Indian Journal of
Applied Radiology

Open Science Publications

Volume 6, Issue 1 - 2020

www.opensciencepublications.com

Role of Chest Radiography for evaluation and Severity Scoring in COVID-19 Pneumonia

Research Article

Parate R[1], Tiwari S[1]*, Parate T[2] and Anand A[1]

[1]*Government Medical College and Hospital, Medical Square, India*

[2]*Indira Gandhi Government Medical College and Hospital, India*

***Corresponding author:** Tiwari S, MBBS, MD Radiodiagnosis(ongoing), Government Medical College and Hospital, Medical Square, Nagpur, Maharashtra, India- 440003, Mailing address- 2, Shastri Layout, Subhash Nagar, Jaitala Road, Nagpur-440022, India, Ph. No. 9096710110; E-mail- shreeya.13.tiwari@gmail.com

Article Information: **Submission: 22/10/2020; Accepted: 04/12/2020; Published: 07/12/2020**

Abstract

Objective: 1. Analysis of radiographic features of Covid-19 pneumonia upon initial presentation to the Emergency Department (ED).

2. Exploring the prognostic utility of chest radiograph by means of a semi-quantitative severity scoring system (modified RALE scoring) for patients with COVID-19 pneumonia.

Materials and methods: In this retrospective study, patients presenting to two tertiary care center EDs with COVID-19 confirmation on real-time Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) were identified. For these patients, the clinico-epidemiological data was recorded and chest radiograph was performed. Each patient's radiograph was divided into 6 zones and examined for opacities. Both lung scores were collated into a total concordant severity score (0 to 8). Correlation between clinical status and radiological severity was looked for.

Results: Of the 1000 patients who had a positive RT-PCR for COVID-19, 611were males (61.1%) and 389 females (38.9%), with a mean age of 45.54 years (range 8-96 years). 423 (42.3%) patients were asymptomatic and 433(43.3%) chest radiographs had no radiological thoracic involvement. In the radiologically positive group, commonly observed alterations included: 397 patients (69.7%) with alveolar opacities, 191(33.5%) with consolidation, 62(10.8%) with diffuse radio-opacities and 100(17.5%) with coexistent alveolar opacities and consolidations. Peripheral (41.1%) and bilateral (76.08%) distribution of opacities was most striking. Chi 2 test showed a significant correlation between modified RALE scores and patient's symptoms. Higher modified RALE score strongly correlated with symptomatic disease (Chi= 133.93, $p<0.001$).

Conclusion: Chest radiograph in COVID 19 pneumonia shows alveolar opacities or consolidation with peripheral and bilateral predominance. Modified RALE score can be used in the emergency setting as a semi-quantitative tool for prediction of clinical severity which is a direct indicator of disease outcome.

Keywords: COVID-19; Clinical features; Chest radiograph pattern; Modified RALE scoring

Abbreviations

COVID-19: Coronavirus Disease-19; SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2; RT-PCR: Reverse Transcriptase Polymerase Chain Reaction; RALE: Radiographic Assessment of Lung Edema; ED: Emergency Department; CT: Computed Tomography; COPD: Chronic Obstructive Pulmonary Disease; HMIS: Health Management Information System

Introduction

At the end of 2019, a novel virus SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) expanded globally from China with the first Indian cases dating back to January 2020 [1]. The disease outbreak in India paced up by the end of May 2020 with the total confirmed cases being 5,562,663 as on September 22, 2020 [2]. This new coronavirus causes a highly infectious disease, commonly called

ISSN: 2581-3919

Coronavirus Disease 19 (COVID-19): Lung infection presents with severe pneumonia to more Aggressive acute Respiratory Distress Syndrome (ARDS) [3,4]. Genetic sequencing of SARS-CoV-2 has enabled the use of Real-Time Reverse Transcription Polymerase Chain Reaction (RT-PCR) for detection of viral nucleic acid, and nowadays this is the diagnostic gold standard [3]. However, this serologic test has several limitations due to the high number of false-negatives and delayed results. Radiological evaluation of patients with clinical-epidemiological suspicion of COVID-19 is indispensable, especially in the Emergency Department (ED) while waiting for RT-PCR results, to have a rapid evaluation of thoracic involvement. The recent COVID-19 radiological literature focuses primarily on Computed Tomography (CT) which is more sensitive and specific than chest radiograph. In particular, in China, CT was used as a first-line diagnostic method for COVID-19 [5]. However, it must be remembered that performing CT scan has its setbacks during this pandemic, ranging from excessive radiation exposure especially to younger patients to the mandatory scanner disinfection procedures. Thus most Indian centers are employing chest radiograph as the first-line method producing faster results compared to those of RT-PCR, especially by using portable X-ray units which reduce the movement of patients and minimize the risk of cross-infection [6-8]. Thus, the purpose of our study is to describe the main radiographic findings in a selected cohort of patients and to correlate the radiological severity with patient's clinical state which is directly related to patient hospitalization or discharge.

Materials and Methods

Ethics

The study was approved by the review board of the institutions and requirement for informed consent was waived since the study had no risk and would not adversely affect the subjects' rights or welfare. Patient selection for this study was consecutive, and no exclusion criteria were applied.

Selection and description of participants

Chest radiographs of patients with clinico-epidemiological suspect of COVID-19 infection performed at the ED of two tertiary care centers in central India from May 30 to August 30, 2020, were retrospectively reviewed. RT-PCR nasopharyngeal-throat swab and chest radiographs were performed immediately at the ED access and clinical-epidemiological data was recorded for COVID-19 infection (fever, cough, dyspnea, respiratory impairment, diarrhea, myalgia and dysgeusia). RT-PCR results were considered the reference standard. For radiological assessment, we selected only patients with RT-PCR-positive results. The outcome was expressed in terms of the correlation between radiological severity and disease symptomatology.

Technical information

All chest radiographs were acquired as digital radiographs with the portable X-ray unit (Allengers and Samsung, Korea) in the isolation wards in the postero-anterior or antero-posterior projection. All images were stored in a data portal, HMIS (Health Management Information System) [9]. A retrospective review of each radiograph was performed to define the predominant pattern of COVID-19 pneumonia presentation in patients with a positive RT-PCR. Radiographic features including consolidation, alveolar opacities, pulmonary nodules and diffuse radio-opacities were diagnosed according to the Fleischer Society glossary of terms [10]. Moreover, chest radiographs were assessed for the presence of a specific distribution of the disease (mostly peripheral or perihilar predominance), monolateral (right or left lung) or bilateral disease or diffuse predominance. All thoracic images were also assessed for evidence of other associated pulmonary pathology (pleural effusion, pneumothorax).

Radiograph scoring

Radiographic Assessment of Lung Edema score (RALE score) was initially proposed by Warren et al. The radiograph was divided into four quadrants. Each quadrant was assigned a consolidation score (0 to 4) to quantify the extent of alveolar opacities and a density score (1 to 3) for more quantitative assessment of the density of opacification by quadrant. The final RALE score was the product of the consolidation and density score for each quadrant ranging from 0 (no infiltrates) to 48 (dense consolidation in >75% of each quadrant) [11].

In our study, a simplified and modified RALE score of 0-4 was assigned to each lung depending on the extent of involvement by consolidation or alveolar opacities (0, no involvement; 1, <25% involvement; 2, 25%-50% involvement; 3, 50%-75% involvement; 4, >75% involvement; Figure 1).The scores for each lung were summed to produce the final severity score from 0 to 8 [12].

Statistics

Collected data was entered into Microsoft excel software and coded. Charts and tables were prepared using Microsoft word and excel software. Descriptive data was presented in frequency and percentage.

The correlation between modified RALE score and presence of symptomatic disease was performed by Chi2 test. P value < 0.05 was considered as statistically significant and statistical software STATA version 14.2 was used for data analysis.

Figure 1: Chest radiography scoring system. A modified RALE score of 0–4 was assigned to each lung depending on the extent of involvement by consolidation or alveolar opacities (0, no involvement; 1, <25%; 2, 25%–50%; 3, 50%-75%; and 4, >75% involvement). The scores for each lung were summed to produce the final severity score. Modified RALE score = 4 (2+2) (the calculation right lung score + left lung score = total score was used). Arrowheads indicate areas of consolidation or alveolar opacities.

Citation: Parate R, Tiwari S, Parate T, Anand A. Role of Chest Radiography for evaluation and Severity Scoring in COVID-19 Pneumonia. Indian J Appl Radiol. 2020;6(1): 155.

Results

Demographic and clinical data of entire cohort

1000 patients admitted to Central India's two tertiary care centers having confirmed COVID-19 pneumonia were retrospectively enrolled in our study from 30 May to 30 August 2020. The demographic and clinical characteristics of patients are summarized in Table 1. In our cohort, the mean age was 45.54 years (range 8 to 96). There was male predominance (61.10% men and 38.9 % women). History of contact with positive patient could be traced in 50% patients. 42.3% patients in our cohort were clinically asymptomatic. Amongst the symptomatic group, the most common symptoms at onset were fever, cough and dyspnoea seen in 370, 308 and 283 patients respectively. Other less common symptoms included sore throat (3.3%), chest discomfort (1.5%), diarrhea (1.2%), haemoptysis (1%) and miscellaneous manifestations (10.9%). The most common comorbidity seen amongst patients was hypertension (23.2%) followed by diabetes mellitus (16.2%), chronic renal disease (2.3%), COPD (1.4%) and chronic liver disease (0.9%).

Radiographic features

433 patients (43.3%) had no demonstrable radiographic thoracic abnormality. Figure 2 depicts the distribution of chest x-ray abnormality in symptomatic and asymptomatic patients. Of the total asymptomatic patients, 289 (68.32%) showed radiographic abnormality. This stratum of patients, which otherwise would have been sent home, could be directed for hospitalization due to the information extracted by a radiograph. In remaining 134 (31.67%) asymptomatic patients the chest radiograph was normal. 142 (24.8%) symptomatic patients had no overt radiographic findings and so CT examination was suggested to uncover the parenchymal changes, if any.

Table 1: Demographic and clinical characteristics of study population.

Characteristic	SARS-CoV-2+ patients	% of total patients
Sex		
Male	611	61.1
Female	389	38.9
Age Range		
0-20	68	6.8
21-40	344	34.4
41-60	372	37.2
61-80	202	20.2
>80	14	1.4
Asymptomatic	**423**	**42.3**
Symptomatic	**577**	**57.7**
History of contact	**500**	**50**
Symptoms		
Fever	370	37
Cough	308	30.8
Dyspnoea	283	28.3
Sore throat	33	3.3
Chest discomfort	15	1.5
Diarrhoea	12	1.2
Haemoptysis	1	0.1
Others	109	10.9
Comorbidities		
Hypertension	232	23.2
Diabetes Mellitus	162	16.2
Chronic Renal Disease	23	2.3
COPD	14	1.4
Chronic liver disease	9	0.9

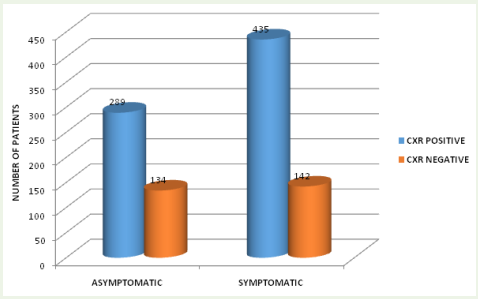

Figure 2: Radiographic findings in asymptomatic and symptomatic COVID-19 pneumonia.

Amongst the radiologically positive group, the typical pattern of radiographic imaging features from our cohort comprised bilateral (76.08%) and peripheral (41.12%) alveolar opacities (69.77%). The following alterations were more commonly observed (Figure 3): 397 patients with alveolar opacities (69.77%), 191 (33.57%) with consolidation and 100(17.57%) patients with consolidations and alveolar opacities coexistent in the same radiograph. We also found nonspecific signs for COVID-19 pneumonia as pleural effusion (4.74%), nodules (3.16%) and pneumothorax (0.17%). Unilateral disease showed left lung involvement (87 patients, 8.7%) more

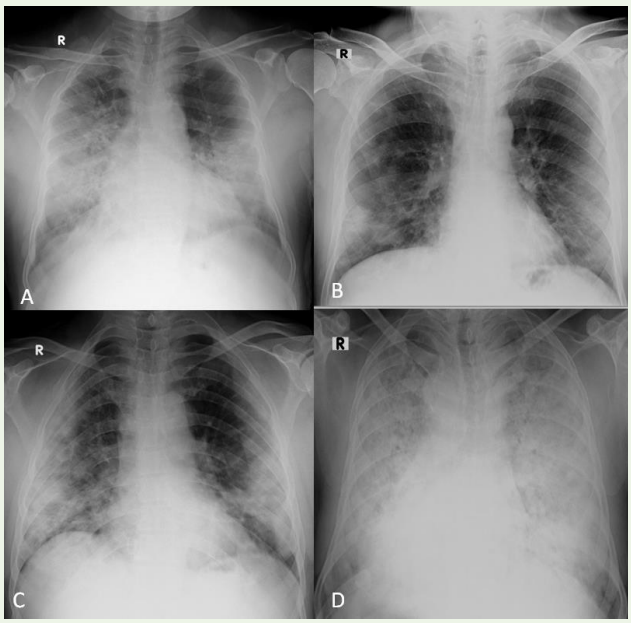

Figure 3: Radiographic patterns in SARS-CoV 2 pneumonia. (A) Alveolar opacities in bilateral mid-zones and right upper zone. (B) Consolidation with alveolar opacities in bilateral lower zones. (C) Patchy consolidation in bilateral lower and mid-zones. (D) Diffuse radio-opacities in bilateral lung fields with dextrocardia.

Citation: Parate R, Tiwari S, Parate T, Anand A. Role of Chest Radiography for evaluation and Severity Scoring in COVID-19 Pneumonia. Indian J Appl Radiol. 2020;6(1): 155.

frequently in our study as compared to the right lung (47 patients; 4.7%). 2 zone involvement (206 patients, 20.6%) was most commonly observed followed by four zone involvement(154 patients, 15.4%). Other radiographic features are described in (Table 2 and 3).

Modified RALE scoring

Inferences from modified RALE scoring using Chi 2 test revealed a score of 0-2 in majority of patients (720, 72.0%). Of these, 389(54.03%) were asymptomatic and 331(45.97%) were symptomatic. 223 of 262(85.11%) patients with a modified RALE score of 3-6 had clinical manifestations of disease. As the RALE score increases, there occurs more evident discrimination between symptomatic and asymptomatic groups. Higher modified RALE score of 6-8 was observed in 18 patients all of whom had symptomatic disease at presentation and required hospital admission for further management (Figure 4).

Table 2: Imaging characteristics of SARS-CoV 2 pneumonia on chest radiograph.

Chest X-RAY features	No.of patients	% of patients	% of radiologically positive patients
Main pattern			
Alveolar opacity	397	39.7	69.77
Consolidation	191	19.1	33.57
Alveolar opacity + consolidation	100	10	17.57
Diffuse GGO	62	6.2	10.89
Related features			
Pleural effusion	27	2.7	4.74
Nodules	18	1.8	3.16
Pneumothorax	1	0.1	0.17
Subcutaneous emphysema	1	0.1	0.17
Others	14	1.4	2.46

Table 3: Geographical distribution of Chest X-RAY changes and RALE Scores in SARS-CoV-2+ patients.

Categories	No.of patients	% of patients	% of radiologically positive patients
Frequency of lung involvement			
Unilateral	134	13.4	23.63
Left lung	87	8.7	15.34
Right lung	47	4.7	8.28
Bilateral	433	43.3	76.3
No of zones affected			
0	433	43.3	-
1	83	8.3	14.63
2	206	20.6	36.33
3	56	5.6	9.87
4	154	15.4	27.16
5	18	1.8	3.17
6	50	5	8.81
Distribution			
Peripheral	234	23.4	41.26
Perihilar	20	2	3.52
Both	226	22.6	39.85
RALE score			
0-2	720	72	
4-Mar	194	19.4	
6-May	68	6.8	
8-Jul	18	1.8	

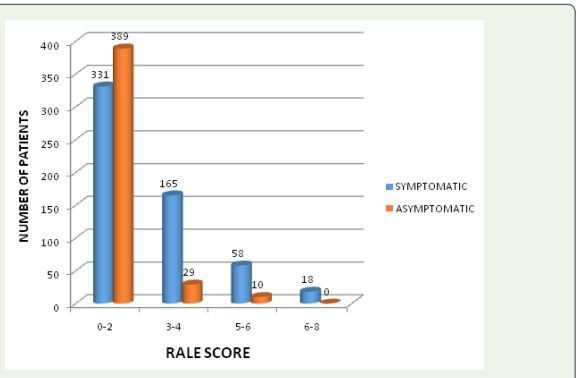

Figure 4: Correlation of RALE score with COVID-19 symptomatolgy.

Discussion

The worth of imaging tests relates to the generation of results that are clinically workable either for establishing a diagnosis or for guiding management, triage, or therapy. That value is diminished by costs that include the risk of radiation exposure to the patient, risk of COVID-19 transmission to uninfected health care workers and other patients, consumption of PPEs, and need for cleaning and downtime of radiology rooms in resource-constrained environments [13]. Chest radiography is widely utilized as a screening tool for detecting COVID 19 infection. However its prognostic utility has not been validated in patients with COVID-19. The profitability of RALE scoring to aid in clinical management has been demonstrated by other several studies conducted by Cozzi D et al. Fabio Ciceri et al. Terrance C. et al etc. [14-16]. It is thus recommended to expand the use of radiographs beyond its present applications, especially in resource-limited regions.

It is operationally more complex to perform CT scans, especially considering the disinfection procedures that come into play after each examination. For this reason, portable X-ray machine is very useful and inexpensive. Radiographs can be taken at the patient's bedside minimizing the risk of cross-infection.

CT must be reserved for additional specific situations: in case of clinical-radiological discordance, in case of clinical deterioration and cases of acute complications (i.e. severe respiratory failure or pulmonary embolism). CT has a high sensitivity (around 97-98%) but it has a very low specificity in detecting typical features of SARS-CoV-2 pneumonia [13,17,18].

The study has several limitations: The study is retrospective with lack of a non-COVID-19 control group limiting evaluation of sensitivity and specificity of chest radiography. The intervals between serial chest radiographs and RT-PCR testing were dictated by clinical need and hence were not uniform. Radiologist's experience in evaluation of radiographs over HRCT holds an important count and could be a subject to bias. Follow up evaluation was not done truncating the correlation with the disease course.

Citation: Parate R, Tiwari S, Parate T, Anand A. Role of Chest Radiography for evaluation and Severity Scoring in COVID-19 Pneumonia. Indian J Appl Radiol. 2020;6(1): 155.

Further research can be directed in this field to effectively overcome the above drawbacks and more robust guidelines can be formulated for radiograph based scoring.

Conclusion

In summary, we have described the features of coronavirus disease 2019 (COVID-19) on chest radiographs and proposed a severity scoring for rapid triage of patients to aid in appropriate management. As the COVID-19 pandemic threatens to overwhelm health care systems worldwide, highlighting the usefulness of a simple radiograph as a tool for identifying and stratifying cases ofCOVID-19 is justified. Determination of radiological severity can aid in effective patient categorization and enforcement of appropriate clinical management.

References

1. Zhu N, Zhang D, Wang W, Li X, Yang B, et al. (2020) A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med, 382: 727-733.
2. WHO (2020) Situation report-109 Coronavirus disease 2019 (COVID-19).
3. Wang C, Horby PW, Hayden FG, Gao GF (2020) A novel coronavirus outbreak of global health concern. Lancet 395: 470-473.
4. Chen N, Zhou M, Dong X, Qu J, Gong F, et al. (2020) Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet 395: 507-513.
5. Yang W, Sirajuddin A, Zhang X, Liu G, Teng Z, et al. (2020) The role of imaging in 2019 novel coronavirus pneumonia (COVID-19). Eur Radiol 1-9.
6. Giovagnoni A (2020) Facing the COVID-19 emergency: we can and we do. Radiol Med 125: 337-338.
7. Neri E, Miele V, Coppola F, Grassi R (2020) Use of CT and artificial intelligence in suspected or COVID-19 positive patients Statement of the Italian Society of Medical and Interventional Radiology. Radiol Med 125: 505-508.
8. (2020) ACR recommendations for the use of chest radiography and computed tomography (CT) for suspected COVID-19 infection. American College of Radiology.
9. (2020) Health Management Information System.
10. Hansell DM, Bankier AA, MacMahon H, McLoud T, Muller Normal, et al. (2020) Fleischner Society: glossary of terms for thoracic imaging. Radiology 246: 697-722.
11. Warren M, Zhao Z, Koyama T, BastaracheJ, Shaver C, et al. (2018) Severity scoring of lung oedema on the chest radiograph is associated with clinical outcomes in ARDS. Thorax 73: 840-846.
12. Wong H, Lam H, Fong A, Leung S, Chin T, et al. (2020) Frequency and Distribution of Chest Radiographic Findings in Patients Positive for COVID-19. Radiology 296: E72-E78.
13. Choi H, Qi X, Yoon SH, Park S, Lee K, et al. (2020) Extension of coronavirus disease 2019 (CVID-19) on chest CT and implications for chest radiograph interpretation. Radiology: Cardiothoracic Imaging 2: 1-8.
14. Cozzi D, Albanesi M, Cavigli E, Moroni C, Bindi A, et al. (2020) Chest X-ray in new coronavirus disease 2019 (COVID-19) infection: findings and correlation with clinical outcome. Radiol Med 125: 730-737.
15. Ceceri F, Castagna A, Querini P, Cobelli F, Ruggeri A, et al. (2020) Early predictors of clinical outcomes of COVID-19 outbreak in Milan, Italy. Clin Immunol 217: 108509.
16. Hui T, Khoo H, Young B, Mohideen S, Lee Y, et al. (2020) Clinical utility of chest radiography for severe COVID-19. Quant Imaging Med Surg 10: 1540-1550.
17. Ai T, Yang Z, Hou HY, Zhan C, Chen C, et al. (2020) Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a repost of 1014 cases. Radiology 296: E332-E40.
18. Fang Y, Zhang HQ, Xie J, Lin M, Ying L, et al. (2020) Sensitivity of chest CT for COVID-19: comparison to RT-PCR. Radiology 296: E115-E117.

Citation: Parate R, Tiwari S, Parate T, Anand A. Role of Chest Radiography for evaluation and Severity Scoring in COVID-19 Pneumonia. Indian J Appl Radiol. 2020;6(1): 155.