ORIGINAL ARTICLE

COVID-19 CT score and oxygen saturation level on pulse oximetry: Do they correlate?

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Abstract

Background: Computed Tomography (CT) scan of Chest was widely used in India during COVID-19 pandemic irrespective of oxygen saturation level of the patients because of wide spread CT availability and prevalence of happy hypoxia in the COVID-19 patients. *Aim and Objectives:* The aim of our study was to determine the correlation between the COVID-19 CT score and oxygen saturation level on pulse oximetry in patients with Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR) positive status with or without fever. *Material and Methods:* Those patients attending the fever clinic of our institution with suspicion of COVID-19 and were subjected to CT chest were the primary study population. Of these patients, those with positive RT -PCR status and underwent CT chest (with positive CT- severity score) and had an oxygen saturation (SpO_2) level value on pulse oximetry were included in the study. *Results:* About 45.02% of the study participants had oxygen saturation below 94% and 55 % of the patients had oxygen saturation above 94%. Those with a lower saturation (<94) had higher CT mean scores in both CT25 and CT40 scoring systems. In the CT25 group, almost half of the study participants (51.1%) of those with saturation < 94% had CT scores between 6-15 (moderate category). Almost 3/4th of the study participants (72%) of those with SpO_2 > 94% had CT scores between 6-15 (moderate category). There was a statistically significant association ($p < 0.5$) between oxygen saturation, gender, mortality and CT25 scores. In the CT40 group, there was a statistically significant association ($p < 0.05$) between CT40 scores and oxygen saturation, diabetes, hypertension and mortality. Almost 84% of those having SpO_2 less than 94% had a CT score above 19 (severe category). Almost half (48%) of those with SpO_2 > 94, had a CT score above 19 (severe category). *Conclusions:* The oxygen saturation level alone cannot be an exclusive factor in deciding whether to consider a chest CT-scan imaging, as a lot of patients with normal SpO_2 had significantly higher CT-severity scores. Individuals with hypoxia have considerably higher CT severity showing substantial inverse association and the higher CT-severity score has important therapeutic and prognostic implications.

Keywords: COVID-19, CT, chest, oxygen, saturation, severity score

Introduction

From the first COVID-19 pneumonia recorded on 31 December 2019 to September 2022, there have been 65,01,469 COVID-19 deaths and 60,83, 28,548 confirmed cases worldwide, as per WHO. While in India, 5,28,273 COVID-19 deaths alongside 4,45,22,777 cases had been reported [1]. The pandemic has promoted research in early diagnostic and prognostic tools. Characteristic Computed Tomography (CT) patterns were observed in a significant proportion of COVID-19 patients. In contrast to Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR), a sensitivity of 98% was observed for chest CT while the latter had a sensitivity of 71% but lower specificity

(37%) and negative predictive value (90%) [2]. In India, there had been extensive use of CT scan during the second wave of COVID-19 pandemic, bordering on indiscriminate use. There were senior doctors on either side calling for caution in using CT as well as advising their use in every one who had an infection [3-8]. However, the government guidelines maintained that there was no role for CT in patients with mild / asymptomatic disease [8-9]. But most of those with COVID-19 or suspected COVID-19 got a CT done during the course of their illness. The main reason for apprehension and extensive use of CT was the occurrence of 'happy hypoxia' during the illness, which contributed to morbidity and mortality. The aim of the present study was to find out if there was any correlation between the COVID-19 CT score and oxygen saturation level (SpO_2) level on pulse oximetry. This would help ascertain whether CT offered any diagnostic advantage among those with normal SpO_2 level. Better understanding of the correlation between the COVID-19 CT score and SpO_2 could help make better clinical decisions and avoid unnecessary radiation exposure to the patients, especially those with mild disease.

Material and Methods

The retrospective observational study was conducted on patients between April and June 2021 in Department of Radio-Diagnosis and Imaging, Sree Balaji Medical College and Hospital. Institutional Ethics Committee (via IRB reference number 027/SBMCH/IHEC/2021/1198) approved this study. Those patients attending the fever clinic of our institution with suspicion of COVID-19 and were subjected to CT chest were the primary study population. Of these patients, those with positive RT-PCR status and underwent CT chest and had SpO_2 measured on pulse oximetry were included in the study. After the scan, SpO_2 readings of every patient came within 6 hours. Patients in CORADS-6 category had been the only ones enrolled in investigation. All cases had been reviewed by experienced radiologists to find severity of lung involvement. Those without positive RT-PCR status, those who neither underwent CT chest nor had a SpO_2 value were excluded from the study. A 16-detector CT scanner (Go; Siemens) was utilized for chest CT imaging. Supine position was employed for assessing every patient. A single inspiratory breath-hold was subsequently utilized to obtain CT pictures. Scanning range covered costophrenic angle along with lung's apex. X-ray tube settings (120 kVp, 350 mAs), rotation time (0.5 sec), pitch (1.0), section thickness (5 mm), intersection space (5 mm), extra reconstruction using sharp convolution kernel, and slice thickness (1.5 mm) were the parameters for CT scan. The institutional database system, Picture Archiving and Communication Systems (PACS), had been employed to evaluate the High Resolution Computed Tomography (HRCT) pictures. The institutional electronic medical record system provided the cohort's clinical data.

CT Severity Scoring (CT-SS) of COVID-19 was done using methods proposed by Yang *et al*. and Li *et al*. [10-11]. Lung opacification was employed by Yang *et al*. as a stand-in for lung disease progression. Both lungs' eighteen sections had been separated into total of 20 regions and the opacity of each region was evaluated subjectively on chest CT. Based on the percentage range of parenchymal opacification – 0%, 1-50% or 51-100%, each of the 20 regions were scored 0, 1 or 2 respectively. The sum of the scores of each region

is the overall CT-SS which ranges from 0-40 points (Figure 1). For identifying severe COVID-19, optimal threshold CT-SS was 19.5 with sensitivity and specificity at 83.3% and 94% respectively [10]. This system shall be named as CT40 in this study. In CT-SS scale proposed by Li *et al*., each of two lungs' 5 lobes was evaluated separately. A score of 0-5 was possible for each lobe depending on percentage of involvement. A score of 0 meant there was no involvement of lobe. A score of 1 was awarded for a lobe having an involvement of less than 5%. If involvement was between 5% and 25%, score awarded was 2. An involvement of 26% to 49% was given a score of 3. For lobes with 50-75% involvement the score awarded was 4 and for lobes with more than 75% involvement score was 5. Combining the points from each lobe, total CT score ranges from 0 (no involvement) to 25 (maximum involvement) [11]. This system shall be named as CT25 in this study. Qualitative assessment classified mild, moderate, as well as severe involvement based on CT-SS of 1–5, 6–14, along with 15–25, respectively [12]. SPSS software version 22 was employed to analyse data after it was entered into Microsoft Excel sheet. Data were displayed in tables utilizing descriptive statistics, and relationship between CT-SS with SpO_2 was assessed using Chi-square test.

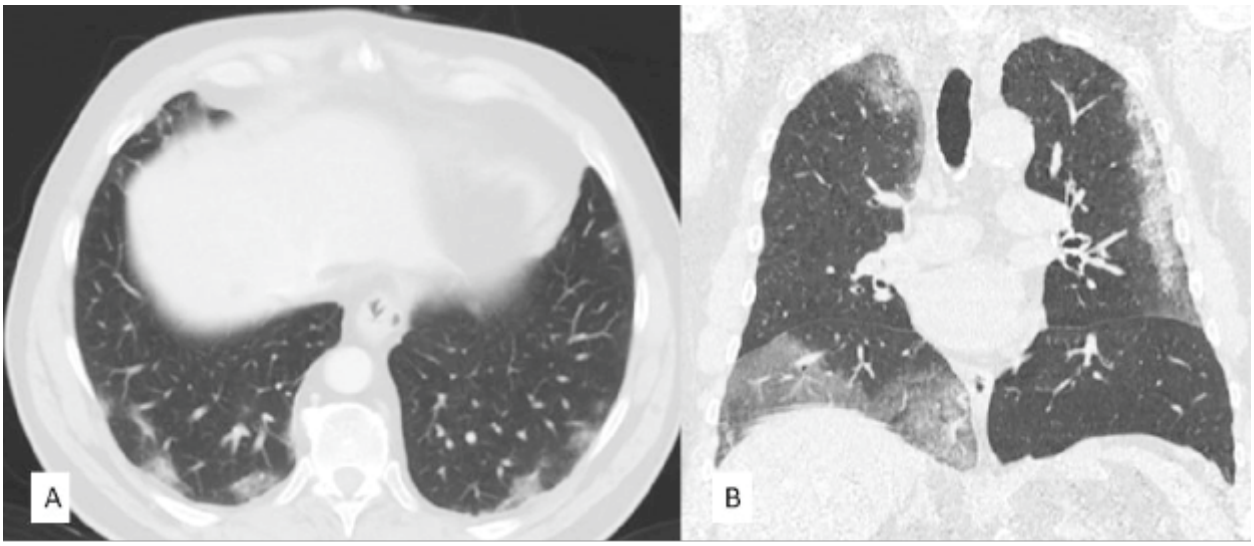

Figure 1: Axial CT chest (A) shows multiple peripheral wedge-shaped ground glass opacities in both lower lobes alone (mild disease) and coronal CT chest reformat (B) shows multiple peripheral wedge-shaped ground glass opacities in both upper and lower lobes alone (moderate disease)

Results

Initially, 720 patients who presented to the fever clinic during the period were selected. Fifty-eight patients without positive RT-PCR status were excluded. Then, 62 patients who did not undergo CT chest examination were excluded. Finally, 27 patients who did not have SpO_2 measured were excluded from study.

Of the 573 patients who fulfilled all the inclusion criteria, 243 patients had CT-SS using CT25 system and 330 patients had CT-SS using CT40 system. There were almost equal number of patients on either side of the age of 55 years. Males made up majority of patients in investigation (65% males vs 35% females). Diabetes and hypertension among the study participants were 39.09% and 33.85 % respectively. Almost 45.02% of the study participants had SpO_2 below 94% and 55% of the patients had SpO_2 above 94% (Table 1).

In the CT25 group, mean CT-SS for the $SpO_2 < 94$ group was 14.22 ± 4.83 and mean CT-SS for $SpO_2 >$ 94 group was 10.21 ± 4.52. In CT40 group, mean CT-SS for the $SpO_2 < 94$ group was 26.15 ± 8.60 and mean CT-SS for $SpO_2 > 94$ group was 16.87 ± 9.14. Those with lower saturation (< 94) had higher CT mean scores in both CT25 and CT40 scoring systems. Regarding gender, males had a higher score as compared to females. CT scores of individuals with Diabetes Mellitus (DM) were greater than those without DM. Those < 55 years of age had lower mean scores in CT25 as well as CT40 groups compared to those > 55 years of age. Mean CT-SS scores among those who suffered mortality due to COVID 19 were higher when compared with COVID survivors (Table 2).

In the CT25 group, almost half of the study participants (51.1%) of those with $SpO_2 < 94\%$ had CT scores between 6-15 (moderate category). Almost 3/4th of the study participants (72%) of those with $SpO_2 > 94\%$ had CT scores between 6-15 (moderate category). 43% of the study participants of those with $SpO_2 < 94\%$ had CT scores between 16-25 (severe category). 10% of the study participants of those with $SpO_2 > 94\%$ had CT scores between 16-25 (severe category). A significant correlation ($p < 0.5$) was observed in CT25 scores, mortality, gender, as well as SpO_2 (Table 3).

In the CT40 group, almost 84% of those having SpO_2 less than 94% had a CT score above 19 (severe category). Almost half (48%) of those with $SpO_2 > 94$, had a CT score above 19 (severe category). Diabetes and hypertension were important risk factors for high CT scores. Statistically significant association ($p < 0.05$) was found between CT40 scores as well as SpO_2, diabetes, hypertension, and mortality (Table 4).

Table 1: Age, sex and comorbidity wise distribution of study participants

Variable	Underwent CT scan N = 573				Total	
	CT25 n = 243		CT40 n = 330		n	%
	n	%	n	%		
Oxygen Saturation						
< 94	103	42.4	155	47.0	258	45.02
> 94	140	57.6	175	53.0	315	54.9
Gender						
Male	157	64.6	217	65.8	374	65.27
Female	86	35.4	113	34.2	199	34.72
Diabetes						
Yes	98	40.3	126	38.2	224	39.09
No	145	59.7	204	61.8	349	60.90
Hypertension						
Yes	58	23.9	136	41.2	194	33.85
No	185	76.1	194	58.8	379	66.1
Age						
< 55 years	123	50.6	167	50.6	290	50.6
> 55 years	120	49.4	163	49.4	283	49.4

Table 2: Mean CT scores of study participants based on related variables

Variable	Mean CT Scores	
	CT25 n = 243	CT40 n = 330
	Mean ± SD	Mean ± SD
Oxygen Saturation		
< 94	14.22 ± 4.83	26.15 ± 8.60
> 94	10.21 ± 4.52	16.87 ± 9.14
Gender		
Male	12.28 ± 4.87	22.06 ± 9.87
Female	11.23 ± 5.33	19.64 ± 10.14
Diabetes		
Yes	12.10 ± 5.22	22.72 ± 8.88
No	11.78 ± 4.95	20.31 ± 10.57
Hypertension		
Yes	11.50 ± 6.11	22.07 ± 9.92
No	12.04 ± 4.68	20.64 ± 10.06
Age		
< 55 years	11.55 ± 4.74	20.34 ± 9.75
> 55 years	12.27 ± 5.35	22.14 ± 10.22
Mortality due to COVID 19		
Yes	14.46 ± 5.86	27.5 ± .8.01
No	11.39 ± 4.72	19.64 ± 9.84

Table 3: Association between CT25 scores and related variables among the study participants

Variable	CT25 scores n = 243						Chi-Square	*p*
	Score 16-25		Score 6-15		Score < 6			
	n	%	n	%	n	%		
Oxygen Saturation								
< 94	38	36.9	60	58.3	5	4.9	32.50	0.000*
> 94	13	9.3	100	71.4	27	19.3		
Gender								
Male	36	22.9	107	68.2	14	8.9	7.24	0.027*
Female	15	17.4	53	61.6	18	20.9		
Diabetes								
Yes	17	17.3	66	67.3	15	15.3	1.663	0.435
No	34	23.4	94	64.8	17	11.7		
Hypertension								
Yes	11	19.0	34	58.6	13	22.4	5.697	0.058
No	40	21.6	126	68.1	19	10.3		
Age								
< 55 years	23	18.7	85	69.1	15	12.2	1.203	0.548
> 55 years	28	23.3	75	62.5	17	14.2		
Mortality due to COVID-19								
Yes	16	39.0	22	53.7	3	7.3	10.040	0.007*
No	35	17.3	138	68.3	29	14.4		

Table 4: Association between CT40 scores and related variables among the study participants

Variable	CT40 scores n = 330				Chi-Square	*p*
	Score > 19		Score < 19			
	n	%	n	%		
Oxygen Saturation						
< 94	131	84.5	24	15.5	48.274	0.000*
> 94	84	48.0	91	52.0		
Gender						
Male	146	67.3	71	32.7	1.266	0.261
Female	69	61.1	44	38.9		
Diabetes						
Yes	93	73.8	33	26.2	6.729	0.009*
No	122	59.8	82	40.2		
Hypertension						
Yes	98	72.1	38	27.9	4.861	0.027*
No	117	60.3	77	39.7		
Age						
< 55 years	99	59.3	68	40.7	5.131	0.023*
> 55 years	116	71.2	47	28.8		
Mortality due to COVID-19						
Yes	57	86.4	9	13.6	16.35	0.000*
No	158	59.8	106	40.2		

Discussion

In the COVID-19 pandemic, chest CT imaging had contributed significantly as a screening and diagnostic tool and an alternative to RT-PCR testing, subject to availability or clinical suspicion with initial negative RT-PCR testing [13]. Using a semi-quantitative CT severity assessment system, disease severity and prognosis was assessed [14]. As the CT imaging objectively assesses the pulmonary parenchymal involvement and assesses burden of disease, it's essential for managing illness, determining its severity, and its potential course as an imaging biomarker for COVID-19 [13-14]. Indicators for additional treatment may be found in overall lung involvement score during second week of COVID-19, which exhibited excellent predictive value (sensitivity of 81.0% and specificity of 69.2%) for clinical severity [15].

As national health authority guidelines insisted on triaging and treating patients based on the SpO_2 values rather than CT score, contrary to extremely prevalent clinical practice of every suspected COVID-19 patient or contact, we were inquisitive to find out whether chest CT had a role in every COVID-19 patient [16]. There were not many studies directly trying to correlate SpO_2 levels and CT chest at the time of proposal submission, and only few studies sought to find the same thereafter [16-21].

An important parameter for severity and progression of disease is SpO_2. Lobar affection along with lung disease progression increases CT-SS and therefore decreases SpO_2. This can be identified most effectively 8 to 14 days after symptoms onset. As those with an increased severity score tend to have decreased oxygen saturation, SpO_2 seems to be inversely correlated with the CT-SS [16]. A cut point of 93 of SpO_2 was associated with a higher CT score [17]. Consolidation lesions on chest CT scans meant patients had extended hospitalization and recovery times. Consolidation in the upper lungs of chest CT scans meant that patients had adverse endpoints and SpO_2 less than 93 [22].

With a correlation coefficient of -0.836, Arora *et al*. discovered a significant inverse relationship between SpO_2 levels of the patient along with their CT-SS. Sensitivity alongside specificity were 95.83 and 95.58 percent, respectively, and they determined that ideal CT-SS cut-off value for oxygen therapy demand was 11/25 [18].

In COVID-19, hypoxia had been linked to mortality, hospitalization, invasive ventilation requirements, as well as ICU admission. Correlation analysis revealed a negative relationship between partial oxygen pressure and SpO_2 and high radiology scores [19].

While a robust statistically significant correlation between oxygen levels and CT-SS in COVID-19 patients had been observed, it is crucial to recognize that infection frequently exhibits gradual radiological progression, reaching its zenith in second week following the onset of symptoms. Second week of illness had greatest incidence of problems, highest CT-SS, as well as lowest SpO_2 level [20]. UK guidelines recommended utilization of pulse oximetry for assessment and monitoring of dyspneic, unwell, or high-risk individuals with suspected COVID-19 [23]. SpO_2 level of 93 percent was proposed as threshold for advancing to imaging studies.

In our study, around 95% of those with CT-SS > 6 in CT25 group had abnormal SpO_2< 94% with about 58% in the moderate category and around

37% in the severe category. Almost 85% of those with CT-SS > 19 in the CT40 group had abnormal SpO_2 < 94%. Similar to our study, inverse correlation between CT-SS and capillary SpO_2 as well as positive correlation between previous medical history and CT-SS were found by Aalinez had *et al*. [24]. Arora *et al*. also discovered that SpO_2 values decreased as CT-SS increased and that patients who had greater CT scores needed more oxygen over course of their illness [18]. Although there is evidence of a direct correlation between low oxygen saturation and extent of pulmonary involvement, this relationship was not observed in individuals between 20-40 years. This suggests that significant lung involvement can occur in younger people with nearly normal oxygen saturation [25]. In same vein, it is imperative to note that 48% of those with CT-SS > 19 in CT40 group had normal SpO_2 > 94%. Around 80% of those with CT-SS > 6 in CT25 group had normal SpO_2 > 94%.

Similar to the statistically significant association ($p < 0.05$) between CT40 scores and oxygen saturation, diabetes, hypertension and mortality found in our study, compared to individuals without diabetes, patients with diabetes had a higher CT lung involvement score, which indicated a higher probability to be suffering from the severe form of COVID-19, according to Rangankar *et al*. [26]. Agarwal *et al*. found significant association between CT-SS and hypertension in COVID-19 [27]. Some authors advocate strategic integration of artificial intelligence with machine and deep learning techniques on CT to enable usage of CT as initial triage tool for COVID-19 and other pneumonias, reducing unnecessary testing [28].

That we had a data set of patients who had CT-SS scoring done using two quantitative methods is a minor limitation; though we addressed it by classifying CT-SS as ordinal variables. Not having a control group of RT-PCR patients with normal CT- SS (0/25 or 0/40) is also a minor limitation.

Conclusion

Measuring baseline SpO_2 was a straightforward and affordable technique that was employed to predict degree of lung involvement throughout SARS-CoV-2 pandemic. Based on our studies as well as the review of literature, when determining whether to undertake chest CT scan, SpO_2 level by itself was not found to be the determining factor, as lot of patients with normal SpO_2 had significantly higher CT-SS scores. CT severity is significantly higher in hypoxic individuals, indicating significant inverse relationship and higher CT-SS has important therapeutic and prognostic implications. CT chest has a definite role in management of COVID-19 patients, irrespective of SpO_2 level, especially if other comorbidities are present.

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