Correlation between Chest CT Score and Outcome of COVID-19 Patients: Experience from A COVID Hospital of Chattogram, Bangladesh

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Abstract

Background: Studies elsewhere in the world observed that, chest Computed Tomography (CT) scoring could help to stratify patient's risk and predict short-term outcome of patients with COVID-19 pneumonia. But report from Bangladesh in this regard is in short supply. This study was aimed to investigate the relationship between the percentage of lung involvement as defined by CT scan score and outcome of COVID-19 patients admitted in a COVID dedicated hospital of Bangladesh.

Materials and methods: This prospective observational study included 103 RTPCR confirmed COVID19 patients admitted in Chittagong Medical College Hospital (CMCH). All patients had a non-contrast HRCT scan done at presentation. Severity of CT score was categorized as Mild: score 7 or less, Moderate: score 8–17 and severe: score 18 or more. Outcome data in terms of oxygen requirement, length of hospital stay and in-hospital mortality were collected.

Results: The mean age was 53.12 ± 12.69 years (58.3% males, 41.7% females). CT severity score was found to be positively correlated with clinical category of COVID-19. The oxygen requirements and length of hospital stay were increasing with the increase in scan severity. Multivariate analysis revealed that CT severity score was the only significant predictor for death (Odds ratio: 1.228; 95% CI:1.019-1.48).

Conclusions: Our data suggest that chest CT scoring system can aid in predicting COVID-19 disease outcome and significantly correlates with oxygen requirements in a sample of Bangladeshi COVID-19 patients.

Key words: COVID-19; CT severity; Mortality.

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Introduction

Coronavirus Disease 2019 (COVID-19) is an ongoing public health threat since the pandemic declaration of World Health Organization (WHO) on 11 March 2020.[1,2] According to the WHO, there have been 144,358,956 confirmed cases of COVID-19 cases and 3,066,113 deaths with a mortality rate of 7.1% as of April 23, 2021.[3] The clinical presentations vary from asymptomatic carriers to patients requiring assisted ventilatory support, and ICU admissions with increased mortality made it an unusual and unprecedented challenge.[4,5] The nasopharyngeal swab real-time Reverse Transcription-Polymerase Chain Reaction (RT-PCR) test has been the diagnostic test used as the standard of reference for disease confirmation.[4] The test is a powerful tool, however, there is a small but significant proportion of false-negative results reported.[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] Moreover, the disease severity can be ascertained from the imaging findings, significantly supporting the clinicians in their clinical judgment and ensuring effective and timely management.[8] Among patients with similar clinical characteristics and with similar treatment regiments, there may be a diversity in clinical outcomes. Therefore, the development and use of an accurate predictor for COVID-19 prognosis will be beneficial for the clinical management of patients with COVID-19, and will help reduce the mortality rate.[9]

Multiple studies have explored the pulmonary involvement on the chest CT images using both visual and software quantitative assessments.[10,11] To our knowledge, the current study was the first study to describe the correlation of chest CT severity scores and the clinical picture of patients with COVID-19 disease in Chattogram, Bangladesh. Our study correlates the CT severity score

with the clinical severity of the hospitalized patients who were confirmed to have COVID-19 disease.

Materials and methods

This prospective observational study was conducted in Chittagong Medical College Hospital. Following the approval from the Ethical Review Committee of Chittagong Medical College (Memo NO.: CMC/PG/2020/109) on August 13, 2020. Informed consent was obtained from competent patients before enrollment. In patients who were unable to give fully informed consent, assent was obtained from a legal representative.

RTPCR confirmed COVID-19 patients having chest CT scan report on admission were included in this study from August 15, 2020 to January 30, 2021. Patients with active cancer or on cancer chemotherapy, having active Pulmonary Tuberculosis, had finished treatment of Pneumonia or lung abscess within six weeks of COVID -19 presentations, known interstitial lung disease, left ventricular failure or congestive cardiac failure were excluded. Relevant outcome data were recorded from case record file. Case definition and severity categorization was done in accordance with the national guideline.[12]

Chest HRCT scans available on the day of patients' admission, within the 1st week of their onset of symptoms, were assessed for whether negative or positive for typical findings of COVID-19 pneumonia as defined by the RSNA Consensus statement.[8,13] Three multidetector CT scanners of three different investigation centers were used for all. Scanning parameters were identical to the manufacturer's standard recommended pre- setting for a thorax routine. All CT images were independently reported by one specialist radiologists of the corresponding investigation center and reviewed by another one fixed radiologist, with more than 10 years of experience, blinded to the clinical data and laboratory indicators, in a standard clinical picture archiving and diagnostic system workstation. Severity was then categorized as mild, moderate and severe as per the CT scan severity score (Mild: score 7 or less, Moderate: score 8-17 and severe: score 18 or more).[14]

Statistical analyses were performed with Statistical Package for the Social Sciences version 23.0 for Windows. Descriptive statistics of patients' demographics, clinical and laboratory results were reported as frequencies (Percentage), mean (±Standard deviation) or Median (Range). Frequencies of CT scores were calculated and compared with other clinical variables. For univariate analysis Chi-square test and Kruskal Wallis test was used. A binary logistic regression analysis yielding odds ratios with 95% confidence intervals (95% CIs) was applied to test predictors of death in COVID-19 patients. p value less than 0.05 was defined statistically significant.

Results

The study population included 103 patients (60 males, 43 females (Mean age 53.12 ± 12.69, range 26-81 years). Majority (65%) of the patients had comorbidity and most frequent comorbid condition was hypertension (46.6%), followed by diabetes (43.7%), ischemic heart disease (21.4%) COPD (17.5%). As per the national guideline majority of the patients (45.6%) were classified as moderate category, followed by 39.8% in mild category and only 14.6% were in severe or critical category. Percentage of lung involvement was ranged from 8-96% in the study with a median value of 24%. CT severity score was ranged from 2-24 with a median value of 6. Mild CT scans changes were observed in majority of the case (54.4%) and only four (3.9%) cases had severe disease on CT scan (Table I).

Table I : Demographic, clinical and CT characteristics of the patients (n=103)

Characteristics	Frequency (Percentage)
Age	
Mean (±SD) age	53.12 (±12.69)
Range	26-81
Sex	
Male	60 (58.3)
Female	43 (41.7)
Comorbidities	
No comorbidities	36 (35.0)
Hypertension	48 (46.6)
Diabetes mellitus	45 (43.7)
Ischemic heart disease	22 (21.4)
Chronic obstructive pulmonary disease	18 (17.5)
Obesity	17 (16.5)
Chronic kidney disease	9 (8.7)
Clinical category	
Mild	41 (39.8)
Moderate	47 (45.6)
Severe/Critical	15 (14.6)

Percentage of lung involvement on CT	
Median (Range)	24 (8-96)
CT severity score	
Median (Range)	6 (2-24)
CT severity category	
Mild	56 (54.4)
Moderate	43 (41.7)
Severe	4 (3.9)

Out of the 103 patients, 28 patients (27.2%) did not require any oxygen support. The remaining 75 patients required oxygen supplement as follows: 29 patients (28.2%) required 1-5 liter of oxygen through nasal cannula, 25 patients (24.8%) required 6-10 liter of oxygen, 6 patients (5.8%) required 11-15 liters of oxygen and 15 patients (14.6%) required a High-Flow Nasal Cannula (HFNC). In terms of clinical outcome, 98 patients (95.1%) were found alive, 5 (4.9%) expired in hospital (Table II).

Table II : Outcome of the patients (n=103)

Outcome parameters	Frequency (%)
Maximum O_2 requirement	
None	28 (27.2)
1-5 liter	29 (28.2)
6-10 liter	25 (24.3)
11-15 liters	6 (5.8)
High flow nasal cannula	15 (14.6)
Develop Acute respiratory distress syndrome	14 (13.6)
Develop Multiorgan dysfunction syndrome	5 (4.9)
Length of hospital stay	
Median (Range)	10 (3-62)
Final clinical outcome	
Alive and discharge	98 (95.1)
Expired in hospital	5 (4.9)

CT score was compared with clinical categories and significant difference was observed when all categories were compared together ($p < 0.001$). CT score was the highest in the severe/critical category (Median value: 13, range 10-24), followed by moderate category (Median value: 7, range 2-18) and the lowest in the mild category (Median value: 5, range 3-14) (Figure 1).

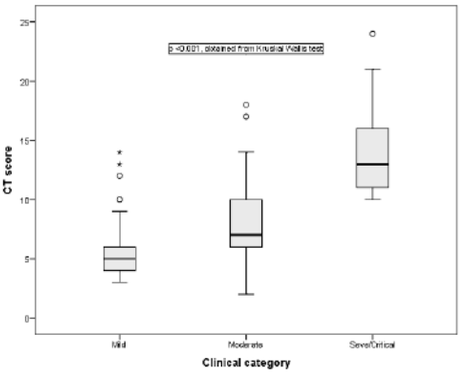

Fig 1 : Comparisons between CT scores versus clinical categories of the patients

The oxygen requirement and CT severity category were found to have statistically significant correlation ($p < 0.001$). Length of hospital stay was also significantly higher in patients having severe CT. All of the patients expired in hospital had severe CT scan at admission (Table III).

Table III : Association of outcome parameters with CT severity category

Outcome parameters	CT severity category			p value
	Mild	Moderate	Severe	
Oxygen requirement				
≤5 liters	41 (71.9)	16 (28.1)	0 (0)	
6-10 liters	0 (0)	25 (100.0)	0 (0)	<0.001*
≥11 liters	0 (0)	6 (28.6)	15 (71.4)	
Length of hospital stay				
Median (range)	6 (3-14)	14 (3-35)	28 (8-62)	<0.001†
Clinical outcome				
Expired in hospital	0 (0)	0 (0)	5 (100.0)	<0.001*
Alive and discharge	41 (41.8)	47 (48.0)	10 (10.2)	

*Chi-square test, †Kruskal Wallis test.

It was found that out of age, sex, number of associated comorbid conditions and CT-severity score only CT-severity score could predict mortality in patients with COVID-19 pneumonia (Table IV). CT severity score had statistically significant predictive value (p value = 0.031, OR = 1.228).

Table IV : Logistic regression of predictors of death

Predictors	Beta	p value	Odds ratio	95% CI for OR	
				Lower	Upper
Age, in years	0.038	0.394	1.039	0.952	1.134
Sex, Female vs. Male	-0.842	0.493	0.431	0.039	4.779
Comorbidity, in number	0.222	0.437	1.248	0.714	2.184
CT severity score	0.205	0.031	1.228	1.019	1.480

OR: Odds Ratio, CI: Confidence Interval.

Discussion

The current study highlights the clinical implication of initial CT findings as a prognostic indicator in patients with COVID-19. Upon comparing those who recovered with those who expired in hospital CT severity score was associated with final outcomes.

CT scan can be a useful tool in evaluating the individual disease burden.[14,15] The quantitative severity can be assessed using a visual method (as in the present study) or software that determines the percentage of affected lung volumes using the deep learning algorithms.[10,16] In our study, and due to unavailability of the software, we used the visual assessment of each of the 5 lung lobes. The severities were further classified based on the total cumulative severity score.

Clinical course of the disease is unpredictable, due to the heterogeneity of its manifestations ranging from asymptomatic and/or subclinical forms to critical disease with ARDS or multiorgan failure. There is no currently available prognostic biomarker to identify patients requiring immediate medical attention and to estimate their associated mortality rate.[17] Our hypothesis was that CT prediction of disease progression and its correlation with clinical findings may be helpful to assist medical staff in triaging patients and to timely establish symptomatic treatment, although COVID-19 therapy is still based on merely empirical decisions rather than on the evidence of large clinical trials.[4,5]

Our data demonstrated that, CT scores were significantly differing among clinical category with the highest CT score in the severe/critical category and the lowest in the mild category. It was similar to the study of Francone et al. who reported CT score was significantly higher in the critical category (Mean value ± SD: 20.3 ± 3, range 15–24) than in the mild category (8.7 ± 4, range 0–19) ($p < 0.0001$).[15]

In the current study as previously observed elsewhere, oxygen requirements increase with the increasing CT severity.[14] The progressive increase in oxygen requirement can be due to the direct damage of the lung by the virus causing inflammatory changes in alveolar wall that limit oxygen exchange, leading to acute respiratory distress, pulmonary fibrosis, and eventually death. Moreover, significant pulmonary thromboembolic effects were also found on autopsies from patients who died from COVID-19 disease.[4,18] Similar to the positive association between oxygen requirement and scan severity length of hospital stay were increasing with the increase in scan severity in the current study.

One of the important findings of the current study was that all of the patients expired in hospital had severe CT scan at admission. CT severity score was the only significant predictor for in-hospital mortality in the current study among age, sex, comorbidity and CT severity score. Similar findings were found in another study where CT severity score had the most statistically significant predictive value for COVID-19 patients' mortality.[19]

Limitations

This study has some methodological limitations which must be considered in the analysis of the results. Sample size was relatively small, collected in non-probability sampling technique from a single hospital. Therefore, our results cannot be generalized. Moreover, laboratory parameters were not considered in the study which were found to be a significant predictors of death.

Conclusions

In conclusion, initial CT scans can have a critical role in assisting physicians in the management plan and work as an indicator for disease severity and possible outcome. CT severity score is positively correlated with clinical severity, length of hospital stays, oxygen requirement in patients with COVID-19 infection and a significant predictor of in hospital mortality.

Recommendations

However, further studies with a larger sample size from different center are recommended to further clarify the value of chest CT for prognostication in COVID-19 disease, including correlation with patient long term outcome.

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Contribution of authors

HD: Conception, designing, data analysis, drafting and final approval.

MMR: Data analysis, drafting and final approval.

MMK: Conception, designing, data analysis, drafting and final approval.

TS: Data collection, drafting and final approval.
RRC: Conception, drafting and final approval
PPC: Data collection, interpretation of data, critical revision and final approval.
MHA: Data analysis, drafting and final approval
SKK : Data analysis, drafting and final approval
SS : Data analysis, drafting and final approval
SP-Data analysis, interpretation of data, critical revision and final approval.

Disclosure

All the authors declared no competing interest.

References

1. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020.
Available from: https://www.who.int/director-general/speeches/detail/ 11-march-2020.

2. Weekly epidemiological update on COVID-19 - 20 April 2021.
Available from: https://www.who.int/publications/m/item/20-april-2021.

3. WHO Coronavirus (COVID-19) Dashboard. World Health Organization. Available from: https://covid19.who.int.

4. Emedicine.medscape.com. Coronavirus Disease 2019 (COVID-19) Clinical Presentation: History, Physical Examination, Complications.2021.
Available from: https://emedicine.medscape.com/ article/2500114-clinical.

5. Li H, Burm SW, Hong SH, Ghayda RA, Kronbichler A, Smith L, et al. A Comprehensive Review of Coronavirus Disease 2019: Epidemiology, Transmission, Risk Factors, and International Responses. Yonsei Med J. 2021;62(1):1-11.

6. Arevalo-Rodriguez I, Buitrago-Garcia D, Simancas-Racines D, Zambrano-Achig P, Del Campo R, Ciapponi A et al. False-negative results of initial RT-PCR assays for COVID-19: A systematic review. PLoS ONE.2020;15(12): e0242958.

7. Liu J, Yu H, Zhang S. The indispensable role of chest CT in the detection of coronavirus disease 2019 (COVID-19). Eur J Nucl Med Mol Imaging. 2020;47(7):1638-1639.

8. Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, et al. Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection. Radiology. 2020;295(3):200463.

9. Gallo Marin B, Aghagoli G, Lavine K, Yang L, Siff EJ, Chiang SS et al. Predictors of COVID-19 severity: A literature review. Rev Med Virol. 2021;31(1):1-10.

10. Li K, Fang Y, Li W. CT image visual quantitative evaluation and clinical classification of COVID-19. Eur Radiol. 2020;30(8): 4407–4416.

11. Zhang HT, Zhang JS, Zhang HH, Nan YD, Zhao Y, Fu EQ et al. Automated detection and quantification of COVID-19 pneumonia: CT imaging analysis by a deep learning-based software. Eur J Nucl Med Mol Imaging. 2020;47(11):2525-2532.

12. COVID-19 Guideline (Version 8). Coronavirus (COVID-19). Accessed: December 7, 2020.
Retrieved from: https://www.dghs.gov.bd/index.php/en?

13. Simpson S, Kay FU, Abbara S, Bhalla S, Chung JH, Chung M et al. Radiological Society of North America Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA - Secondary Publication. J Thorac Imaging. 2020; 35(4):219-227.

14. Saeed GA, Gaba W, Shah A, Al Helali AA, Raidullah E, Al Ali AB et al. Correlation between Chest CT Severity Scores and the Clinical Parameters of Adult Patients with COVID-19 Pneumonia. Radiol Res Pract. 2021;2021: 6697677.

15. Francone M, Iafrate F, Masci GM, Coco S, Cilia F, Manganaro L et al. Chest CT score in COVID-19 patients: correlation with disease severity and short-term prognosis. Eur Radiol. 2020;30(12):6808-6817.

16. Lessmann N, Sánchez CI, Beenen L, Boulogne LH, Brink M, Calli E et al. Automated Assessment of COVID-19 Reporting and Data System and Chest CT Severity Scores in Patients Suspected of Having COVID-19 Using Artificial Intelligence. Radiology. 2021;298(1):E18-E28.

17. Chowdhury MEH, Rahman T, Khandakar A, Al-Madeed S, Zughaier SM, Doi SAR et al. An Early Warning Tool for Predicting Mortality Risk of COVID-19 Patients Using Machine Learning. Cognit Comput. 2021:1–16.

18. Iba T, Connors JM, Levy JH. The coagulopathy, endotheliopathy, and vasculitis of COVID-19. Inflamm Res. 2020;69(12):1181-1189.

19. Mohamed IAI, Hasan HA, Abdel-Tawab M. CT characteristics and laboratory findings of COVID-19 pneumonia in relation to patient outcome. Egypt J RadiolNucl Med. 2021;52(1):1-7.