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Original Research Article

Retrospective epidemiological surveillance of COVID-19 patients in the Department of Radiodiagnosis in M. G. M. Medical College and Associated Hospitals: an audit

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ABSTRACT

Background: Epidemiological surveillance is the cornerstone for the prevention and control of any pandemic. The purpose of the study was using clinical and radiological data of COVID-19 positive patients to describe the clinical features, risk factors, grading of severity on the basis of chest X-ray and their survival outcome.
Methods: A retrospective observational study comprising 9100 COVID-19 positive patients was done in the Department of Radiodiagnosis, M.G.M. Medical College and M.Y. Hospital, Indore. Patients' data including demography, clinical findings, vaccination status and imaging findings was collected and assessed in between March 2020 and March 2022. In the descriptive statistical analysis, continuous variables were noted in terms of the mean and standard deviation and nominal variables were noted in terms of percentage.
Results: In our study, there were 9100 patients proven with positive COVID-19 disease had abnormal CXRs were detected in 7553 of 9100 patients (83%). In our study, B/L lung involvement (69%) was found to be more with lower lung zone predominance (86.5%) and peripheral predominance opacities (83.7%). The most common finding of chest X-ray pattern is consolidation (65.7%), followed by ground glass opacity (29.0%). Most of the vaccinated patients were found to be in mild category and majority of mild cases didn't require oxygen support. The chi-square statistic is 79.3372. The result is significant at $p<0.05$
Conclusions: The chest x-ray severity scoring (CXR-SS) system used in this study is a valuable method of disease prognostication in COVID-19. In our study, we found a significant reverse relationship between chest X-ray severity score and oxygen saturation, which has great clinical importance.

Keywords: COVID-19, Chest X-ray, Corona virus infection, Severity score, CXR-SS

INTRODUCTION

At the end of 2019, a novel virus, named SARS-CoV-2 (Severe acute respiratory syndrome corona virus 2), expanded globally from China, with the first Italian cases dating back to February 2020.[1] Since then, there have been numerous cases outside of China, as evidenced by a declaration of a "public health emergency of international concern" by the world health organization (WHO) on 30, 2020.[2] Since the onset of the pandemic in 2020, the world has seen millions of people succumb to death due to COVID-19 and related complications.[3]

The complications of COVID-19 overwhelmed healthcare facilities worldwide. The cornerstone of any prevention and control measures is the epidemiological surveillance. Surveillance is "the ongoing systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event in order to take action". Surveillance is a critical part of public health practice.

Real-time analyses of epidemiological data are urgently required for increasing the awareness about the problem and for prompt interventions. Identification of the newly suspected or confirmed COVID-19 cases is an essential element for effective public health interventions and for the prevention of future pandemics.[4]

The key to good surveillance and prognosis for COVID-19 cases lies in early diagnosis and appropriate management. Early identification of disease is possible with the identification of associated clinical and radiological features in the setting of predisposing factors.[5] The study of clinical characteristics, imaging findings, associated risk factors, and clinical outcomes helps in a better understanding of the disease pathology. In our tertiary care hospital, we conducted one of the largest retrospective surveillance studies using clinical and radiological data of COVID-19 positive patients to describe the clinical features, risk factors, grading of severity on the basis of chest X-ray and their survival outcome. The study also aimed to describe the chest X-ray findings of COVID-19 and stage the patients on the basis of imaging findings and correlate the disease severity with the clinical risk factors, co-morbid conditions, vaccination status, and survival outcome.

METHODS

A retrospective observational study comprising of 9100 COVID-19 positive patients was conducted after approval from the institutional ethics and scientific review committee of M.Y. Hospital, Indore. Patients' data, including demography, clinical findings, vaccination status, and imaging findings, were collected from the medical record department of all the M.G.M.M.C. associated hospitals and those who presented to our tertiary care institution between March 2020 and March 2022 were assessed and analysed.

Inclusion criteria

Fever (≥37.0 °C) and /or respiratory symptoms (e.g., cough, sputum production, hemoptysis, shortness of breath, wheezing, and chest pain, etc.), known COVID-19 positive patients were included in the study.

Exclusion criteria

Pregnant females and COVID-19 negative patients were excluded from the study.

The stated comorbidities, presenting complaints, clinical examination findings, laboratory parameters, past history, and survival outcomes were thoroughly studied, compiled, tabulated, and analyzed.

Radiological examination was performed using digital portable x-ray machine or fixed digital X-ray system. Imaging data was acquired through the hospital's picture archiving and communication system (PACS). Images were analysed at the workstation and reports were prepared using a dedicated format for chest X-ray reporting. Patients were segregated on the basis of the radiological staging of the disease. The chest X-ray will be evaluated for the pattern of lung involvement, the zone of lung involvement and will be graded upon the severity of lung involvement according to the following modified chest X-ray severity grading score criteria. The pulmonary parenchymal involvement was assessed using a semiquantitative severity score, subdividing each lung into three zones (Figure 1): the upper zone (from the lung apex to the aortic arch profile), middle zone (from the aortic arch profile to the lower margin of the left pulmonary hilum), and the lower zone (from the lower margin of the left pulmonary hilum to the diaphragm). For each zone, a score on a scale from zero to three in 1-point increments was assigned: 0, normal lung parenchyma; 1, only interstitial involvement; 2, radiopacity for less than 50% of visible lung parenchyma; 3, radiopacity for 50% or more of visible lung parenchyma.[6] A total score is calculated by adding the scores of each lung zone and assigned to one of the following categories: mild (from 0 to 6), moderate (from 7 to 12), and severe (from 13 to 18) (Figure 1).

Figure 1: CXR subdivision, with three parts for each lung: superior zone (from the lung apex to the aortic arch profile), middle zone (lung hilum, from the aortic arch profile to the inferior margin of the left pulmonary hilum), and inferior zone (from the inferior margin of the left pulmonary hilum to the diaphragm.

All clinical and radiological imaging data were tabulated and comparisons were done using IBM Statistical Package for the Social Sciences (SPSS) software for Windows, Version 26.0. Armonk, NY: IBM Corp. The mean and standard deviation of the quantitative variables were calculated. A chi-square test was used for the comparison of categorical variables. One-way ANOVA was used to find association between patients' clinical parameters and the radiological stage of the disease. P values less than 0.05 considered statistically significant.

RESULTS

Patients that had a RT-PCR positive for COVID-19 infection were 9100 in total: 5457 males (59.96%) and 3643 females (40.03%), with a mean age of 50.67 years. Most of the cases in this study were found to be in the 40-60-year age group (40.1%), followed by the 60-80 year age group (28.1%). The most common clinical symptoms were fever (7462, 82%), cough (6991, 76.8%), lethargy (6321, 69.4%), and shortness of breath (4844, 53.2%).

Table 1: Demographic presentations of the patients.

Characteristics	No. of patients (%)
Total patients	9100
Age (years)	50.67±11
Age bracket, N (%)	
<18	218 (2.3)
18-40	2311 (25.3)
40-60	3653 (40.1)
60-80	2566 (28.1)
>80	352 (3.8)
Gender	
Male	5457 (59.96)
Female	3643 (40.03)

In this study, we analysed the CXR findings and severity scores of patients proven to have COVID-19 in different stages of disease. CXRs abnormalities were detected in 7553 of 9100 patients (83%) at certain points of the disease course. The total severity score was estimated in the baseline and follow-up CXR and it ranged from 0-18. Mild findings with a total severity score ranging between 0 and 6 found in 3786 patients (41.6%) and moderate severity scores ranging between 7 and 12 were found in 3241 patients (35.6%), while severe cases with a severity score ranging between 13 and 18 found in 2073 patients (22.7%). Mild CXR-SS affected the most people between the ages of 18 and 40 (2049, 22.5%), while moderate and severe CXR-SS affected people between ages of 40 and 60 (Moderate: 1907, 20.9% and severe: 1061, 11.6%).

In our study, B/L lung involvement (6279, 69%) was found to be more than U/L lung involvement (2821, 31%), with lower lung zone predominance (7873, 86.5%). On the evaluation of chest X-ray pattern, the most common finding encountered is consolidation (5982, 65.7%), followed by ground glass opacity (2647, 29.0%), followed by nodular pattern (209, 2.3%) and pleural effusion (262, 2.8%). In most of the cases, we found peripheral opacities (7620, 83.7%) more commonly than a combination of both peripheral and central (1173, 12.8%) or central opacity (307, 3.3%).

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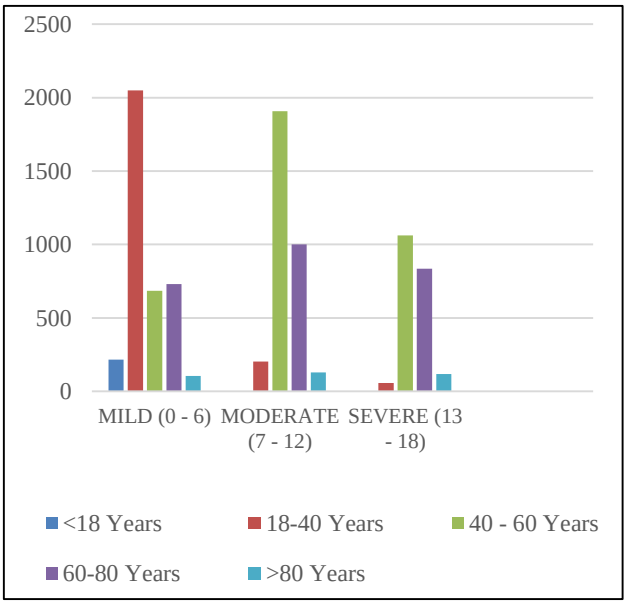

Figure 2: CXR severity score and grading.

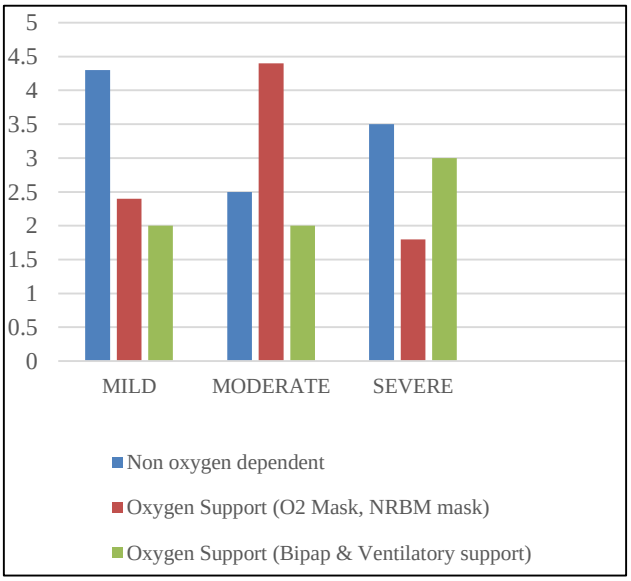

Figure 3: Disease severity with oxygen requirement.

The majority of mild category patients did not require O_2 support (Mild-2942, 32.3%), whereas the majority of moderate and severe category patients required O_2 support on O_2 mask, NRBM mask (Moderate-2348, 25.8%) and ventilator support (Severe-2011, 22%), respectively. Arterial hypertension represented the most common comorbidity (1906, 20.94%), followed by diabetes mellitus (1639, 18.01%).

Table 2: Table representing vaccination status, severity of disease and survival outcome.

Patient severity	Vaccinated (%)	Unvaccinated (%)
Mild	2110 (23.1)	1676 (18.4)
Moderate	411 (4.5)	2830 (31)
Severe	79 (0.8)	1994 (21.9)
Total	2600 (28)	6500 (72)

Table 3: Table representing comparison of survival outcome in vaccinated and unvaccinated patients.

Variables	Discharge	Death	Row totals
Vaccinated	2558 (2476.29) [2.70]	42 (123.71) [53.97]	2600
Un-vaccinated	6109 (6190.71) [1.08]	391 (309.29) [21.59]	6500
Column totals	8667	433	9100 (Grand total)

The chi-square statistic is 79.3372. The p<0.00001. The result is significant at p<0.05.

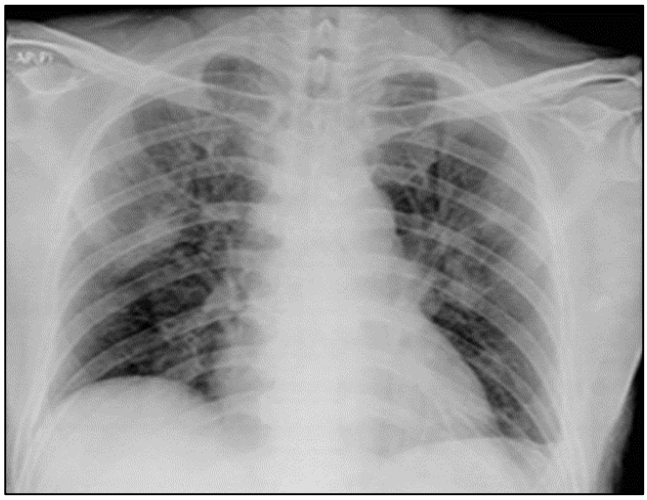

Figure 4: Case 1.
A 41-yeasr old, vaccinated male COVID-19 positive patient with history of fever, cough and lethargy having chest X-ray severity score - 4 (0 1 1 0 1 1) lies in mild category.

In our study, out of 9100, 2600 patients were vaccinated (28%), and 6500 were nonvaccinated (72%). The majority of the vaccinated patients fell under the mild category (2110, 23.1%) and the nonvaccinated patients fell under the moderate (2830, 31.01%) to severe (1994, 21.9%) category. Out of 2600 vaccinated patients, 2558 (98.38%) patients were discharged and 42 (1.61%) patients were deceased; and out of 6500 unvaccinated patients, 6109 (93.98%) patients were discharged and 391 (6.01%) patients were deceased (chi-square statistics-79.33, p<0.00001). In our study of 9100 patients, out of 3786 mild cases, 3765 patients (41.3%) were discharged, and 21 patients (0.23%) were deceased. Out of 3241 moderate cases, 3185 patients (35%) were discharged and 56 patients (0.61%) were deceased.

Out of 2073 severe cases, 1719 (18.89%) were discharged, while 356 (3.91%) died (Chi-square statistics 917.3262, p<0.0001). So, in total, 8667 patients (95.3%) were discharged, and 433 patients (4.7%) were deceased.

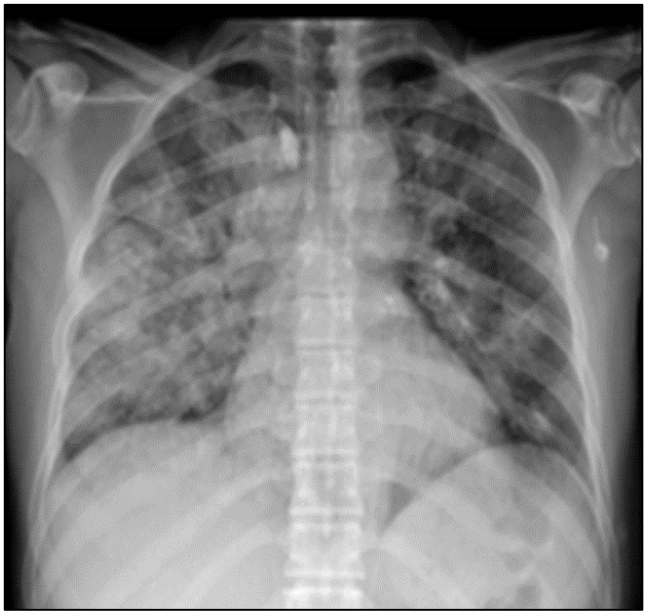

Figure 5: Case 2.
A 82 year old, unvaccinated male COVID-19 positive patient with history of breathlessness, fever, cough having chest X-ray severity score - 11 (2 3 3 1 1 1) lies in moderate category.

DISCUSSION

COVID-19 is a highly infectious disease that has been spread widely throughout the world. The disease management strategies primarily depend upon the early disease diagnosis.[7] Early prognostication of disease has been a prevailing challenge in the ongoing COVID-19 pandemic, especially in developing countries where healthcare resources are limited. Previously published data from China and the developed world has highlighted the potential role of imaging in the early identification and prognostication of COVID-19.[8-10] An accurate radiological approach is necessary for a more rapid classification of COVID-19 patients. CXR may not be as sensitive as CT, but it still plays a major role in developing countries that lack more sophisticated modalities. Moreover, CXR can be done on the patient's bedside, minimizing the risk of cross-infections.[11]

In our study, the most common age group involved was 40-60 years old, with a mean age of 50.67 years and with male predominance. The study by Fogante et al revealed there was a male predominance of positive COVID-19 cases in all three groups, without a significant difference between groups in gender distribution.[12]

In our study, fever and cough were the most common primary complaints. The study by Lee et al regarding symptoms, stated that 698 patients (92%) had at least one of the following: fever, cough, sputum, dyspnea, myalgia, sore throat, sensory loss, nausea, or vomiting. The remaining 63 patients (8%) were asymptomatic.[13]

In most cases (3786 patients, 41.6%), the chest X-ray severity score was mild, ranging between 0 and 6 followed by 3241 patients (35.6%) having a moderate severity score ranging between 7 and 12. Severe cases with a severity score of ranged between 13 and 18 were found in 2073 patients (22.7%).

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.[14]

Yasin et al found in their study that 65.7% had mild findings with total severity score of 0-2, while moderate and severe cases with more extensive lung involvement was seen in 23.4% and 10.9% patients, who had severity scores of 3-5 and 6-8, respectively.[7]

In our study, most of the patients showed bilateral lung affection (6279 patients, 69%) with lower zonal predominance (7873, 86.5%) and peripheral distribution (7620 patients, 83.7%). The most common CXRs features detected in COVID-19 cases were consolidation, seen in 5982 patients (65.7%), followed by GGO seen in 2647 patients (29.0%). Some of the cases showed pulmonary nodules seen in 209 patients (2.3%) and pleural effusion seen in 262 patients (2.8%).

This is in agreement with Wong et al who did a study on 64 COVID-19 patients, they found that peripheral predominance was seen in 41% of CXR abnormalities with lower zone distribution (50%) with bilateral lung involvement (50%). Also, Consolidation was the most common finding (47%), followed by GGO (33%). Pleural effusion was uncommon, only seen in 3%.[8]

Also, Lomoro et al performed a study on thirty-two patients of COVID-19 disease; they found that consolidation is the most common finding (46.9%) with bilateral lung affection in (78.1%) and lower zone involvement (52%). No pleural effusion was identified.[17]

Out of the 9100 patients, 2942 patients (32.3%) did not require any oxygen support were mostly belonged to the mild category, 2348 patients (25.8%) required oxygen support in the form of oxygen mask and NRBM mask mostly belonged to moderate category and remaining 2011 patients (22%) required oxygen support in the form of BIPAP and ventilator support and were mostly from the severe category. As expected, and found in our data, oxygen requirements increase with the increase in chest severity score showing non-linear correlation.

This is in concordance with Saeed et al study stated that the progressive increase in oxygen requirement can be due to the direct damage of the lung by the virus causing inflammatory changes in alveolar wall that limit oxygen exchange, leading to acute respiratory distress, pulmonary fibrosis, and eventually death.[18] Moreover, significant pulmonary thromboembolic effects were also found on autopsies from patients who died from COVID-19 disease.

The risk factors considered included hypertension, diabetes mellitus, asthma, COPD, coronary artery disease, and chronic kidney disease. Risk factors were found in 3966/9100 patients (43.5%), among them most common comorbid condition was hypertension, followed by diabetes mellitus.

This agreed with Kaleemi et al study revealed that the commonest comorbids in their patients were hypertension (HTN: 46.7%) and diabetes mellitus (T2DM: 37.3%).[10]

Out of the 9100 patients, 6500 (72%) were unvaccinated and 2600 (28%) were vaccinated at the time of diagnosis. In our study, most of the mild category patients were from the vaccinated group, and the moderate and severe category patients were from the unvaccinated group.

Study done by Lee et al stated that vaccination is negatively associated with the development of pneumonia in patients with COVID-19.[13] Given the steady increase in vaccination rates, the role of diagnostic imaging in patients with suspected COVID-19 may need to be redefined.

In our study, out of 9100 patients, almost 95.3% (8667 patients) were discharged, and mortality was present in 4.7% (433 patients). In the present study, most of the patients who died had a score of more than 12 (severe category); while among patients with a score of less than 12 (mild and moderate category), most of them recovered and were discharged.

When the baseline CXR score was compared with the patient's final outcome, the p was less than 0.00001, which was statistically significant, implying an association between the two. Hence, this scoring system can be adopted to accurately predict the outcome of patients infected with COVID-19. The results were in sync with the study by Bhorgesi et al.[14]

Bhorgesi et al in his study, scored initial CXRs of 302 patients with Brixia scoring system and concluded that

high Brixia score was associated with a highest risk of in hospital mortality.[14]

Limitations

The major limitation of this study was that we used only the baseline CXR severity score as an independent indicator of prognosis of the final outcome. The next limitation was the absence of a follow-up on a long-term basis for all the discharged patients. We obviously realize that this method requires further studies to confirm its validity because the score depends mainly on the quality of the CXR images and the experience of the observers.

Therefore, many more studies will be required to analyse the worsening of opacities on the chest radiographs, which will be done on a follow-up basis.

CONCLUSION

The major strength of this study is its large sample size. This is one such study which has assessed the effectiveness of this particular scoring system to forecast the final outcome with regard to discharges and deaths in patients infected with COVID-19. The chest X-ray severity scoring (CXR-SS) system used in this study is a valuable method of disease prognostication in COVID-19, as the initial and highest subsequent CXR-SS show a strong association with ICU admission and mortality. The benefits of this CXR-SS lie in its reproducibility, ability to convey easily understandable objective information between radiologist and treating physician, and feasibility in resource-constrained settings. CXR-SS more than 12 was associated with a higher risk of mortality due to COVID-19. It provides the necessary information for bedside clinical assessment of COVID-19 patients. The modified scoring system can help determine the severity of the disease progression in COVID-19 patients, especially in areas with shortages of facilities and specialists.

Here we showed that patients with hypoxia have significantly higher chest x-ray severity scores. We showed that there was a significant reverse relationship between chest x-ray severity score and oxygen saturation, which has great clinical importance.

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