Chest CT Severity Score in association with disease severity and outcome in COVID-19

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Background:
The outbreak started in Wuhan, December 2019, spread to every continent after reporting its first case on December 22, 2020. Because radiological findings consistent with COVID-19 have been seen in patients with negative RT-PCR, combining the two modalities saves time and money by eliminating need for repeat PCR testing for diagnosis while also allowing for identification of the stage and severity of lung involvement. We analyzed numerous radiological indications of COVID-19 infection on non-enhanced CT chest and determined their relationship to severity and outcome in this retrospective investigation.
Methods:
This study was conducted at Ziauddin Hospital Clifton, Karachi, Pakistan from April 2020 to December 2020. Patients aged 18 and above were included and patients with underlying interstitial lung disease or destructive lung diseases were excluded. The WHO standards were used to categorize severity of the disease. Certified radiologist reviewed the CT scans and graded them using Chest CT Severity Score developed by Dutch Radiological Society, calculated by separating 18 bronchopulmonary segments into 20 regions.
Results:
Mean age of study population was found 60.1±14.7. Males were predominant 154 (72.6%) while females were 58 (27.3%). We found that critical patients are significantly associated with the outcome than the mild, moderate and severe. We found strong association of age (p-value 0.001), length of hospital stay (p-value 0.001), clinical severity (p-value 0.001), CT severity score (p-value 0.001), and CT severity group (p-value 0.002).
Conclusion:
In patients with COVID-19 infection, CT severity score is linked to length of hospital stay, outcome, and severity.
Key Words: COVID, Severity, Pneumonia, CT, Score

I. INTRODUCTION

SARS COV-2 infection is a highly contagious disease that primarily affects the lungs, with symptoms ranging from mild pneumonia to severe acute respiratory distress syndrome, requiring mechanical ventilation and prolonged intensive care admission, with eventual progression to sepsis, septic shock, and multiorgan dysfunction syndrome occurring in a minority of cases. (1) The epidemic, which began in a small Chinese city in December 2019, has already spread across all continents, with Antarctica reporting its first case on December 22, 2020. (2) On February 26, 2020, the city of Karachi announced the first incidence of Corona virus in Pakistan. Since then, 532,412 instances have been documented across the country, resulting in 11,295 deaths. (3)

It is clear that early detection of COVID 19 is critical for both the patient and the surrounding population in order to intervene effectively while also preventing communal transmission. (4) RT-PCR assays, obtained using oropharyngeal and nasopharyngeal PCR samples, are the current gold standard modality. (5) However, in clinical practice, a combination of parameters such as illness duration, viral load, rate of viral replication in the upper respiratory tract, and sample quality have resulted in a sensitivity of 64.8 percent. In epidemic areas, however, computed tomography (CT) examination has gained appeal as a diagnostic tool due to its great sensitivity. (6) The fact that radiological findings consistent with COVID-19 infection have been seen in patients with negative RT-PCR explains why combining both modalities saves time and money by eliminating the need for repeated PCR testing for diagnosis while also allowing for the identification of the stage and severity of lung involvement. (7) Based on this premise, CT scores have been utilized to not only diagnose quickly, but also to forecast the patient's prognosis and correlate with illness severity. (8)

Multifocal bilateral peripheral ground glass opacities, with or without focal consolidations, in lung regions near to pleural surfaces, particularly the fissures, are the most worrisome CT findings for COVID-19 infection in the lungs. (9) Despite the fact that subpleural involvement is common, subpleural sparing may also be present. (10) This retrospective study will allow us to examine several radiological manifestations of COVID-19 infection on non-enhanced CT chest and establish its relation to illness severity and outcome.

II. METHODS

This retrospective study was conducted at Ziauddin Hospital Clifton, Karachi, Pakistan from April 2020 to December 2020. Patients aged 18 and above 18 who fulfilled the WHO case definition for COVID-19 were included in the study. Patients who are below 18 years of age, those who have underlying Interstitial Lung Disease or destructive lung disease due to any cause were excluded.

Data collection procedure:

The study was carried out after receiving approval from the Dr Ziauddin University Hospital's Ethical Review Committee. All patients hospitalized to COVID Ward, COVID

HDU, and COVID ICU from April to December 2020 had their records removed. Data from epidemiology, clinical practice, microbiology, and radiology were examined. The WHO standards were used to categorize the severity of the disease. A certified radiologist reviewed the CT scans and graded them using the Chest CT Severity Score. Throughout the research, confidentiality was maintained.

CT Severity Score:

The CT Severity Score is based on a criterion first used in 2003 to report ground glass opacity, air trapping, and interstitial opacity in SARS patients. This score, developed by the Dutch Radiological Society, is calculated by separating 18 bronchopulmonary segments into 20 regions. The upper left lobe's apicoposterior segment is separated into apical and posterior sections, whereas the lower left lobe's anteromedial basal segment is divided into anterior basal and medial basal regions. The scoring is done based on the proportion of region involved, with 0 representing 0%, 1 representing less than 50%, and 2 representing 50% or more opacification of parenchyma, for a total of 40 for both lung fields. (11)

Severity of COVID-19:

All the patients recruited were classified according to the WHO guidelines for the severity of COVID-19 disease as follows. (12)

1. **MILD DISEASE**

Symptomatic patients meeting the case definition for COVID-19 without evidence of viral pneumonia or hypoxia.

2. **MODERATE DISEASE**

Adult with clinical signs of pneumonia (fever, cough, dyspnea, fast breathing) but no signs of severe pneumonia, including SpO2 ≥ 90% on room air.

3. **SEVERE DISEASE**

Adult with clinical signs of pneumonia (fever, cough, dyspnoea, fast breathing) plus one of the following: respiratory rate > 30 breaths/min; severe respiratory distress; or SpO2 < 90% on room air.

4. **CRITICAL DISEASE/ ACUTE RESPIRATORY DISEASE SYNDROME:**

Onset: within 1 week of a known clinical insult (i.e. pneumonia) or new or worsening respiratory symptoms.

Chest imaging: (radiograph, CT scan, or lung ultrasound): bilateral opacities, not fully explained by volume overload, lobar or lung collapse, or nodules.

Origin of pulmonary infiltrates: respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (e.g. echocardiography) to exclude hydrostatic cause of infiltrates/edema if no risk factor present. Oxygenation impairment in adults: • Mild ARDS: 200 mmHg < PaO2/FiO2 a ≤ 300 mmHg (with PEEP or CPAP ≥ 5 cmH2O). • Moderate ARDS: 100 mmHg < PaO2/FiO2 ≤ 200 mmHg (with PEEP ≥ 5 cmH2O).b • Severe ARDS: PaO2/FiO2 ≤ 100 mmHg (with PEEP ≥ 5 cmH2O)

STATISTIC ALANALYSIS:

SPSS software and the R programming language were used to conduct statistical analysis. Continuous variables were expressed as mean standard deviation, while discrete variables were expressed as percentages (SD).

For categorical variables, the chi-square test or Fisher's exact test were used to compare frequency. For continuous variables, the Student's t-test or the Mann-WHITNEY U TEST WERE USED.

III. RESULTS:

Total 212 patients of different severities were recruited during the study periods by the consecutive sampling technique. Mean age of all study population was found 60.1±14.7. Males were predominant in the current study 154 (72.6%) while females were 58 (27.3%). Majority of the patient were PCR positive 166 (78.3%) and 46 (21.7%) were negative for rt-PCR. Mild cases were 32 (15.0%), moderate were 32 (15.0%), severe were126 (59.4%) and critical were 22 (10.3%) of all patients. As shown in Table1.

We wanted to seek out the association of the different variables of the study population with the outcome of the patients included in the study. We found strong association of age (p-value 0.001), length of the hospital stay (p-value 0.001), clinical severity of the patients (p-value 0.001), CT severity score (p-value 0.001), CT severity group (p-value 0.002), shown in Table 2.

We further evaluated to look for any statistical link of the outcome with the study variables to seek the significant clinically classified severity groups by applying the multivariant logistic regression. We found that critical patients are significantly associated with the outcome than the other mild, moderate and severe patients. CT severity score and length in hospital stay are also significantly associated with the outcome. Table 3 and 4

Table. 1: Demographics and clinical parameters of study subjects

Variables	Total number of patients n (%)
Total number of admissions	212
Age	60.2±14.7
Sex • Female • Male	 58 (27.3%) 154 (72.6%)
Duration of illness	7.8 (4.5)
COVID PCR • Positive • Negative	 166 (78.3%) 46 (21.7%)
Length of stay (ICU)	9.5 (8.7)
Disease classification • Mild • Moderate • Severe • Critical	 32 (15.0%) 32 (15.0%) 126 (59.4%) 22 (10.3%)
CT score	23.1 (8.7%)
Outcome • Deaths • Discharged	 64 (30.1%) 148 (69.8%)

Table. 2: Statistical link of study population by outcome of the patients

Variables	Deaths n (%)/Mean	Discharged n (%)/Mean	p-value
Total number of patients	64 (30.1%)	148 (69.8%)	
Ageα	63.6±1.6	58.7±1.2	0.001*
Sexβ Female Male	 16 (25%) 48 (75%)	 42 (28.3%) 106 (71.6%)	 0.73
Duration of illness (days) α	7.4±4.8	8.0±4.4	0.37
COVID PCRβ Positive Negative	 53 (82.8%) 11 (17.1%)	 113 (76.3%) 35 (23.6%)	 0.36
Length of stay in ICU (days) α	14.4±10.9	7.4±6.6	0.001*
Disease classificationβ Mild Moderate Severe Critical	 3 (4.6%) 4 (6.2%) 39 (60.9%) 18 (28.1%)	 29 (19.5%) 28 (18.9%) 87 (58.7%) 4 (2.7%)	0.001*
CT Severity Scoreα	26.5±8.6	21.7±8.3	0.0002*
CT Severity group β Normal (0) Mild (1-9) Moderate (10-19) Severe (>19)	 0 (0.0%) 5 (7.8%) 6 (9.3%) 53 (82.8%)	 2 (1.3%) 17 (11.4%) 26 (17.5%) 103 (69.5%)	 0.25

α Mean±standard deviation (independent sample t-test)
β Pearson Chi-square test

Table. 3: Univariate Logistic Regression

Variables	OR (95% CI)	p-value
Age	0.97 (0.95,0.99)	0.02*
Sex	1.18 (0.60,2.32)	0.61
Duration of illness	1.02 (0.96,1.09)	0.37
COVID PCR	1.49 (0.70,3.16)	0.28
Length of ICU stay	0.89 (0.86,0.93)	<0.001*
Disease classification Mild Moderate Severe Critical	Reference 0.73 (0.14,3.53) 0.23 (0.06,0.80) 0.02 (0.00,0.11)	<0.001*
CT severity score	0.92 (0.88,0.96)	<0.001*

Table. 4: Multivariable Logistic Regression Final Model

Variables	OR (95% CI)	p-value
CT severity score	0.96 (0.91,1.0)	0.05*
Disease classification Mild Moderate Severe Critical	Reference 0.84 (0.16,4.34) 0.54 (0.14,2.09) 0.03 (0.00,0.16)	 0.84 0.38 <0.001*
Length of ICU stay	0.90 (0.86,0.95)	<0.001*

IV. DISCUSSION:

When rt-PCR testing is not available, in case of delayed test results, or when there is a clinical suspicion of covid-19 despite initial negative rt-PCR testing, the who recommends using chest imaging as part of the diagnostic workup for covid-19 disease. (13) clinicians and radiologists should collaborate to create the best imaging modality decision possible. (14)

CT scan can be helpful in determining the severity of a patient's condition. the quantitative severity can be determined using a visual method (as in our study) or software that uses deep learning algorithms to determine the percentage of afflicted lung volumes. (15, 16)

we used the visual assessment of each of the 5 lung lobes in our investigation due to the lack of software. the severity levels were then divided into categories depending on the total cumulative severity score. (17, 18)

Our sample had a male inclination and was of a somewhat middle age (mean 60.2 years). this can be explained by the population's unique characteristics in Pakistan, which include a high prevalence of young male exposed workers. (2)

Males were the ones who had the most severe sickness (72.6%). according to studies, this disparity can be attributable to a variety of variables, including behavioral differences and the potential protective impact of estrogen. (19, 20) the middle-aged group had the most severe illness and the greatest fatality rates. this can be influenced by a variety of factors, including the stage of the pandemic at the time of the study, the presence of patients' comorbidities, the maturity and preparedness of the healthcare system, and the presence of senior nursing homes where disease can spread more quickly. (21)

A comprehensive study conducted by rees et al. found that the length of hospital stay for patients with covid-19 disease varied based on several parameters such as admission and discharge criteria, bed demand and availability, and different timing within the pandemic (22). patients with severe ct results had a considerably higher death rate in our sample, as has been shown in other research. (23, 24)

The study has numerous limitations, the first of which is the need for a bigger multicenter sample to improve the accuracy of the findings, and the second of which is the fact that determining the severity of disease on CT scans can be subjective. this was mitigated by enlisting the help of two seasoned readers to establish an agreement. finally, other factors that may influence illness outcome, such as lifestyle and reliance on self-reporting/underreporting of comorbidities, should be taken into account.

V. Conclusion:

To summarize, CT scans can play an important role in assisting physicians with their management plans and can serve as a predictor of disease severity and outcome. in patients with covid-19 infection, CT severity score is linked to length of hospital stay, outcome, and severity. more research is needed, however, to better understand the relevance of chest ct for covid-19 disease prognosis, especially the association with patient outcome.

CONFLICT OF INTEREST:

The authors declared no conflict of interest and all authors have studied and approved the final manuscript.

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Not applicable

ETHICAL APPROVAL:

IRB: Approved by Ethical Review Committee, Ziauddin Medical University,

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AUTHOR'S DECLARATION:

AK and MG conceived the idea, designed the project, and did bench work. He also supervised the whole project. SK and ZM wrote the manuscript done the statistics, MA and FI helped in sampling, reviewing and extraction of data. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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