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Correlation between HRCT chest findings and clinical condition of coronavirus disease (COVID-19)

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Abstract:

Introduction: SARS-CoV-2 infection, also known as COVID-19 is not limited to the respiratory system only but also it can affect other organs. Ground glass opacities (GGOs), and bilateral and peripheral distributions are more common in CT findings among COVID-19 patients. Radiological imaging such as High-Resolution Computed Tomography (HRCT) of the chest could be considered a diagnostic tool for COVID-19.

Aim of the study: To evaluate and correlate the usage of HRCT in COVID-19 disease.

Subjects and Methods: Fifty individuals diagnosed as COVID-19 patients enrolled in the study. Full clinical, laboratory and radiological investigations were performed on each individual. CT score was calculated and compared accordingly to all patients' data.

Results: There was a negative correlation between CT score and oxygen saturation with r =-0.352 and p =0.012. Results revealed that there was no significant difference between the CT score and any of the patients' descriptive data nor the laboratory data where p >0.05. Bilateral and unilateral GGOs, pleural effusion as well and consolidation were observed after radiological investigations where the majority of the patients had bilateral GGO involvement covering 84% of the patients.

Conclusions: Radiological imaging may be useful in the diagnosis of suspected individuals and accurately evaluate the degree of pulmonary affection.

Keywords: Ground glass opacities; COVID-19; High Resolution Computed Tomography; CT Score.

1. Introduction

The coronavirus family has been previously known since 1965 which causes upper respiratory tract infection in individuals [1]. Symptoms varied between mild and moderate but became severe from the pandemics caused by the three known viruses of the coronavirus family: in 2002 SARS (SARS-CoV); in 2012 MERS

(MERS-CoV) and 2019 SARS-CoV-2 (COVID-19) [2].

Reverse transcription polymerase chain reaction (RT-PCR) assay is not just the diagnostic tool for predicting COVID-19 patients. Radiological imaging has a vital role in the diagnosis and management of COVID-19 pneumonia which is the predominant clinical manifestation of the disease. High-Resolution Computed Tomography (HRCT) of the chest is considered the first-line imaging modality in highly suspected patients [3-6].

CT scan of the chest is reliable in the diagnosis of COVID-19 symptomatic patients. Various researchers reported that chest CT has a high sensitivity and specificity for detecting lung lesions in patients with COVID-19. Bilateral peripheral multifocal ground glass opacities (GGOs) as well as patchy sub-segmental consolidations are typical patterns of COVID-19 viral pneumonia in HRCT chest [7,8].

The work aims to correlate and compare HRCT chest findings and the severity of the clinical condition of coronavirus disease.

2. Subjects & Methods

2.1. Subjects

A total number of 50 subjects were enrolled in the study. All patients were subjected to full medical history taking, clinical examination, PCR test, HRCT assessment of the chest, and full lab assessment including complete blood count with differential, serum ferritin, D-dimer and C-reactive protein (CRP). O_2 saturation assessment by pulse oximeter to assess hypoxemia has been performed as well.

For the sample size calculation, the following equation was used with absolute error/precision of 13%, agreeing on 50 subjects for each group to be included in the study [8]:

$$N = \frac{Z_{1-\frac{\alpha}{2}}{}^2 \, p(1-p)}{d^2} = 48.6$$

Inclusion criteria

Positive PCR COVID-19 patients showed evidence of pulmonary affection in the HRCT scan.

Exclusion criteria

Patients with advanced pulmonary diseases such as tuberculosis, interstitial lung diseases, human immunodeficiency virus or bronchogenic carcinoma and/or with negative PCR were excluded.

2.2. Study design

The present study is a retrospective study carried out from in Radiology department, Faculty of Medicine, Fayoum University Hospitals. The patients were collected from the period between May 2020 and May 2021. The study is fulfilling the rules of the Declaration of Helsinki 1975. Ethical approval number M500 was obtained on 10/11/2020 from the ethical committee of the Faculty of Medicine, Fayoum University.

Non-contrast HRCT images were performed by Canon Aquilion Prime unit, made in Japan. HRCT of the chest was done using CT scans with thin sections (1.2 mm up to 1.5 mm thickness of the slice throughout the lungs) and a reconstruction algorithm with high spatial frequency to image pulmonary parenchymal and small airway diseases. It was carried out by using single breath hold volumetric raw data permitting reconstruction of spaced and/or overlapping HRCT images.

The patient lies down in a supine position with extended arms over his head and holding his breath following deep inspiration. The scanning begins at the thoracic inlet cranially down to the upper abdomen caudally. The acquired HRCT images were processed and reconstructed into soft tissue mediastinal and lung windows in axial and coronal sections.

2.3. Statistical Methods

Data access and evaluation were performed using a statistical package of social science on Windows 8.1(SPSS 17.0). The Kolmogorov-Smirnov test was used for analysis and Skewed data, median/range was used. Mann-Whitney U test was used for determining the statistical significance at *p*-value <0.05. The chi-square test was used to compare demographic data i.e. gender and comorbidity for categorical variables. Data are shown as percentages; odd ratios and 95% confidence interval. For Normal quantitative parametric data, a student t-test was used to measure and compare two independent groups. A one-way ANOVA test was used to evaluate and compare more than two independent groups. The Kolmogorov-Smirnov test was used for the evaluation of non-parametric data.

Mann-Whitney U test was used to compare outcomes between 2-independent groups. The Kruskall-Wallis test was used for comparing more than three groups. A Bivariate Pearson correlation test was used to find out the association between groups. ROC Curve (Receiver Operating Character), sensitivity and specificity were generated.

3. Results

Fifty patients with positive PCR diagnosed as COVID-19 were enrolled in the present study with a mean age of 47±14.87 years. Baseline characteristics, laboratory investigations as well as radiological findings for COVID-19 patient group are shown in **(Table 1).**

Table 1. Baseline Characteristics, laboratory investigations and radiological findings for patients with COVID-19.

Variable		Frequency
Demographic Characteristics		
Age (years) (Mean±SD)		47 ±14.9
Sex	Male	37 (74%)
	Female	13 (26%)
Comorbidity	None	34 (68%)
	Diabetes Mellitus	28 (56%)
	Hypertension	22 (44%)
Symptoms		
Fever	Yes	37 (74%)
	No	13 (26%)
Dyspnea	Yes	24 (48%)
	No	26 (52%)
Cough	Yes	40 (80%)
	No	10 (20%)
Fatigue	Yes	13 (26%)
	No	37 (74%)
GIT symptoms	Yes	8 (16%)
	No	42 (84%)
Laboratory Investigations		
Lymphocytes	Lymphocytosis	1 (2%)

	Lymphopenia	16 (32%)
	Normal	33 (66%)
d-dimer	Elevated	10 (20%)
	Normal	40 (80%)
Serum ferritin	Elevated	14 (28%)
	Normal	36 (72%)
CRP	Negative	22 (44%)
	Positive	28 (56%)
GGO Analysis	Bilateral GGOs involvement	42 (84 %)
	Unilateral GGOs involvement	8 (16%)
	Multi-lobar involvement	41 (82%)
	Consolidation	17 (34%)
	Pleural effusion	4 (8%)
Oxygen saturation (Mean±SD)		92.4 ±7
CT score (0-25) (Mean±SD)		7.9 ±5.1

An Independent sample T-test is used for age parameters. The chi-square test is used for sex, smoking and comorbidity variables.

Based on the radiological investigations, our findings showed that GGO was predominant among the studied group. The majority of the patients 84% had bilateral GGO involvement. Also, multi-lobar GGOs, unilateral GGOs, pleural effusion as well as consolidation were reported with percentages of 82%, 16%, 8% and 34% respectively.

CT severity score was determined for each one of the five lung lobes and then the final total score was calculated by the sum of each lobe score which ranges from 0 up to 25. CT severity score index was calculated and given for all patients to each one of the five lung lobes ranging from 0 to 5. Score 0, 0% affection; score 1, less than 5% affection; score 2, 5% to 25% affection; score 3, 26% to 49% affection; score 4, 50% to 75% affection; and score 5, more than 75% affection [9].

Accordingly, patients were subdivided into two groups according to WHO COVID-19 disease severity:

- Moderate: 37 (74%).
- Severe: 13 (26%).

Then we compared the CT score for all patients with the descriptive data, laboratory data as well and other radiological findings.

No significant difference was found between the CT score and any of the patients' descriptive data/laboratory data where $p > 0.05$ **(Table 2). Figure 1** shows a CT scan for random patient selection involved in the present study.

Table 2: Relation between CT Score and COVID-19 patients' investigations.

Parameters		CT score (0-25)		*P*-value
		Mean±SD	Median (Range)	
Sex	Female	8.9 ±4.5	7 (3-19)	0.258
	Male	7.6 ±5.3	7 (1-25)	
Co-morbidities	DM	6.2 ±2.8	7 (1-11)	0.171
	HTN	5.4 ±3.9	5 (2-12)	
	No	8.9 ±5.6	8 (1-25)	0.329
Fever	Yes	8.2 ±4.9	7 (1-25)	
	No	7.2 ±5.7	6 (1-19)	0.793
Dyspnea	Yes	8.4 ±6.5	6.5 (1-25)	
	No	7.5 ±3.4	7.5 (1-17)	0.933
Cough	Yes	8.1 ±5.5	7 (1-25)	
	No	7.1 ±2.7	8 (2-11)	0.346
Fatigue	Yes	6.3 ±3.1	7 (1-10)	
	No	8.5 ±5.6	7 (1-25)	0.442
GIT symptoms	Yes	6.3 ±2.8	6.5 (2-10)	
	No	8.2 ±5.4	7 (1-25)	0.052
Lymphocytes	Lymphocytosis	11	11 (11-11)	
	Lymphopenia	10 ±5.8	9 (2-25)	
	Normal	6.8 ±4.5	7 (1-19)	0.526
d-dimer	Elevated	10.3 ±8	7 (1-25)	
	Normal	7.3 ±4	7 (1-17)	0.573
Serum ferritin	Elevated	8.5 ±4.7	7 (3-19)	
	Normal	7.7 ±5.3	7 (1-25)	
CRP	Negative	8 ±5.7	**7** (1-25)	0.868
	Positive	7.9 ±4.7	**7** (1-19)	

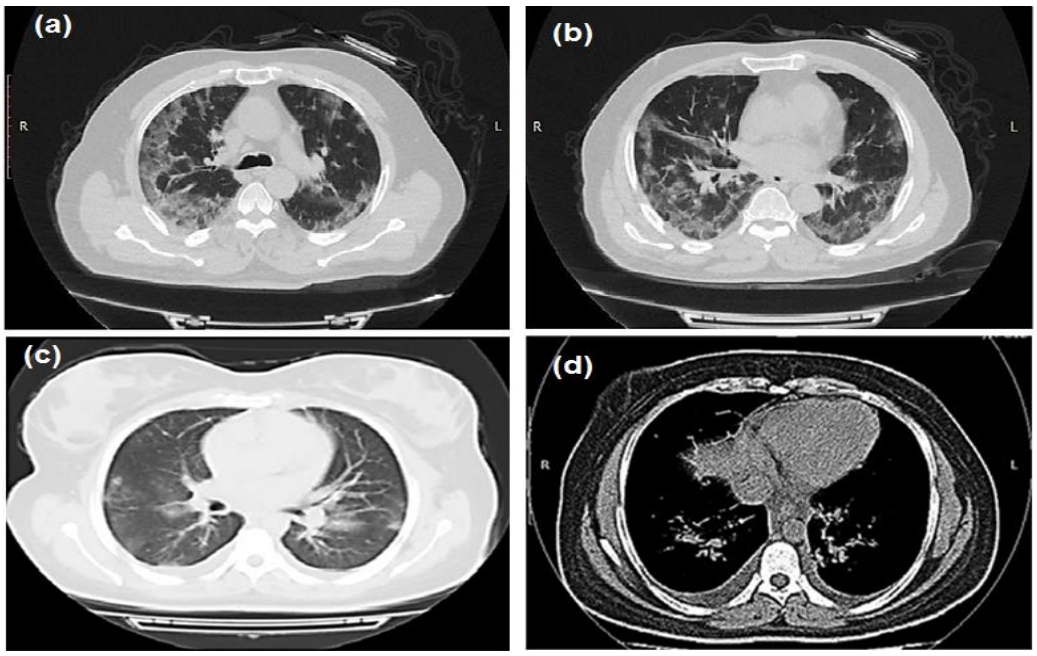

Figure 1. CT Scan for Random COVID-19 Patients. (a)(b) Male Patient with 75% oxygen saturation, CT severity score index: 19/25, classified as severe COVID-19 with symptoms of cough and dyspnea. HRCT chest lung window shows well-defined peripherally located patchy areas of ground glass opacities associated with vascular thickening and fibrous bands scattered at both lung fields, being more evident on both lower lung lobes. (c) Female Patients with 90% oxygen saturation, CT severity score index: 6/25, classified as moderate COVID-19 with symptoms of fever and cough HRCT chest lung windows show rather defined peripherally located patchy areas of ground glass opacities associated with vascular thickening and fibrous bands scattered at both lung fields, being more evident on both lower lung lobes. (d) HRCT chest mediastinal window shows mild bilateral pleural effusions.

Pearson correlation was used among patients' data which showed that there was a negative correlation between CT score and oxygen saturation (r =-0.352, p =0.012). There were no other correlations found among the patients (**Figure 2**).

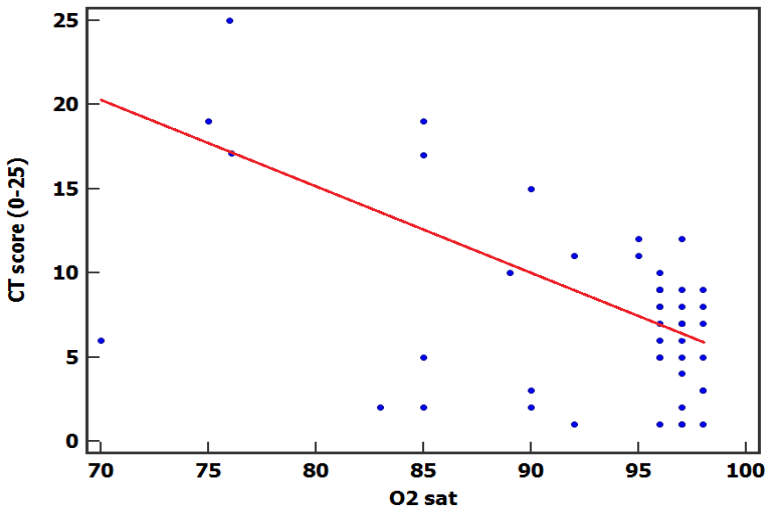

Figure 2. Correlation between CT Score and Oxygen Saturation among patients with COVID-19.

Within the studied group, only three patients covering 6% of the total patients died. However, after evaluating the CT score concerning the cure and death rate, results revealed that between cure and death patients there was no significant difference with a mean and standard deviation of 8 ±5.2 and 7 ±4.0 respectively with p =0.939.

4. Discussion

COVID-19 virus is highly transmissible from one individual to another mainly through respiratory droplets such as cough and sneezing. Early detection and disease identification of COVID-19-infected individuals has become mandatory to control the spread of the virus [10,11].

Cytokine storm or raised inflammatory cytokines as well as hyper inflammation syndrome are responsible for functional impairment of the immune system and are precipitated by the COVID-19 virus [12].

In severely chronically ill patients, the patient's immunity as well as the virulence of the organisms are determining factors for the disease outcome whereas elder males are more susceptible to infection due to their incompetent immunity [13].

In the present study and based on the demographic data, our finding showed that

males are more likely to have COVID-19 infection than females with a percentage of 74%. Males were more likely to be infected with COVID-19 because of the high levels of ACE2 receptors which are present in the epithelial cells (EC) of the trachea, bronchi, alveoli, and macrophages which are utilized by the virus to enter the targeted cell [11, 14-16].

Out of fifty patients, 30.0% had comorbidities either hypertension or diabetes or both. Cough, fever, and dyspnea were the most common symptoms among patients with 80, 74 and 48% of patients.

In agreement with our finding, it was reported that most infected patients had other comorbidities including hypertensive patients [16-19]. Cough, fever and dyspnea are also combined clinical manifestations and symptoms of COVID-19 [9, 20].

Furthermore, studies concluded that elevated D-dimer levels and CRP are more common and found in patients with positive COVID-19 and are basic predictors for the disease outcome. These laboratory investigations result from the severe inflammatory response and disseminated intravascular coagulopathy present in infection generally [21, 22].

In the present study, full laboratory investigations were performed among patients where 66% of patients showed normal lymphocytic count, 32.0% lymphopenia and 2.0% lymphocytosis, with normal serum ferritin covering 72.0% of the patients and only 28% were with elevated serum ferritin. As for CRP, 56% of the patients were positive 44% were negative and 80% with normal D-dimer and only 20% were elevated. That was most likely in agreement with various studies [13, 23, 24], while by the work of others [9, 25].

The main radiological manifestation of COVID-19 patients is GGOs which are characterized by being unilateral or bilateral, mainly multifocal, lower lobar and peripheral in location as well as consolidations [2, 27]. In addition, vascular dilatation and traction bronchiectasis are common GGO findings in COVID-19 patients [3, 18].

Based on the clinical and radiological investigations we reported that 84% of the patients had Bilateral GGO involvement, 82% had Multi-lobar involvement, 16% had Unilateral GGO involvement, 8% were Pleural effusion and 34% were Consolidation.

Although, CT imaging results may reflect the disease severity, yet, the discrepancy in radiological findings among the clinical stages of COVID-19 disease is not well known [3]. The correlation between radiological findings and laboratory results as well as oxygen saturation may be beneficial and aid in the treatment of the COVID-19 virus [28].

We reported that there is a negative correlation between CT score and oxygen saturation among COVID-19 patients. This could be a strong indicator of a high mortality rate whereas lung affection in HRCT increases, admission to the intensive care unit or even death also increases [22, 29-31].

5. Conclusion

Radiological imaging such as HRCT chest could be considered a useful diagnostic tool for suspected individuals and accurately evaluate the degree of pulmonary affection.

Ethical approval and consent to participate: The Ethics Committee of the Faculty of Medicine, Fayoum University approved this work with approval number M500 and date of approval 11/10/2020).

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Conflicts of Interest: All authors declare they have no conflicts of interest.

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