0-92.0]

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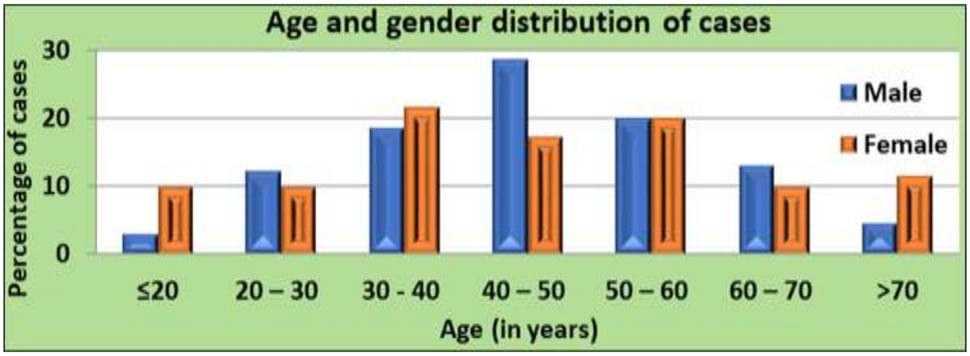

Chart B: Age and gender distribution of cases

Table C: Gender distribution of cases

Gender	Number of cases	Percentage of cases
Male	130	65.00
Female	70	35.00
Total	200	100%

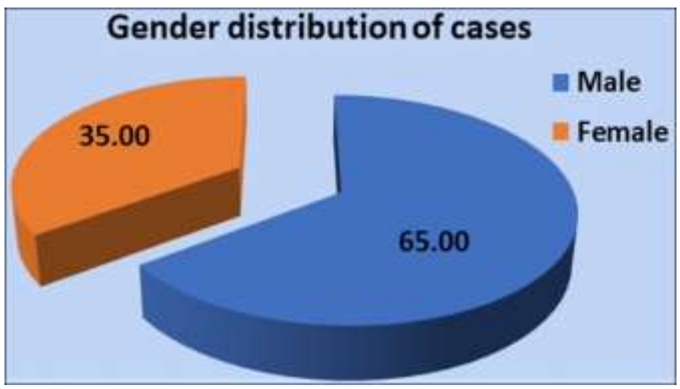

Chart C: Gender distribution of cases

1. Determining proportion of various Chest X-Ray findings in patients having CO-RADS 4 or above on their High-Resolution CT chest scans.

Table 1.1: Chest X ray findings in study participants

Chest X Ray Findings	Number of cases	Cases per cent
Ground Glass Opacities (GGO) *	129	64.50
Consolidations *	48	24.0
Reticulations *	16	8.00
Bilateral presence	171	85.50
Peripheral distribution (predominantly)	174	87.00

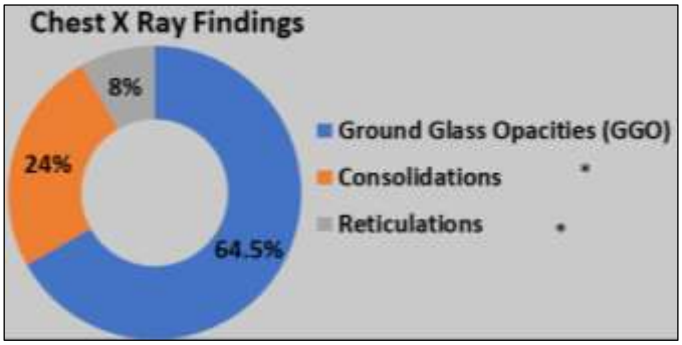

Fig 1.1: Chest X ray findings in study participants

*All abnormal CXR had GGOs-with or without other concurrent morphologies.

Table 1.2: Abnormal CXR finding at different location

CXR site	Number of cases	Percentage
Right Upper Lateral	68	34.00
Right Upper Medial	16	8.00
Right Mid Lateral	113	56.50
Right Mid Medial	42	21.00
Right Lower Lateral	114	57.00
Right Lower Medial	64	32.00
Left Upper Lateral	74	37.00
Left Upper Medial	15	7.50
Left Mid Lateral	106	53.00
Left Mid Medial	40	20.00
Left Lower Lateral	117	58.50
Left Lower Medial	51	25.50

Table 1.2.1: Presence of various, typical CXR imaging findings relative to each other

Only GGO	Predominantly Con.	Predominantly Reti.	Predominantly GGO + Con.	Predominantly GGO+Reti.	GGO+ Con.+Reti
129	48	16	47	15	05

GGO= Ground Glass Opacity; Con.= Consolidation; Reti.= Reticulation

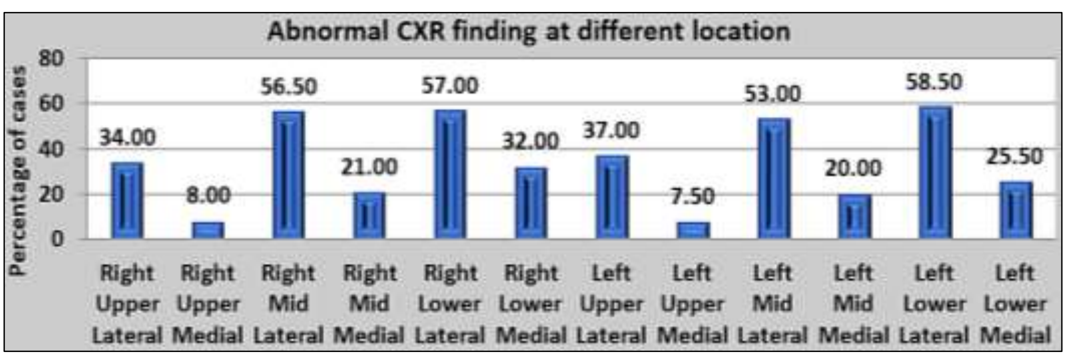

Fig 1.2: Abnormal CXR finding at different location

Chest X-Ray has been a widely used, conventional modality to assess atypical pneumonia. This study aims at describing key imaging findings on Chest X-Ray of patients clinically suspected to have atypical pneumonia, in the setting of Covid-19 pandemic and categorized on HRCT as having abnormalities suspicious of COVID or typical of COVID (CO-RADS 4 and 5, respectively) and/or had their RT-PCR test for COVID determined positive (CO-RADS 6). The reason for choosing CO-RADS as a benchmark is to compare the effectiveness of

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Chest X-Ray with respect to High Resolution Computed Tomographic scan.
In our study, the 200 patients having mean age of 47 years, median of 45 years (65% males and 35% females) showed predominantly ground glass opacity (GGO) as sole finding in 129 patients (64.5%); GGO with consolidation in 45 patients (22.5%); GGO with reticulation in 15 patients (7.5%); GGO with consolidation and reticulation in 5 patients (2.5%); exhibiting no significant difference in pattern based on age and gender. The distribution of ground glass opacity or consolidation was predominantly in the lower and mid-peripheral lung zones. Pleural effusion, lymphadenopathy are uncommon and atypical findings.

Fig D.1: A Characteristic chest radiograph (PA-view) in a 53-year-old woman presenting with difficulty in breathing and fever. Chest radiographic findings are bilateral patchy and confluent, band like ground-glass and consolidative opacity in a peripheral, mid to lower lung zone distribution (red arrows)

Fig D.2: A chest radiograph (PA-view) in a 40-year-old woman presenting with cough, difficulty in breathing and fever. CXR findings are bilateral patchy and confluent, band like ground-glass and consolidative opacity predominantly in a peripheral, mid to lower lung zone distribution red arrows)

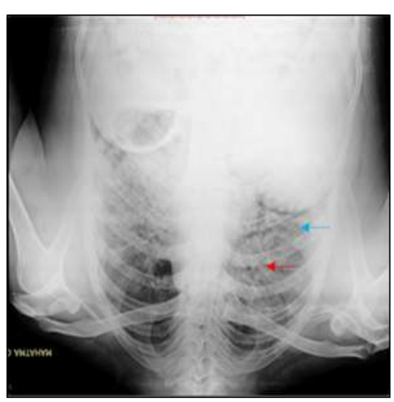

Fig D.3: Chest radiograph (PA-view) of a 29 yr. old male, who presented with cough, difficulty in breathing and fever, showing peripheral (blue arrow) as well as central (red arrows) ground glass opacity and consolidation

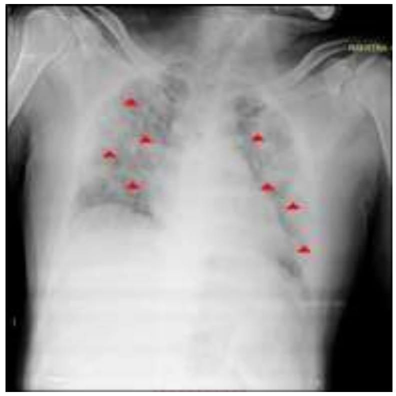

Fig D.4: Multiple, patchy, peripheral as well as central ground glass opacity and consolidation (red arrow heads) in a 35-year-old male patient in CXR-AP view

Fig D.5: CXR (PA-view): A 45 years' old male patient having subtle peripheral ground glass opacities (red arrows)

Fig D.6: CXR (PA-view): 50 years' old male patient with ground glass opacities and nodular reticulations (red arrow)

These findings are similar to those found by Smith *et al*. [23] who concluded that the presence of bilateral patchy and/or confluent, band like ground-glass opacity or consolidation in a peripheral and mid to lower lung zone distribution on a chest radiograph, in the setting of COVID-19 pandemic is highly suggestive of SARS-CoV-2 infection and can be used in conjunction with clinical judgment to make a diagnosis, especially when rapid and reliable serologic testing is unavailable.

A. Abougazia *et al*. [24] showed that GGO was the most common chest radiographic finding with peripheral lower zone and bilateral lung involvement. This study shows similar results. In our study, only two patients had minimal pleural effusion with no patients showing significant lymphadenopathy, which is also in

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agreement with the study conducted by A. Abougazia *et al.* [24].

Durrani M. *et al.* [25] suggested that COVID-19 chest radiographs usually show a spectrum of pure ground glass, mixed ground glass opacities to consolidation in bilateral, peripheral, middle and lower lung zones, which corroborates findings of this study.

Litmanovich *et al.* [26] proposed a four categories-based reporting language for COVID radiographic findings and described typical, indeterminate, atypical and 'negative for pneumonia' categories. The present study showed similar pattern of COVID radiographs as described by them, that is multifocal, bilateral, peripheral opacities remained typical of COVID pneumonia, predominant central distribution of opacities remained indeterminate for COVID pneumonia while pleural effusion, lymphadenopathy, solitary lung nodule or mass/mass like lesions remained atypical to unlikely and no lung opacities as negative for pneumonia.

Rousan*et al.* [16] and Santos JA *et al.* [27] found that the imaging findings in COVID are highly affected by timing of the image acquisition. Chest radiographs may remain essentially feature-less early in the course of disease (till ~3 to 5 days from the symptom onset) and may show consolidation pattern after 8 to 15 days, followed by reticulation and resolution pattern later in the disease course.

Not only the use of chest radiographs was to be evaluated for attempting to diagnose COVID patients early considering the aspect of 'isolation' but also their use in monitoring the disease was to be explored, since the latter application is rather more in line with conventional practice of following up patients of atypical pneumonia, even after advent of HRCT.

2. Assessment of severity of atypical pneumonia in included patients (having CO-RADS 4 or above on CT) by CXR in relation to CT.

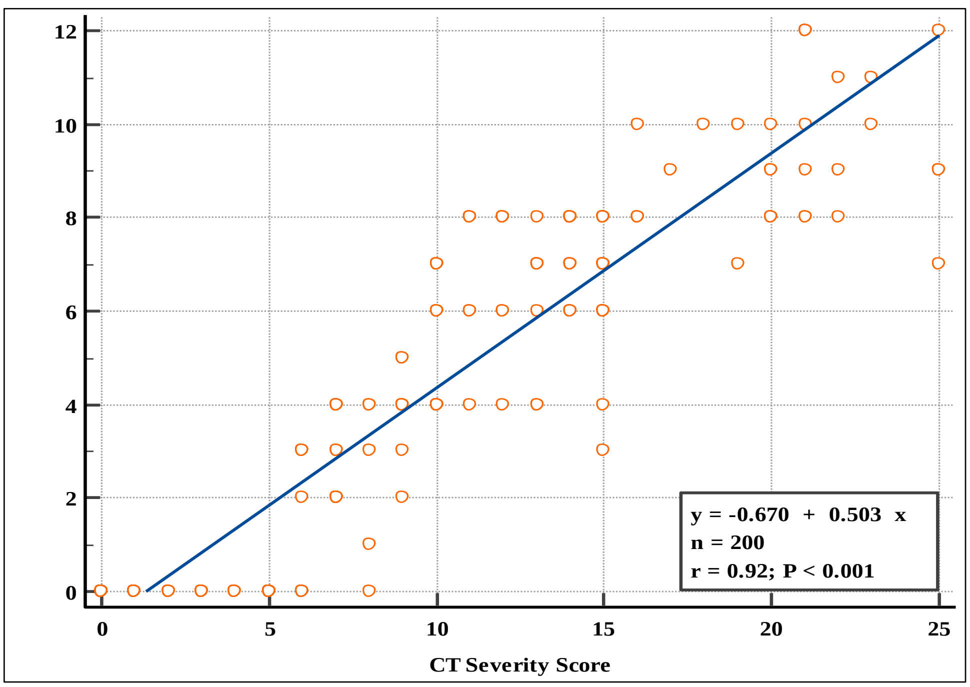

Fig 2.1: Scattered diagram showing correlation between CXR score with CT score

Scatter diagram

Dependent Y	CXR Score
Independent X	CT Severity Score
Sample size	200
Coefficient of determination R^2	0.8439

Regression Equation

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y = -0.6702 + 0.5034 x					
Parameter	**Coefficient**	**Std. Error**	**95% CI**	**t**	**P**
Intercept	-0.6702	0.1792	-1.0236 to -0.3168	-3.7399	0.0002
Slope	0.5034	0.01542	0.4729 to 0.5338	32.6397	<0.0001

Inter-rater agreement (kappa)-Between CXR score and CT score

Weighted Kappa[a]	0.27558
Standard error	0.02091
95% CI	0.23459 to 0.31658

(Cohen 1960; Cohen 1968; Fleiss *et al*., 2003).

Agreement is quantified by the Kappa (K) statistic:

- K is 1 when there is perfect agreement between the classification systems.
- K is 0 when there is no agreement better than chance.
- K is negative when agreement is worse than chance.

The *K* value can be interpreted as follows (Altman, 1991)

Value of *K*	Strength of agreement
< 0.20	Poor
0.21 - 0.40	Fair
0.41 - 0.60	Moderate
0.61 - 0.80	Good
0.81 - 1.00	Very good

Table 2.1: Correlation between CXR score severity with CT score severity as per grading

CXR score severity grade	Total [n=200]	CT score grading as per severity		
		Mild	Moderate	Severe
Mild [n=42]	21.00%	21 (50.0%)	21 (50.0%)	00
Moderate [n=68]	34.00%	00	58 (85.29%)	10 (14.71%)
Severe [n=19]	9.50%	00	00	19 (100%)
Total [n=129]	64.50%	21 (16.28%)	79 (61.64%)	29 (22.48%)

Quadratic weighted

Weighted Kappa	0.72772
Standard error	0.044760
95% CI	0.63999 to 0.81545

Linear weighted

Weighted Kappa	0.65083
Standard error	0.054974
95% CI	0.54308 to 0.75858

This study essentially benchmarked the severity of COVID assessed by HRCT scoring so as to provide evidence of effectiveness of chest x- rays in this regard. This approach was adopted to ensure that the ‘imaging tools’ can be compared ‘directly’ irrespective of RT-PCR or other molecular diagnostic aid, since the latter had unsatisfactory sensitivity, availability and evolving uncertainties due to the nature of mutations in the virus. Additionally, the aim was more to gauge severity thus triage and critical management rather than diagnosis and isolation only.

In this study, out of 67 (33.5%) patients, who were categorized as mild by HRCT scoring, 22 (11%) were characterized mild by CXR as well and 45 (22.5%) of these patients were characterized as having “No imaging finding” by the same. Out of 79 (39.5%) patients, declared as moderately affected by HRCT, 58 (29%) were

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characterized as moderate and 21(10.5%) as mild by CXR. 29 (14.5%) patients were characterized as “severe” by HRCT scoring, out of these 19 (9.5%) were also characterized as “severe” by CXR and 10 (5%) of them were characterized as “moderate” by the same. 25 (12.5%) of the included patients were identified as having “no imaging finding” by HRCT and all of these patients were also found not having any imaging finding by CXR as well. By analyzing the data using Cohen-kappa inter-rater agreement, the value of ‘k’ (k= kappa coefficient) came as 0.27558 (linear weights) for CXR score and CT score, which falls under “fair agreement” category. For the grading of severity, the Cohen’s kappa coefficient came as 0.72772 and 0.65083 on linear and quadratic weights respectively, effectively meaning “good” agreement between the two modalities. Here a point of note is that while calculating these values, since the goal was to find out agreement between two modalities with respect to “severity- grading”, therefore “no imaging finding” patients were excluded from this calculation. On adding these patients, the value of Cohen’s kappa coefficient came as 0.64843 on linear weights and 0.80299 on quadratic weights. Thus, on linear Cohen’s kappa their agreement remained “good”. Though the study was not designed to calculate the sensitivity of CXR as a diagnostic modality for COVID yet with respect to HRCT, the sensitivity from the acquired data came out to be 73.71%.

A. Abo-Hedibah S *et al*. [20] studied 195 patients, whose COVID-19 was confirmed by RT-PCR test and who underwent chest X-ray and computed tomography (CT) studies to assess parenchymal disease severity and found CXR based severity scoring was reliable to assess the severity of COVID-19 pulmonary parenchymal disease, especially in moderate and severe cases, with the tendency of overestimation of severe cases. While largely our study remained in agreement with their conclusion but showed that CXR underestimates the mild cases and overestimates the moderate cases to severe.

Borakati A. *et al*. [4] reviewed 1198 patients who attended the emergency department with paired reverse transcriptase PCR (RT-PCR) swabs for SARS-CoV-2 and CXR and found Sensitivity and specificity of CXR for COVID-19 diagnosis to be 0.56 (95% CI 0.51 to 0.60) and 0.60 (95% CI 0.54 to 0.65), respectively. For CT scans, these were 0.85 (95% CI 0.79 to 0.90) and 0.50 (95% CI 0.41 to 0.60), respectively. Suggesting significant mean increase in sensitivity with CT of 29% (95% CI 19% to 38%, $p<0.0001$) compared with CXR. Specificity was not significantly different between the two modalities. The present study indirectly corroborates their conclusion by showing fair to good consistency of CXR in assessing the severity of the COVID, yet it underestimates the disease severity thus failing to diagnose “mild” cases and sometimes underestimating severe cases as moderate, probably for its two-dimensional nature compounded with complex anatomy of the thorax.

While attempting to find out determinants of chest radiography sensitivity for COVID-19, in a retrospective multi-institutional study where 254 patients with reverse-transcription polymerase chain reaction-verified COVID-19, who underwent at least one chest radiography examination or chest CT, were compared with 254 age-and sex-matched controls who were confirmed negative for COVID-19, Stephanie *et al*. [28] concluded that normal or mild severity chest radiographs were the main determinants of false-negative chest radiograph interpretations, which conforms to the observation made in the present study about underestimation of COVID cases by CXR. The sensitivity of chest radiography in detecting COVID-19 increases with time and serial chest radiography.

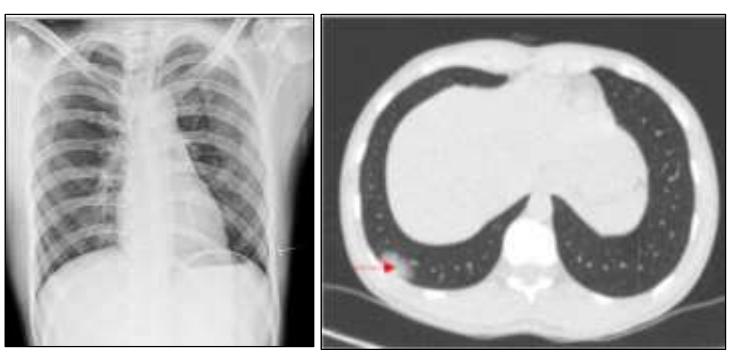

Fig D.7: A 23 yr. old, male patient, ~ 4 days of symptom onset, categorized as “no imaging finding-normal” by CXR (PA-view) and “mild” with a CT Severity score of 3/25: phenomenon of underestimation of “mild” cases by CXR and superior sensitivity of CT, specially early in the course of disease. One of the GGOs marked by red arrow

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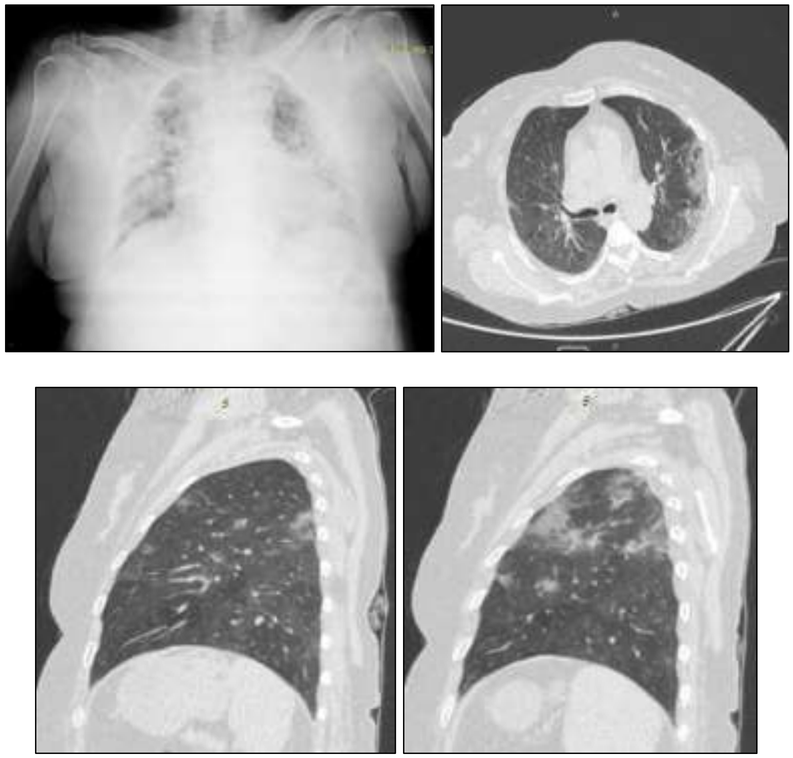

Fig D.8: A 60 years' old female, characterized as "moderate" on CXR (8/12); from HRCT- CT severity score (9/25)- characterized as "moderate"; images from top right- clockwise- CXR (PA view); axial, right and left sagittal HRCT

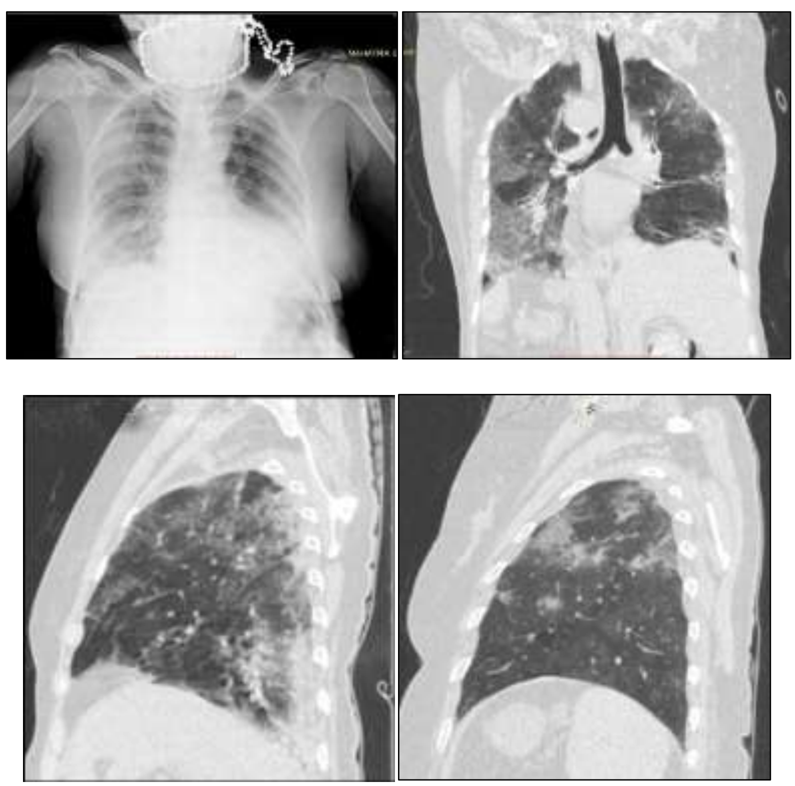

Fig D.9: 83 yr. old female, characterized as moderate on CXR as well as CT. CXR (AP-view); coronal, right sagittal and left sagittal HRCT (from top right then clockwise)

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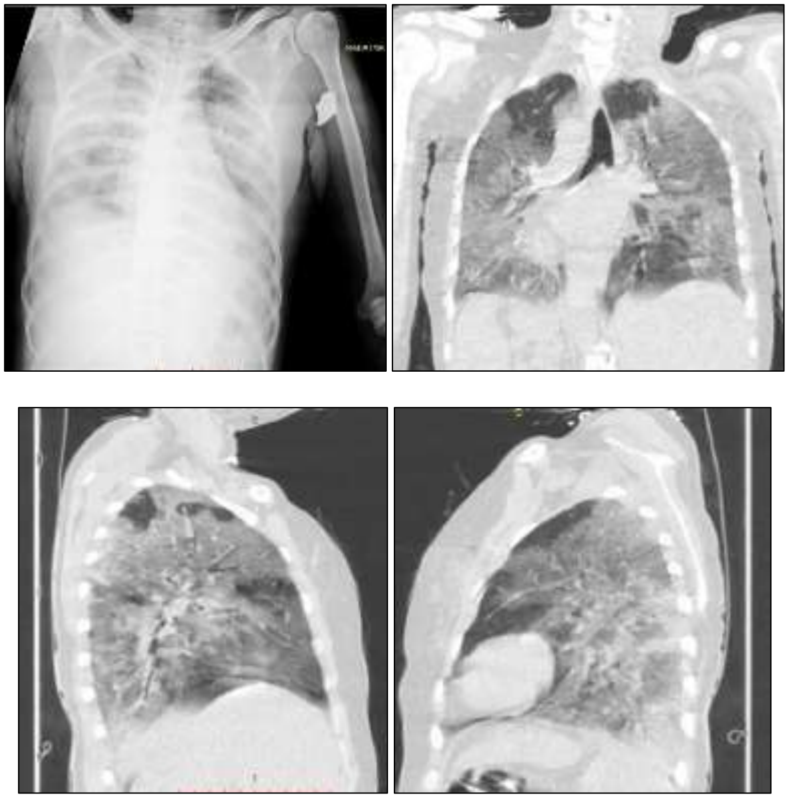

Fig D.10: 50 yr. old male, characterized as severe on CXR as well as CT. CXR (AP-view); coronal, right sagittal and left sagittal HRCT (from top right then clockwise)

Limitations

- The modified and simplified RALE (Radiographic Assessment of Lung Edema) scoring system utilized in this effort should help non-radiologists to assess and manage COVID-19 patients better. However, this scoring method is yet to be validated for use in the form and for the purpose implied in this study and has some inherent drawbacks of distributing equal value to the lung- zones, irrespective of ventilation-perfusion physiology.
- A larger cohort with control population and a molecular gold-standard incorporated could have provided with a study design capable of determining sensitivity, specificity of CXR to further elaborate its use in early diagnosis, isolation, triage, severity- assessment, follow up and other aspects of management of COVID-19.

Despite cursory efforts of excluding co-morbid cases, the data denoted significantly worse outcome in older population, which may indicate the need to design this study with age- group distribution taken into account to better ascertain the role of CXR in management of COVID-19.

Conclusion

- The typical chest x ray findings of COVID-19 are bilateral, patchy and confluent, band- like, ground-glass and consolidative opacities in a peripheral, mid to lower lung zone distribution. Pleural effusion, lymphadenopathy are uncommon and atypical findings.
- Chest X Ray cannot be used as a screening modality to consider 'isolation' in COVID-19 pandemic; however, its use is of eminence in the serial follow ups. The sensitivity of chest x ray increases with time since symptom onset in diagnosing COVID and it becomes more reliable for management in the later stages of the disease.
- COVID-19 severity at initial presentation is better assessed by HRCT nevertheless documenting initial chest x ray with an objective scoring helps manage the patient later, especially in critical care setting.

- The technique of CXR image- acquisition, including patient- positioning, post processing (windowing etc.) has overwhelming impact on analysis and individual observer's evaluation. The inter-observer differences remained mentionable. The formation of standardized protocols is imperative to optimally utilize the cost effective and versatile modality of chest x ray in managing atypical pneumonia such as COVID.

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Abbreviations

ACE-2: Angiotensin-Converting Enzyme-2.
AP: Antero-posterior.
ARDS: Acute Respiratory Distress Syndrome.
Bi.: Bilateral.
CNN: Convoluted Neural Network.
Con.: Consolidation.
CO-RADS: Coronavirus disease 2019 (COVID-19) Reporting And Data System.
COVID-19: CoronaVirus Disease of 2019.
CT Scan: Computed Tomography Scan.
CXR: Chest X- Ray.
F: Female.
GGO: Ground Glass Opacity.
HRCT: High Resolution Computed Tomography.
IEC: Institutional Ethics' Committee.
M: Male.
PA: Postero-anterior.
PCR: Polymerase Chain Reaction.
Pe.: Peripheral.
PET-CT: Positron Emission Tomography-Computed Tomography.
RALE: Radiographic Assessment of Lung Edema.
r-CXR: Reconstructed-Chest X-Ray.
Reti.: Reticulation.
RSNA: Radiological Society of North America.
RT-PCR: Reverse Transcriptase- Polymerase Chain Reaction.
SARS CoV-2: Severe Acute Respiratory Syndrome, Corona Virus 2.
USG: UltraSonoGraphy.