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Correlation Between Chest CT Severity Score and the Oxygen Saturation of Patients with COVID-19 Pneumonia

Zana J. Mohammad[a*], Zahir S. Khoshnaw[b]

[a]*Internist, Respiratory Medicine, Kurdistan Higher Council of Medical Specialties, Erbil, Kurdistan Region of Iraq ,44001*

[b]*MBChB., H.I.M., F.I.B.M.S. (Med), F.K.B.M.S (Res), Consultant Internist and pulmonologist, Erbil, Kurdistan Region of Iraq, 44001*

[b]*Department of Medicine, Hawler Medical University, College of Medicine. Erbil Kurdistan Region, Iraq,44001*

[a]*Email: zanajamaladdin@gmail.com,* [b]*Email: Zahir.salih@hmu.edu.krd*

Abstract

Background

In COVID-19 Pneumonia both capillary oxygen saturation and chest Computed tomography scan are important tools to assess severity of the disease. Here, we investigated the relation between computed tomography severity score and capillary oxygen saturation in patients with the infection. **Objective**: This study is assigned to assess the correlation between computed tomography lung findings and capillary oxygen saturation using pulse oximeter among patients with Coronavirus Disease – 19. **Patients and Method:** A cross-sectional study consisted of 120 adult patients (72 male, 48 female) with Coronavirus Disease-19 who were initially seen in the Rozhawa Emergency Hospital, Lalav Hospital for Respiratory Care Unit and Outpatient clinic in Erbil city from August 1st 2020 to July 31sd 2021. All patients underwent pulmonary CT-scan, and measurements of capillary oxygen saturation using pulse oximetry at the time of admission or first medical contact. **Results:** The total number of patients was 120. Their mean age (SD) was 54.7 (14.2) years, the median was 56 years, and the age range was 23 – 83 years. More than half of the patients were aged ≥ 50 years, and 60% were males. The majority (86.7%) were non-smokers, and only 11.7% had history of chronic lung disease. It is evident that there was a strong inverse significant correlation between the SpO2 and the degree of lung involvement. The more the % of lung involvement, the less the SpO2 levels($p < 0.001$).It is evident that 20.2% of the non-smokers had extensive lung involvement (> 75%) while none of the ever smokers had extensive lung involvement; in addition to that, 31.3% of the ever-smokers had limited lung involvement (< 5%) compared with 1.9% among the non-smokers ($p < 0.001$).

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* Corresponding author.

The degree of lung involvement was 51-75% among 71.4%, and >75% among 14.3% of the patients with history of chronic lung disease, compared with 26.4% and 17.9% respectively among those with no such a history (p = 0.017). **Conclusion**: The present study showed that patients with hypoxia had significantly higher computed tomography severity score and lung involvement.

Keywords: COVID-19; CT-Scan Scoring; Severity of Chest.

1. Introduction

Chest imaging has been considered as part of the diagnostic workup of patients with suspected or probable COVID-19 disease where RT-PCR is not available, or results are delayed or are initially negative in the presence of symptoms suggestive of COVID-19. Imaging has been also considered to complement clinical evaluation and laboratory parameters in the management of patients already diagnosed with COVID-19 [1]. Although the reference standard diagnostic tool of COVID-19 infection is the reverse transcription-polymerase chain reaction assay (RT-PCR) which estimates viral load from a nasopharyngeal swab or tracheal aspirate [2,3] However, recent studies reported low sensitivity of RT-PCR in the early stage (reaching from 37 to 71%), probably due to the respiratory tract viral load, samples source, the procedures, and timing of samples acquisition, as well as the intrinsic features and quality of the testing kits [4], while chest computed tomography (CT) has established 56–98% sensitivity in detecting COVID-19 early presentation and can be helpful in correcting false-negative RT-PCR through the early phases of the disease [5,6]. A non-contrast, high resolution CT chest imaging plays a pivotal and essential role in the early disease detection, particularly in patients with false-negative RT-PCR results, as well as in managing and monitoring the course of disease [7,8]. Moreover, the disease severity can be assessed from the CT findings, significantly supporting the physicians in their clinical decision and delivering effective and timely management [9]. CT severity score is a semi-quantitative scoring system that is developed to determine the severity and extent of pulmonary involvement in viral pneumonia [10]. In order to standardize the radiological descriptions, multiple chest CT scoring systems have been developed, including chest CT severity score (CT-SS), chest CT score, the total severity score (TSS), modified total severity score (m-TSS), and 3-level chest severity score in correlation with the clinical staging of disease [11-14]. In addition, the Coronavirus Disease 2019 (COVID-19) pandemic has caused an increase in the use of pulse oximeters, is a device that is usually placed on a fingertip. It uses light beams to estimate the oxygen saturation of the blood and the pulse rate. It is a non – invasive method to determine the severity of hypoxia. Guidance published in January 2021 by the WHO includes a provisional recommendation for “use of pulse oximetry monitoring at home as part of a package of care, including patient and provider education and appropriate follow-up”[15]. To the best of our knowledge, no study in the country investigated the correlation between CT severity score and oxygen saturation, however one study in the country correlated the CT severity index with some clinical parameters [16], and globally we found one study in Iran in which the extent of CT lung involvement was correlated with capillary oxygen saturation using pulse oximeter [17]. Thus, our study's objective is to evaluate and to estimate the correlation between CT lung findings and capillary oxygen saturation using pulse oximeter among patients with COVID – 19.

2. Materials and Methods

This is a cross-sectional study consisted of 120 adult patients with COVID-19 who were initially seen in the Rozhawa Emergency Hospital, Lalav Hospital for Respiratory Care Unit and Outpatient clinic at Erbil city from August 1st 2020 to July 31st 2021. The inclusion criteria were as follows: all adult patients were aged ≥ 18 years with confirmed SARS – CoV2 infection using RT-PCR test of nasal and throat swab specimens, who underwent pulmonary CT-scan, and measurements of capillary oxygen saturation using pulse oximetry at the time of admission or first medical contact, and having written informed consent to participate in the study. The exclusion criteria were: Age of less than 18 years, pregnancy, severe anemia, any history of severe hemoglobinopathy. Patients were considered to be current smokers if they had smoked at all during the last month; ex-smokers if they had ever smoked; and nonsmokers if they had never smoked. Demographic data of patients, including age, sex, and the presence of any chronic lung diseases were collected. The non-contrast lung CT scan was requested for all patients during first medical contact. Different experienced radiologists with a board certificate in the field of pulmonary imaging examined the lung CT scan of all patients and calculated the severity of lung involvement using the CT scan score. The Chest CT score is a quantitative image scoring system used to assess the lung changes and involvement by COVID-19 based on approximate estimation of pulmonary involved areas. Each of the five lung lobes has been visually scored and given a score from 1 to 5: 1: representing less than 5% lobar involvement, 2: 6–25% lobar involvement, 3: 26–50% lobar involvement, 4: 51–75% lobar involvement, 5: > 75% lobar involvement. The resulting total CT score is the sum of each individual lobar score and ranges from 0 to 25. The capillary blood oxygen saturation was also measured for all subjects using over the counter oximeter that was placed on a fingertip. Hypoxia was defined as a capillary oxygen level of< 95%. An informed written consent was obtained from each patient, the study was consistent with the World Medical Association (WMA) Declaration of Helsinki medical research protocols and approved by the local KBMS ethical committee. Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 25). Fisher's exact test was used (instead of the Chi square test) when the expected frequency (value) was less than 5 of more than 20% of the cells of the table. The Pearson correlation coefficient was calculated to assess the strength of correlation between two numerical variables. A p value of ≤ 0.05 was considered as statistically significant. Follow this order when typing manuscripts: Title, Authors, Affiliations, Abstract, Keywords, introduction, materials and methods, results, conclusion, Acknowledgements, References, Appendix. Collate.

3. Results

The total number of patients was 120. Their mean age (SD) was 54.7 (14.2) years, the median was 56 years, and the age range was 23 – 83 years. Table 1 presents the age distribution and shows that more than half of the patients were aged ≥ 50 years, and 60% were males. The majority (86.7%) were non-smokers, and only 11.7% had history of chronic lung disease (Table 1).

Table 1: Basic characteristics of the studied sample.

	No.	(%)
Age (years)		
< 30	6	(5.0)
30-39	14	(11.7)
40-49	25	(20.8)
50-59	26	(21.7)
60-69	32	(26.7)
≥ 70	17	(14.2)
Gender		
Male	72	(60.0)
Female	48	(40.0)
Smoking		
Ever smoker	16	(13.3)
Non-smoker	104	(86.7)
History of chronic lung disease		
Yes	14	(11.7)
No	106	(88.3)
Total	120	(100.0)

Figure 1 shows that there was a strong inverse significant correlation between the SpO2 and the degree of lung involvement. The more the % of lung involvement, the less the SpO2 levels (Figure 1).

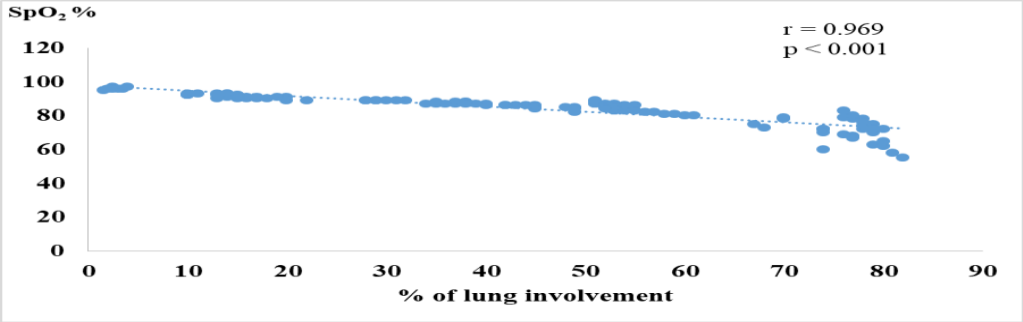

Figure 1: Correlation between degree of lung involvement and SpO2.

It is evident in Table 4 that the more the degree of lung involvement, the more the percentage of patients who had moderate or severe decrease in SpO2 level ($p < 0.001$).

Table 2: SpO2 levels by degree of lung involvement.

		SpO2				
		Normal	**Mild**	**Moderate**	**Severe**	
Percentage of lung involvement	**N**	**No. (%)**	**No. (%)**	**No. (%)**	**No. (%)**	
< 5	7	7 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	
6-25	24	0 (0.0)	24 (100.0)	0 (0.0)	0 (0.0)	
26-50	30	0 (0.0)	0 (0.0)	30 (100.0)	0 (0.0)	< 0.001*
51-75	38	0 (0.0)	0 (0.0)	10 (26.3)	28 (73.7)	
> 75	21	0 (0.0)	0 (0.0)	0 (0.0)	21 (100.0)	
Total	120	7 (5.8)	24 (20.0)	40 (33.3)	49 (40.8)	

*By Fisher's exact test.

It is evident in Table 3 that 20.2% of the non-smokers had extensive lung involvement (> 75%) while none of the ever smokers had extensive lung involvement; in addition to that, 31.3% of the ever-smokers had limited lung involvement (< 5%) compared with 1.9% among the non-smokers (p < 0.001).

Table 3: Degree of lung involvement by smoking status.

Percentage of lung involvement	Ever smoker No. (%)	Non-smoker No. (%)	Total No. (%)	p
< 5	5 (31.3)	2 (1.9)	7 (5.8)	
5-25	1 (6.1)	23 (22.1)	24 (20.0)	
26-50	4 (25.0)	26 (25.0)	30 (25.0)	< 0.001*
51-75	6 (37.5)	32 (30.8)	38 (31.7)	
> 75	0 (0.0)	21 (20.2)	21 (17.5)	
Total	16 (100.0)	104 (100.0)	120 (100.0)	

*By Fisher's exact test.

The majority of those with a history of chronic lung disease had extensive lung involvement where it is evident in Table 4 that the degree of lung involvement was 51-75% among 71.4%, and >75% among 14.3% of the patients with a history of chronic lung disease, compared with 26.4% and 17.9% respectively among those with no such a history (p = 0.017).

Table 4: Degree of lung involvement by history of chronic lung disease.

	History of chronic lung disease			
Percentage of lung involvement	**Yes No. (%)**	**No No. (%)**	**Total No. (%)**	**p**
< 5	0 (0.0)	7 (6.6)	7 (5.8)	
5-25	0 (0.0)	24 (22.6)	24 (20.0)	
26-50	2 (14.3)	28 (26.4)	30 (25.0)	0.017*
51-75	10 (71.4)	28 (26.4)	38 (31.7)	
> 75	2 (14.3)	19 (17.9)	21 (17.5)	
Total	14 (100.0)	106 (100.0)	120 (100.0)	

*By Fisher's exact test.

4. Discussion

In this cross-sectional study, we found that patients with hypoxia had significantly higher CT severity score and lung involvement, specifically there was a strong inverse significant correlation between the SpO2 and the degree of lung involvement. The more the % of lung involvement, the less the SpO2 levels.

This finding is parallel of the same results of *Aalinezhad M* and his colleagues [17] in which there was a significant reverse relationship between CT severity score and oxygen saturation.

In another recent study conducted in United Arab Emirates, *GA Saeed* and his colleagues found that oxygen requirement increase with the increasing CT severity [18].

This progressive increase in oxygen requirement can be due to the direct damage of the lung by the virus causing inflammatory changes in the alveoli that limit oxygen exchange, leading to acute respiratory distress, pulmonary fibrosis, and death. In addition, significant pulmonary thromboembolic effects were also found on autopsies from patients who died from COVID-19 disease [19, 20].

In a study by *Yang* and his colleagues in China, quantitative and semi-quantitative indicators of chest CT scan and their relationship to the clinical conditions of patients were investigated. They studied the CT scan findings of 102 patients with COVID-19 infection and conducted that the total CT severity score was significantly higher in patients with severe COVID-19 infections compared to mild cases. They also suggested that a CT severity score could be used to evaluate the severity of pulmonary involvement [21].

Another preliminary data in Italy by *Marco Francone* and his colleagues suggest the potential role of CT score for predicting the outcome of SARS-CoV-2 patients. CT score is highly correlated with laboratory findings and disease severity and might be beneficial to speedup diagnostic workflow in symptomatic cases [22]. However; none of the above-mentioned studies investigated the correlation between CT severity scores and the degree of hypoxia as our work did. We showed that there is a significant relation between chronic lung diseases and extensive lung involvement on CT scan imaging and specifically they had lower SpO2 saturation on presentation in comparison to those without chronic lung disease. The same finding had been conducted from the results of *Aveyard P* and his colleagues and *Sanchez-Ramirez DC* and his colleagues [23,24].

It had been concluded that tobacco smoking was associated with adverse outcomes and risk factor for severity among patients with COVID-19 [25, 26], 27However; in our study we found that ever smokers had less severe disease and lesser degree of hypoxia and lung involvement. The same findings observed in individual studies of *Chen Q* and his colleagues Dong *X* and his colleagues *Kim ES* and his colleagues, *Park SY* and his colleagues and *Zheng Y* and his colleagues [28, 29, 30, 31, 32].

5. Conclusion

In this cross-sectional study, we found that patients with hypoxia had significantly higher CT severity score and lung involvement, specifically there was a strong inverse significant correlation between the SpO2 and the degree of lung involvement. Moreover, those with chronic lung diseases had more extensive lung involvement and lower SpO2 on presentation

6. Limitations

There are several limitations in our study: First, small sample size and the need for a larger multicenter cohort to increase the accuracy of the findings. Second, we did consider the limited impact of other comorbidities on CT severity. Third, CT images as well as peripheral capillary oxygen saturation were obtained once and no long term follow up data were obtained. Finally, some of chest CT score estimations are approximate and subjective

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7. Recommendations

Our recommendation is that the future larger studies are expected to better clarify the estimated % of lung involvement by measuring the peripheral oxygen saturation using a pulse oximeter.

8. List of Abbreviations

Table 5

Abbreviation	Stands for
COVID-19	Corona Virus Disease – 19
CT	Computed Tomography
SpO2	Peripheral Capillary Oxygen Saturation
WHO	World Health Organization
RT-PCR	Reverse Transcription –Polymerase Chain Reaction
SARS – CoV2	Severe Acute Respiratory Syndrome – Coronavirus
CT – SS	Computed Tomography – Severity Score
TSS	Total Severity Score
m-TSS	Modified Total Severity Score

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