Semi-Quantitative Chest Computed tomography Score in Novel Coronavirus (SARS-Cov-2) Patients: Its Correlation with Oxygen Saturation (SpO2) and Role in Predicting Oxygen Therapy Requirement.

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Abstract

Context: Quantitative and semi-quantitative indicators of lung involvement in COVID-19 could help to stratify the patients and thus help in triaging and speeding up the entire workflow in hospitals as patients with higher severity scores require early therapeutic intervention and critical care.

Objective: To calculate Computed Tomography (CT) severity score for COVID-19 infection based on lobar involvement of the disease and correlate the score with oxygen saturation levels (SpO2) of the patient and further predict oxygen therapy requirement.

Settings and Design: Prospective study.

Methods and Material: This is a prospective study of 154 proven novel coronavirus (SARS-CoV-2) infected (COVID-19) patients. SpO2 values of all the patients were obtained within 6 hours of scan. All the scans were reviewed and semi-quantitative CT score was calculated based on the extent of lobar involvement.

Statistical analysis used: Scatter plot correlation and ROC curve analysis were performed.

Results: CT score and SpO2 values of patients were plotted in scatter plot chart and Pearson correlation co-efficient (r) was calculated, which was -0.836 suggesting a strong negative correlation. Forty-six patients were given oxygen therapy and they had oxygen saturation value \( \leq 94\% \) with CT score ranging from 10-22. ROC curve analysis was performed to determine and reach an optimum cut off value of 11 for oxygen therapy requirement with sensitivity and specificity of 95.83% and 95.58% respectively.

Conclusions: CT score in COVID-19 patients has strong negative correlation with oxygen saturation and it definitely helped to predict the requirement of the oxygen therapy in our study.

Introduction:

A rapid outbreak of novel coronavirus which predominantly causes acute respiratory illness has initially appeared in Wuhan City, China since December 2019. Soon, it has become a public health emergency of international concern. The World Health Organization (WHO) announced this outbreak as a public health emergency on January 30, 2020[1]. As of October 2020, there are approximately 40 million COVID-19 infected cases with ~1.1 million deaths [2].

The incubation period is generally 3 to 14 days with median time of 4–5 days [3]. COVID-19 infection can have variable clinical outcomes based on severity of disease. Fatigue, headache, and myalgia are the frequent symptoms in people with mild disease requiring no hospital admission, whereas fever, cough, and shortness of breath are the symptoms which needs to be managed with hospital admission. Although there is a significant overlap in clinical features of COVID-19 compared to other acute respiratory illnesses, patients with COVID-19 were more likely to be admitted to the hospital, have longer
hospitalizations and develop acute respiratory distress syndrome (ARDS), and were unlikely to have co-existent viral infections[3,4].

At present, the diagnosis of COVID-19 largely depends on real-time reverse transcriptase polymerase chain reaction (RT-PCR) or next-generation sequencing. However RT-PCR has limitations like availability, sampling errors (inadequate sampling or sample contamination) and it takes time up to 24 hours to provide the result. The sensitivity of RT-PCR is 63–71% for nasopharyngeal swab [5,6]. Hence positive RT-PCR tests can be useful to “rule-in” covid-19, a negative swab test cannot be considered definitive for “ruling out.” The sensitivity of CT to diagnose COVID-19 is 86–97% in RT-PCR positive cases. In a study by Ai et al.[7] about 60% of patients had typical CT features consistent with COVID-19 even before the initial positive RT-PCR results, and almost all patients had initial positive chest CT scans before or within 6 days of the initial positive RT-PCR results.

CT is, therefore considered, in many patients showing typical symptoms of viral pneumonia with negative RT-PCR, and in patients with positive RT-PCR to know the severity. Typical CT findings of COVID-19 infection are bilateral and peripheral ground-glass and consolidative pulmonary opacities. In later days of infection linear opacities, crazy-paving pattern, and the reverse halo sign are seen.[8,9]

Main role of CT in this pandemic is to demonstrate classical imaging findings in lungs of suspected cases presenting with typical symptoms of Covid – 19 infection, thus helping in risk stratification of the patients. CT is also helpful in diagnosing any pre-existing pulmonary disease, to monitor temporal resolution or progression of the disease and, to assess any associated complications at presentation or those developing during the hospital stay.

**Subjects And Methods:**

This is a prospective study comprising of 154 patients (102 men and 52 women; age range, 21–83 years; mean age ± SD, 48.3 ± 13.7 years) referred to radiology and imageology department from 1st July 2020 to 15th September 2020 in suspicion of COVID-19 infection. Approval of the institutional scientific and ethical committee was taken to conduct the study. Informed consent from the patients was waived off by the committee

All the patients were proven positive for COVID-19 infection either prior to or following CT scan by reverse transcriptase polymerase chain reaction (RT-PCR) test (Applied biosystems by Thermoscientific, Quantstudio 5). Oxygen saturation (SpO2) values were recorded and noted for all the patients at the time of the scan. Patients were followed up for 3 to 29 days during their hospital course. Any type of oxygen therapy (low flow, high flow, CPAP, ventilator support) given to the patients were noted.

**Ct Protocol:**
Two multidetector CT scanners (Philips 16 slice CT; 128 slice SOMATOM Definition AS+ / SEIMENS) were used for all examinations.

Scanning parameters were identical to the manufacturer's standard recommended pre-setting for a thorax routine.

CT scan parameters: 153mA, 120 kV with field of view- 345 mm and slice thickness of 1.0 mm for lung window and 5mm for mediastinal window. Ultra sharp kernel convolution filter used for lung window images. Coronal and sagittal multiplanar reconstructions were also available in all cases.

Appropriate safety measures were taken by all the staff during and after the scan.

Image Analysis:

All the cases were reviewed by experienced radiologists and CORADS category, as proposed by Prokop et al. [10] was allotted to every case of HRCT chest with suspicion of COVID-19 infection. A total of 154 cases with CORADS-5 and 6 category were included in the study.

In all cases, a semi-quantitative CT severity scoring as proposed by Pan et al. [11] was calculated for each lobe based on the extent of involvement. For each lobe the score ranges from 0–5: 0 being no involvement; 1, < 5% involvement; 2, 5–25% involvement; 3, 26–50% involvement; 4, 51–75% involvement; and 5, > 75% involvement. The global score, which ranges from 0–25 is calculated by summing up all the lobar scores. CT severity score from 0 to 8 was considered as mild, while between 9–15 was labelled moderate and more than 15 was considered severe.

Statistical analysis:

Quantitative data were expressed as mean ± standard deviation. Scatter plot correlation was done to establish the relation between two continuous variables (SpO2 and CT severity score (CT-SS)). Receiver operator characteristic (ROC) curve analysis was performed to determine and reach an optimum cut off value for oxygen therapy requirement.

Results:

Our study was comprising of 154 RT-PCR proven COVID-19 patients who underwent HRCT chest and admitted in our hospital, from 1st July 2020 to 15th September 2020. In our study group, patients were in age the range of 21–83 years with mean value of 48.3 ± 13.7 years. Majority of the cases were in 51–60 years age group (51 cases. 33.1%) followed by 41–50 years age group (38 cases. 24.7%). Male cases were predominant in our study with 102 males (66.2 %) and 52 females (33.8 %). Patients were grouped based on CT severity score into mild, moderate and severe. Mild CT scores were observed in 85 patients [55.2%. (54 males and 31 females)]. Fifty-four patients [35.06%. (38 males and 16 females)] were having moderate CT scores and 15 patients [9.74% (10 males and 5 females)] were having severe CT scores. CT
was showing no findings in 9 patients and were given score of zero. Combined percentage of moderate and severe cases were noted increasing from 21–30 years to 81–90 years age group compared to the mild cases (21–30 years- 25%; 31–40 years- 39.1%; 41–50 years- 44.7%; 51–60 years- 47%; 61–70 years- 54.5%; 71–80 years- 70% and 81–90 years- 100%)(Fig. 1).

Scatter plot chart was plotted with SpO2 on x-axis and CTSI on y-axis to establish relation between them. Correlation coefficient was calculated (r) from the chart. We got a r value of -0.836 at p value of < .00001 which suggested strong negative correlation between CTSI and SpO2 values (Fig. 1).

Forty six (29.87%) patients in our study required oxygen therapy. Of these 46 patients 31 cases were having moderate CT score and 15 patients were having severe CT scores. Hence we can conclude that 57.4% (31 out of 54 cases) of cases with moderate CT score and 100 % (15 out of 15) of cases with severe CT score required oxygen therapy during their hospital course. The CT scores of these 46 patients were ranging from 10 to 22. Figures 5, 6 and 7 are showing CT images of patients with mild, moderate and severe involvement.

ROC curve analysis was performed to determine and reach an optimum cut off value for oxygen therapy requirement. Optimum cut off value was determined to be 11 with sensitivity and specificity of 95.83% (95% CI: 85.75–99.49%) and 95.58% (95% CI: 89.98–98.55%) respectively.

**Discussion:**

COVID-19 pandemic resulted in huge burden on health care departments all over the world. In developing nations like India, there is a large resource-requirement mismatch in skilled manpower and other related health services. Clinical examination and laboratory investigations are necessary for diagnosis and appropriate clinical staging of the patients, but many patients are asymptomatic in initial days of infection and availability of certain laboratory investigations like inflammatory markers are limited in many regions. In these settings, CT is a useful tool not only for diagnosing classical imaging findings in suspected cases, but also for risk stratifying the cases, so that services can be streamlined for those who really require it as shown in Figs. 2, 3 and 4. We could not find any study correlating saturation of oxygen with CT severity score or trying to prognosticate the oxygen requirement. During our literature review, we found that Yang et al. [12] evaluated the role of CT severity score in differentiating clinical forms. The study concluded that, optimal CT-SS threshold for identifying severe COVID-19 was 19.5 out of 40 with 83.3% sensitivity and 94% specificity, however it used a little different scoring method than used in our study.

Francone et al. [13] correlated CT score with disease severity and short term prognosis. The study revealed that CT score of ≥ 18 was associated with an increased mortality risk and was found to be predictive of death.

Bhandari et al. [14] correlated CT score with clinical status of the patients. The study revealed good correlation between them with mild cases showing score < 15/25 in 45.83% patients and severe cases
showing CT severity score > 15/25 in 87.50% patients.

Our study showed a strong negative correlation between CT severity score and SpO2 values of the patients. Value of correlation coefficient between them is -0.836, suggesting SpO2 values decreases with increasing CT scores.

Oxygen therapy was required in 46 patients (29.87%) in our study. Out of 46 patients, 31 patients were having moderate CT score and 15 patients were having severe CT score. The CT scores of these 46 patients were ranging from 10 to 22. ROC analysis was done to determine a optimum cut off value of CT score to predict oxygen requirement. Optimum cut off value was determined to be 11 with sensitivity and specificity of 95.83% and 95.58% respectively. This cutoff value can be used to increase the monitoring level of the patient.

Our study has some limitations of being a single center study and short duration of follow up only during their hospital stay. Role of comorbidities and other laboratory parameters were not considered in oxygen requirement of patient.

**Conclusion:**

CT can be a useful tool for quick analysis of suspected COVID-19 patients and stratifying the patients. We found that patients with higher CT scores have increased oxygen requirement during their course of disease and hence, so these patients require vigilant and close monitoring.

**Declarations**

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| Literature search        |               |               |               |
| Clinical studies         |               |               |               |
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Figures

Figure 1

Scatter plot chart with SpO2 on x-axis and CTSI on y-axis.
Figure 2

A 57-Year-old male patient came with complaints of fever and myalgia. CT images showing multiple patch ground-glass opacities in peripheral subpleural distribution involving both lungs with predominant posterior involvement. CT score of 4 was given. The patient had a saturation of 97%. The patient became asymptomatic after 1 week and discharged.
A 31-Year-old male patient presented with fever and SOB. CT showing multifocal involvement of both lungs with patchy GGO and consolidations predominantly in peripheral location. CT score of 13 was given. The patient had a SpO2 of 89% and was given oxygen therapy.
A 51-year female patient presented with fever and SOB. CT showing extensive involvement of both lungs with crazy-paving pattern. CT score of 17 was given. The patient had a SpO2 of 78%. She was shifted to ICU and given ventilator support.