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ORIGINAL ARTICLE

Correlation between Oxygen Saturation and Lung Involvement on Chest X-ray in COVID-19 Patients.

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Abstract

Background and objectives: The unprecedented outbreak of COVID-19 pneumonia, is putting to test the healthcare facilities of many countries worldwide. In this article we have investigated the correlation between the degree of lung involvement on chest x-ray (CXR) based on a severity score and the oxygen saturation (SpO2) of admitted patients.
Methods: In this retrospective observational study, the radiographs of 250 COVID-19 patients taken prior to admission, with confirmed reverse transcriptase polymerase chain reaction (RT-PCR) test were analysed using a severity score which was then compared with their blood oxygen saturation levels recorded using pulse oximeter. Also comparison of X-ray severity score was done with age and gender of patients.
Results: We found a significant correlation between the CXR score and blood oxygen saturation of patients who were not on oxygen support. However, there was no correlation found between the CXR score and blood oxygen saturation of patients who were on non-invasive ventilation. There was a significant correlation between the CXR score and age of the patient with the severity of the score increasing with the increase in age. There was no correlation found between the CXR score and sex of the patients.
Conclusion: We found a significant correlation between SpO2 and CXR findings in patients not on oxygen support, thus indicating that monitoring of patients with SpO2 will prove to be simple and cost effective with the use of radiography limited in patients who are on oxygen support, have worsening disease or for post procedure evaluation.

Keywords: blood oxygen saturation, chest x-ray, COVID-19, pulse oximeter.

Introduction

A novel coronavirus named severe acute respiratory syndrome coronavirus-2 causes coronavirus disease 2019 (COVID-19) which is a highly infectious disease and is spreading rapidly throughout the world at present.[1] WHO declared the outbreak a Public Health Emergency of International Concern on January 30, 2020.[2] On March 11, 2020, the outbreak was declared as a pandemic by WHO.[3] The outbreak has been spreading worldwide rapidly ever since with 16.2 million cases diagnosed in India and 186,928 deaths at the time of writing this article. This unprecedented pandemic has put to test the healthcare capacity of many countries with many hospitals struggling with excessive patient inflow and limited infrastructure. Imaging has an important role in the management of COVID-19. However, it is important to use imaging judiciously especially in a resource constrained environment. Many patients who require hospital admission are hypoxemic. Blood oxygen saturation (SpO2) measurement by pulse oximetry is a simple, cost-effective, and easily available method to identify respiratory distress. In this article, we have compared the chest x-ray (CXR) findings based on a severity score with the SpO2 of COVID-19 patients at the time of admission.

The purpose of this study was to find the comparison between chest x-ray (CXR) findings based on a severity score with SpO2 in patients on admission. The relationship between the chest x-ray score and age, gender of patients was also analysed.

Materials and methods

The study population included 250 admitted patients who tested positive for real-time reverse transcriptase polymerase chain reaction (RT-PCR) test for COVID-19 and underwent chest radiography on admission from 5th June to 2nd July in a tertiary care hospital from India. In this retrospective observational study, the study population included 77 females, 173 males with age ranging from 17 to 70 years. For every patient who was admitted, a single CXR was obtained for analysis. The CXRs were analysed by two radiologists with 7 years of experience, in case of disagreement between the findings, a senior radiologist with 18 years of experience analysed the radiographs. Each CXR was divided into six zones. Age, sex, SpO2, and non-invasive ventilatory parameters whenever applicable were collected for analysis. The SpO2 of the patients was obtained when they came to the radiology department. For patients who came walking to the department, it was obtained in sitting position after a rest of 30 minutes. Patients for whom bedside radiographs were acquired, SpO2 were measured in sitting or lying position before obtaining the CXR.

Inclusion Criteria:
Admitted patients with COVID-19 confirmed on oropharyngeal or nasopharyngeal RT-PCR swab test.

Exclusion Criteria:

1. Patients with non-reportable CXRs due to motion artefacts and under or overexposed CXRs.
2. Patients with associated comorbidities such as chronic obstructive pulmonary disease, cardiac failure, congenital heart disease, severe anaemia or interstitial lung disease which would cause hypoxaemia.

Statistical analysis
Complete concordance and Cohen's kappa coefficient was used to assess agreement in CXR interpretation between the two radiologists. Data was entered into Microsoft Excel (Windows 7; Version 2007) and analyses were done using the Statistical Package for Social Sciences (SPSS) for Windows software (version 22.0; SPSS Inc, Chicago). Association between variables was analysed by using the Chi-Square test for categorical variables and Mann–Whitney U-test

for continuous variables. The level of significance was set at 0.05.

Image analysis

The CXRs were divided into three zones on either side. The upper zone extended from the lung apex to the lower border of the anterior end of second rib. The mid zone extended from the lower border of the second rib to the lower border of the anterior end of fourth rib and the lower zone extended from the lower border of the anterior end of fourth rib to the lower border of anterior end of seventh rib. The CXRs were analysed for ground glass opacities, septal thickening, and consolidations which are the findings seen in COVID-19 pneumonia. A score of 1 was assigned to each zone which was involved (Figure 1). The scores ranged from 0 to 6. (Figure 2). Associated abnormalities such as pleural effusion was also noted however, were not assigned a score.

Ethical consideration

This was a retrospective observational study done with de-identified data of patients. Written informed consent of the patient was obtained for chest radiography. Institutional ethical approval was also obtained.

Results

The average blood oxygen saturation of patients for each CXR score has been mentioned in table 1. We found that in patients without oxygen support as the CXR score increased, their blood oxygen saturation dropped, however the same was not true for patients on non-invasive ventilation. Thus, there was a significant correlation between the CXR score and blood oxygen saturation (p- value < 0.001) of patients who were not on oxygen support (Figure 3). However, there was no correlation found between the CXR score and blood oxygen saturation (p-value = 0.213) of patients who were on non-invasive ventilation (Figure 4). Also, we found a significant correlation between the CXR score and age of the patient with the severity of the score increasing with the increase in age (Figure 5). There was no correlation found between the CXR score and sex of the patients (Figure 6). There was substantial inter-observer agreement with a Cohen's kappa coefficient of 0.76.

Discussion

A novel coronavirus named severe acute respiratory syndrome coronavirus - 2 (SARS-CoV-2) was first identified from Wuhan city, China causing unusual cases of coronavirus disease 2019 (COVID-19) pneumonia.[4-7] The disease has been spreading rapidly ever since across the continents in all parts of the world. India which is currently in the 2nd position, below U.S.A in the number of infected cases. The disease presents as a respiratory tract infection and in few cases can lead to acute respiratory distress syndrome which is characterised by hypoxemia. Risk factors for the development of severe disease are age more than 60 years, diabetes mellitus, hypertension, cardiac disease, obesity, and immunosuppression. Various mutations are noted in the virus which has increase in number of cases in the country. The cause of ground glass opacities and consolidation on chest x-ray is pulmonary alveolar oedema in acute stage and interstitial thickening and fibrosis in later stages. Hypoxemia in COVID-19 occurs due to persistent ventilation of the non-ventilated alveoli and due to micro-thrombi formed in the pulmonary vasculature.

According to a multinational consensus statement from Fleishner society, imaging is indicated in patients with mild disease who have risk factors for disease progression; in patients with moderate or severe COVID-19 disease; in patients with moderate or severe disease with negative or unavailable COVID test and in all patients with worsening symptoms.[8] CXR is usually the first imaging modality of choice due to its easy availability and low cost. However, imaging can be labour intensive especially in resource constrained places. In department as well as portable chest radiography harbours a chance of cross infection as well as infection of the imaging personnel and health care workers. Need for disinfection of the imaging room results in downtime of the imaging suite. Positioning seriously ill patients for portable radiography can lead to complications such as malposition of lines, tubes, or devices.[9] Radiation exposure also adds to the disadvantages of radiography. Consumption of personal protective equipment can also be a cause of concern in a resource limited environment.

In early or mild COVID-19 infection, CXR has been shown to be insensitive.[10] Unselective or daily chest radiography makes no difference in the adverse outcomes of admitted or ICU patients.[11,12] Chest radiography should be performed only if it would alter the management of the patient in COVID-19 positive patients.[8] In our study we found a significant correlation of SpO2 with the severity of pulmonary involvement on CXR.

Hence routine use of SpO2 monitoring instead of imaging may be beneficial in assessing the extent of pulmonary involvement or disease progression, especially in a resource constrained environment. CXR is beneficial to rule out the development of pneumothorax or pleural effusion. CXR is indicated after the placement of endotracheal, nasogastric tubes, or catheters such as central venous line or Swan-Ganz catheters.[13] In patients with worsening symptoms, chest CT instead of CXR may be beneficial to rule out complications such as pulmonary thromboembolism or myocarditis.

Conclusion

Currently, the world is grappling with an unprecedented outbreak of COVID-19. The judicious use of resources is the need of the hour. We found a significant correlation between SpO2 and CXR findings in patients without oxygen support, thus indicating that monitoring of patients with SPO2 will prove to be simple and cost-effective with the use of radiography limited in patients on oxygen support and whenever clinically necessary to rule out suspected complications, pleural effusion, pneumothorax or post- procedure or alternative diagnosis.

Conflict of Interest

The authors declare no conflict of interest.

Table1. Average blood oxygen saturation of patients for each CXR score.

CXR Score	Average blood oxygen saturation
0	97%
1	95%
2	94%
3	93.2%
4	90.7%
5	86.7%
6	84.9%

Figure 1. The CXRs divided into three zones on either side. The upper zone extended from the lung apex to the lower border of the anterior end of second rib. The mid zone extended from the lower border of the second rib to the lower border of the anterior end of fourth rib and the lower zone extended from the lower border of the anterior end of fourth rib to the lower border of anterior end of seventh rib.

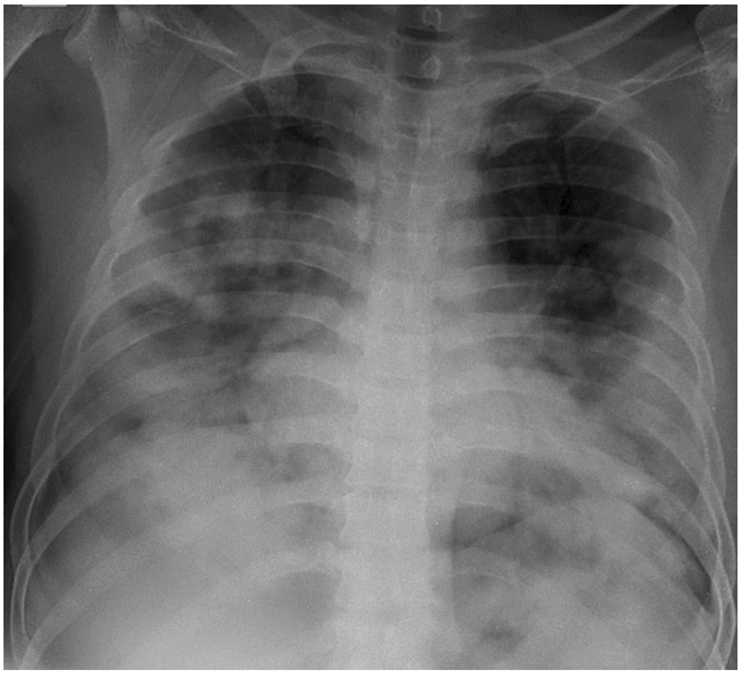

Figure 2. Chest x-ray showing example of the scoring system. Areas of consolidation are seen involving bilateral middle and lower zones, thus giving the CXR a score of 4.

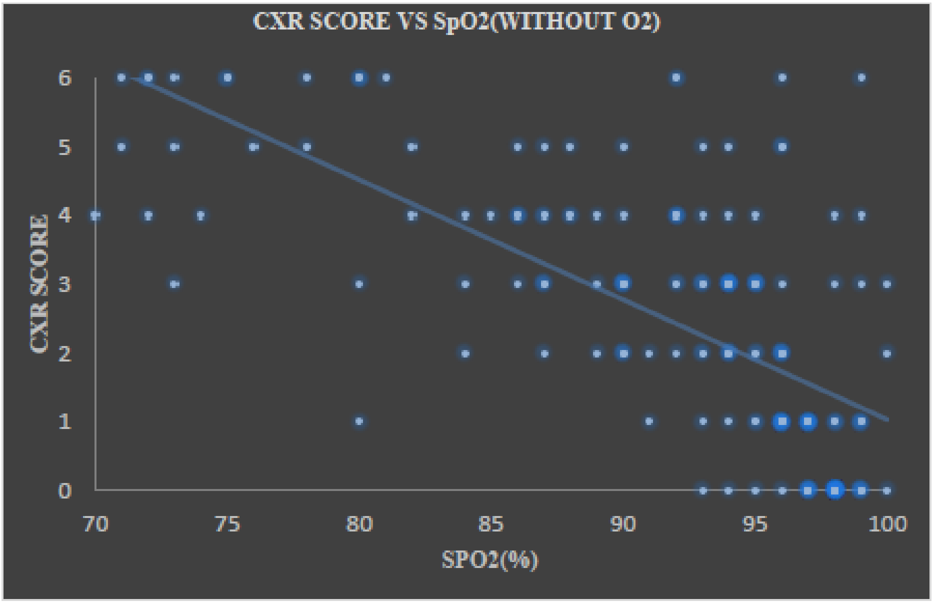

Figure 3. Scatter plot shows the relation between the chest x ray scores of patients and blood oxygen saturation in patients without oxygen support.

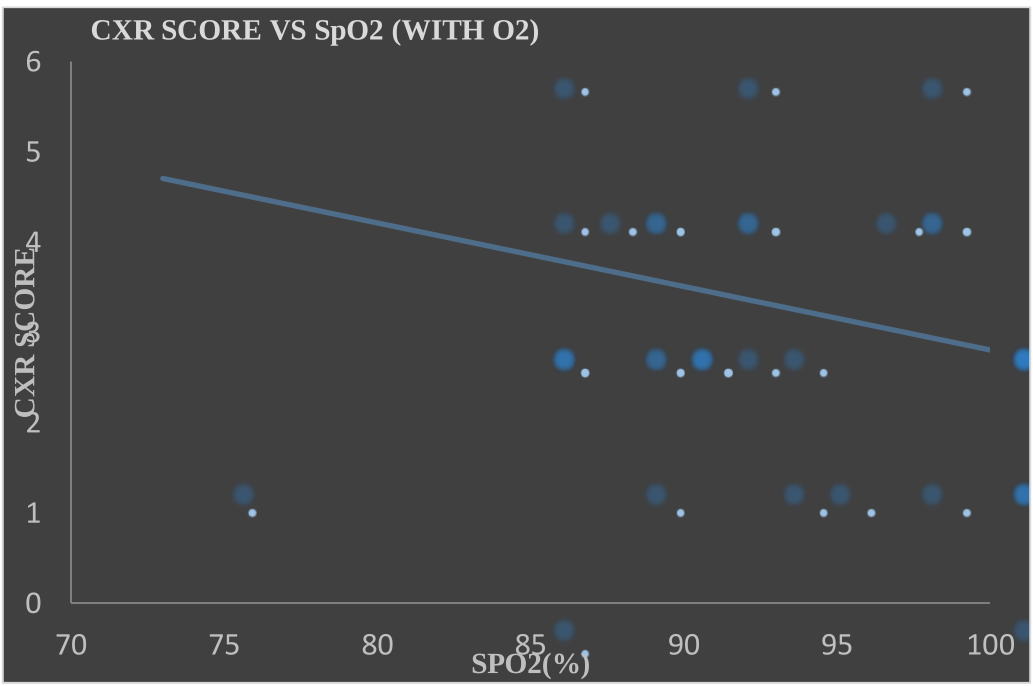

Figure 4. Scatter plot shows the relation between the chest x ray scores of patients and blood oxygen saturation in patients on non-invasive ventilation.

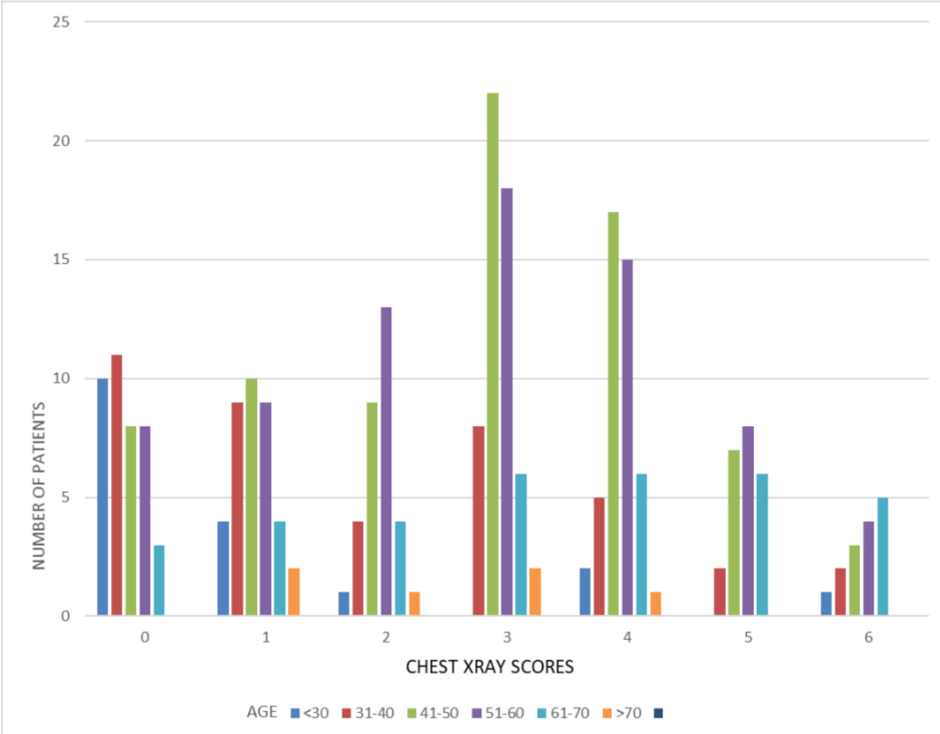

Figure 5. Bar diagram shows the relation between the chest x ray scores of patients and age of patients.

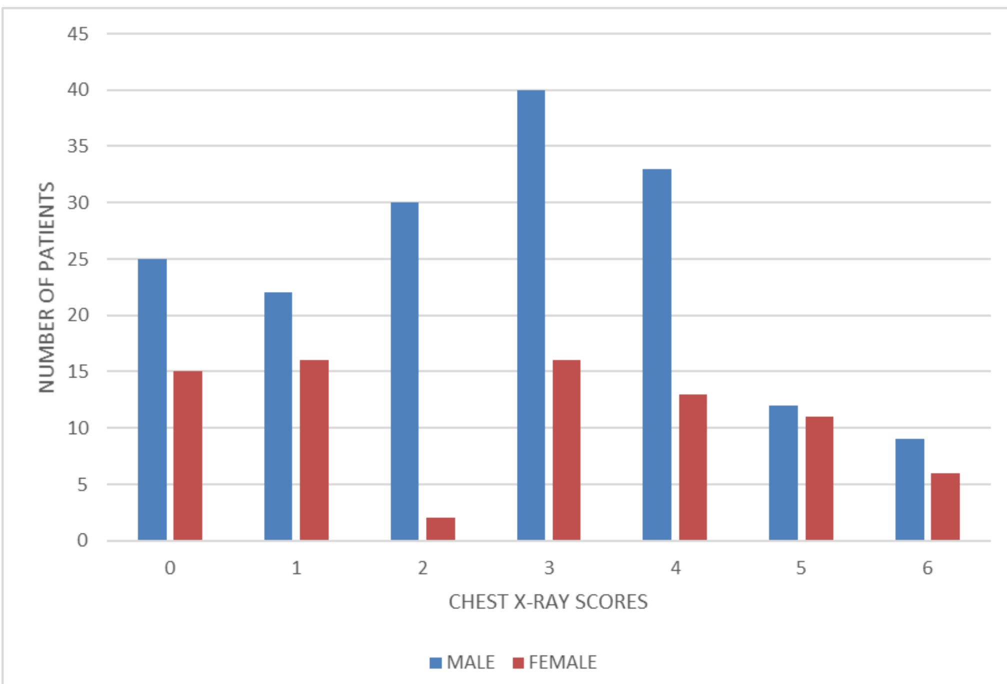

Figure 6. Bar diagram shows the relation between the chest x ray scores of patients and the gender of patients.

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