Chest CT severity score as a predictor of mortality and short-term prognosis in COVID-19

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ABSTRACT

Background: As India was slowly coming out of shock from the second wave wrecked by the Delta strain, the world population is now struck once again with a new strain of coronavirus disease 2019 (COVID-19), designated as B.1.1.529, named as OMICRON. Though several international studies have evaluated the role of computed tomography (CT) in diagnosis, predicting prognosis, and monitoring the progression of disease, to our best knowledge, there are no Indian studies published in this context. Objective: (1) To determine the use of chest CT severity score as predictor of mortality in COVID-19 patients. (2) To determine the prognosis based on length of hospital stay. Materials and Methods: A observational cohort study was done at Travancore Medical College Hospital. A retrospective analysis of patients who presented to the Emergency Medicine Department with a positive COVID antigen or reverse transcriptase-polymerase chain reaction (RT-PCR) results and those who underwent a CT chest at the time of presentation was conducted. Data was analyzed by using Statistical Package for Social Sciences (SPSS) version 16. Descriptive statistics such as mean, frequency, and percentages were calculated. Chi-square test was used to find the statistical significance. The Kaplan–Meier method was used to evaluate the relationship between CT score and mortality, which was compared with the log-rank test. Results: A total of 252 patients with positive COVID antigen or RT-PCR who underwent CT chest were included in our study. Our study population was composed of 139 (55.2%) males and 113 (44.8%) females. Only one patient with mild CT severity score required >14 days of ICU stay, whereas two (2%) and five (9.6%) patients with moderate and severe CT severity score, respectively, required ICU stay for >14 days. The P value was 0.001, which again is statistically significant. In our study, out of 44 patients categorized under mild CT severity score, only two (4.5%) patients had expired. Out of 98 patients categorized under moderate CT severity score, 14 (14.3%) patients had expired, whereas out of 52 patients categorized under severe CT severity score at the time of admission, 25 (48.1%) patients had expired. The P value was 0.001, which is statistically significant. Conclusion: Our study could prove that patients with CT severity score ≥15 had high risk of mortality and required prolonged ICU stay of >5 days. CT severity score helps the primary care physicians to predict probable outcome and length of hospital stay at the time of admission itself and allocate the limited resources appropriately.

Keywords: Chest CT Severity Score, COVID-19, CRP, D-dimer, hospital stay, ICU stay, mortality predictor, prognosis

Introduction

As India was slowly coming out of shock due to the second wave wrecked by the Delta strain, the world population is now struck once again with a new strain of coronavirus disease 2019 (COVID-19), designated as B.1.1.529, named as OMICRON.¹ As the country is widely unlocked, already strained Indian health sector is facing a third wave due to the new strain.

Chest X-ray is generally not considered as a sensitive tool in detecting pulmonary abnormalities, especially in the early stages of disease, but can be useful in monitoring rapid progression of lung involvement in COVID-19 patients admitted to intensive care unit (ICU).¹⁻⁴ Computed tomography (CT) chest can help in prompt diagnosis, guide clinical decision-making, and...
monitor disease progression and is considered as more effective in detecting lung abnormalities in early stage of the disease.\textsuperscript{2, 4}

**CT scoring in COVID-19**

Yan et al. evaluated the use of chest CT severity score (CT-SS) in differentiating the clinical forms of coronavirus disease and found that CT-SS could be used to evaluate the severity of pulmonary involvement quickly and objectively.\textsuperscript{2, 3} CT-SS was adapted from a previous method used during the severe acute respiratory syndrome (SARS) pandemic.\textsuperscript{3} Based on the anatomic structure, lung has 18 segments and was divided into 20 regions.\textsuperscript{3} The posterior apical segment of the left upper lobe was subdivided into apical and posterior segmental regions, whereas the anteromedial basal segment of the left lower lobe was subdivided into anterior and basal segments.\textsuperscript{3} The lung opacities in all 20 lung regions were subjectively evaluated and attributed scores of 0, 1, and 2 if parenchymal opacification involved 0%, <50%, or ≥50% of each region, respectively. The CT-SS was defined as the sum of individual scores in the 20 lung segment regions, which may range from 0 to 40 points.\textsuperscript{3}

Li et al.\textsuperscript{3} developed the chest CT score, which is much simpler and a widely used scoring system. They assessed five lobes of the lung separately. Each lobe was awarded a CT score from 0 to 5, depending on the percentage of the involved lobe [Table 1]. The overall CT score was the sum of the points from each lobe and ranged from 0 to 25.\textsuperscript{3}

Several international studies have evaluated the role of CT in diagnosis, predicting prognosis, and monitoring the progression of disease.\textsuperscript{2, 3–8} As the virus is continuously evolving newer strains, reinfections have become an emerging threat. To our best knowledge, there are no published Indian studies using CT severity score to predict mortality and short-term prognosis; hence, we would like to determine their use as a tool for primary care physicians.

**Materials and Methods**

**Study design, study population, and duration**

This was an observational cohort study done on patients who presented to the Emergency Medicine Department at Trivandrum Medicity Medical College Hospital between May 1, 2021 and June 30, 2021. Approval from Institution ethical committee was obtained on 6/12/2021.

**Inclusion and exclusion criteria**

Patients presenting to the Emergency Medicine Department with symptoms consistent with COVID-19 and a positive COVID antigen or reverse transcriptase-polymerase chain reaction (RT-PCR) result and Age >18 years were included in the study.

**Methodology**

Our study made a retrospective analysis of patients who presented to the Emergency Medicine Department with a positive COVID antigen or RT-PCR results and those who underwent a CT chest at the time of presentation. Patients were categorized based on the disease severity. Chest CT severity score was obtained from the reports. Patients' demographic data and values of D-dimer and C-reactive protein (CRP) at the time of presentation were obtained from electronic medical records. All the patients were subjected to standard treatment according to COVID protocol. The primary outcome was assessed as the patient having been discharged or expired. Secondary outcomes were analyzed as the total number of days in the hospital and requirement for ICU stay.

**Statistical analysis**

Data was analyzed by using Statistical Package for Social Sciences (SPSS) version 16. Descriptive statistics such as mean, frequency, and percentages were calculated. Chi-square test was used to find the statistical significance. The Kaplan–Meier method was used to evaluate the relationship between CT score and mortality, which was compared with the log-rank test. A P value < 0.05 was considered to be statistically significant.

**Results**

**Demographics and clinical profile**

A total of 252 patients with positive COVID antigen or RT-PCR who underwent CT chest were included in our study. Our study population was composed of 139 (55.2%) males and 113 (44.8%) females [Table 2]. The mean age among patients in our study population was 52.93, 55.07, and 59.42 years in patients with mild, moderate, and severe CT severity score, respectively.

CT chest severity score was obtained and patients were categorized based on the severity into mild (<8), moderate (from 9 to <15), and severe (≥15). Out of 252 patients, 194 patients had positive findings for COVID-19 infections at the time of presentation. Out of 194 patients with positive CT findings, 44 (22.7%) patients had mild CT severity score (<8), 98 (50.5%) had moderate CT severity score (from 9 to <15), and 52 (26.8%) had severe CT severity score (≥15) [Figure 1].

Our study population was composed of 11 (4.4%) patients under mild category (Cat. A), 64 (25.4%) patients under moderate category (Cat. B), and 177 (70.2%) patients under severe category (Cat. C), based on severity of COVID-19 infection [Table 3]. A total of 107 (42.4%) had oxygen requirement, 53 (21.3%) patients had noninvasive ventilation (NIV), and 13 (5.1%) patients required mechanical ventilation at the time of presentation. Sixty-nine patients required more than 10 days
of hospital stay, whereas 76 patients required 5–14 days of ICU stay and eight patients required >14 days of ICU stay [Table 3].

Out of 252 patients, 141 (56%) patients had diabetes mellitus, 131 (52%) patients had hypertension, 29 (11.5%) patients had coronary artery disease (CAD), 15 (6%) patients had chronic kidney disease (CKD), and six (2.4%) patients had chronic liver disease (CLD) [Figure 2].

Out of 194 patients with positive CT findings, 25 (56.8%), 58 (59.2%), and 32 (61.5%) patients had diabetes mellitus, whose CT severity score was mild, moderate, and severe, respectively. Their $P$ value was 0.896, which is not statistically significant [Table 4]. Twenty-one (47.7%), 46 (46.9%), and 34 (65.4%) patients had hypertension, whose CT severity score was mild, moderate, and severe, respectively. Their $P$ value was 0.080, which is not statistically significant [Table 4]. Five (11.4%), 11 (11.2%), and seven (13.5%) patients had CAD, whose CT severity score was mild, moderate, and severe, respectively. Their $P$ value was 0.916, which is not statistically significant [Table 4]. Seven (7.1%) and five (9.6%) patients had CKD, whose CT severity score was moderate and severe, respectively. Their $P$ value was 0.128, which is again not statistically significant. Five (5.1%) patients with moderate CT severity score had CLD. Their $P$ value was 0.081, which is also not statistically significant [Table 4].

CT severity score and prognosis

Only seven (15.9%) patients required hospital stay >10 days among patients with a mild CT severity score, whereas 31 (31.6%) and 24 (46.2%) patients having moderate and severe CT severity score, respectively, required more than 10 days of hospital stay. The $P$ value was 0.003, which is statistically significant [Table 5].

Only six patients with mild CT severity score required 5–14 days of ICU stay, whereas 31 (31.6%) and 35 (67.3%) of patients with moderate and severe CT severity score, respectively, required ICU stay for 5–14 days. Only one patient with mild CT severity score required >14 days of ICU stay, whereas two (2%) and five (9.6%) patients with moderate and severe CT severity score, respectively, required ICU stay for >14 days. The $P$ value was 0.001, which again is statistically significant [Table 5].

Sixteen (16.3%) patients with moderate CT severity score required NIV, whereas 36 (69.3%) patients with severe CT severity score required NIV at the time of presentation. Three (3.1%) patients with moderate CT severity score required mechanical ventilation, whereas 10 (19.2%) patients with severe CT severity score required mechanical ventilation at the time of presentation. The $P$ value for requirement of NIV and mechanical ventilation in patients with moderate and severe CT severity score was 0.001, which is statistically significant [Table 5].

CT severity score and mortality

In our study, out of 44 patients categorized under mild CT severity score, only two (4.5%) patients had expired. Out of 98 patients categorized under moderate CT severity score, 14 (14.3%) patients had expired, whereas out of 52 patients categorized under severe CT severity score at the time of admission, 25 (48.1%) patients had expired. The $P$ value was 0.001, which is statistically significant [Table 5].

CT severity score correlation with D-dimer and CRP

Sixty (61.2%) patients and 46 (88.5%) patients among those with moderate and severe CT severity score, respectively, had elevated D-dimer values. The mean values of D-dimer among patients with moderate and severe CT severity score were 1326.34 and 2273.67, respectively. The $P$ value was 0.001, which is statistically significant [Table 6].

Ninety-one (92.9%) patients and 52 (100%) patients among those with moderate and severe CT severity score, respectively, had elevated CRP values. The mean values of CRP among patients with moderate and severe CT severity score were 1326.34 and 2273.67, respectively. The $P$ value was 0.001, which is statistically significant [Table 6].
baseline CT scan of patients observed that baseline CT scan of patients with COVID-19 also found that patients with CT-SS ≥12.5 had about four times the risk of ICU admission and death. Similarly, Khosravi et al. observed that baseline CT scan of patients with COVID-19 pneumonia can predict adverse outcomes and is weakly correlated with initial disease severity.

In our study, we did not find any significant relationship with CT severity score and comorbidities like diabetes mellitus, systemic hypertension, CAD, CKD, and CLD. Though 32 (61.5%) and 34 (65.4%) Patients with severe CT severity score had diabetes mellitus and hypertension, respectively, we could not prove any statistical significance with CT severity score. But Sanyaolu et al. from his retrospective meta-analysis of several peer reviewed journal concluded that patients with history of hypertension, diabetes, cardiovascular disease have worst prognosis & patients with CKD are at significantly increased risk of death.

Our study also found that patients with severe CT severity score had higher levels of D-dimer at the time of presentation and this was predictive of higher chance for mortality. A study done by Zhang et al. on 343 COVID-19 patients revealed that 12 out of 67 patients with D-dimer levels ≥ 2.0 µg/mL on admission expired, compared with only one out of 267 patients who had levels < 2.0 µg/mL. Another study done by Zobo et al. had also shown that D-dimer levels ≥ 1.0 µg/mL on admission were associated with higher in-hospital mortality. A similar study done by Francone et al. also proved that the risk of death correlated with elevated D-dimer values.

Similarly, our study also found that patients with severe CT severity score had higher levels of serum CRP at the time of presentation and this was predictive of higher mortality. A study done by Tan et al. also showed that CRP correlated well with CT severity during the initial stages and could predict the severity of COVID-19. A study done by Francone et al. also proved that the risk of death correlated with elevated CRP values.

### Discussion

Our observational study found that patients with CT severity score >15 at the time of presentation required prolonged ICU stay (>5 days) and respiratory assistance, that is, either oxygen support, NIV, or mechanical ventilation. Our study also found that patients with CT severity score >15 at the time of presentation had higher mortality risk.

Our findings are similar to those of a study done by Francone et al. who concluded that patients with CT severity score ≥18 were associated with an increased mortality risk. A study done by Hajahmadi et al. to predict the adverse outcomes in patients with COVID-19 also found that patients with CT-SS ≥12.5 had higher D-dimer levels ≥ 1.0µg/mL on admission. Another study done by Zoho et al. had also shown that D-dimer levels ≥ 1.0 µg/mL on admission were associated with higher in-hospital mortality. A similar study done by Francone et al. also proved that the risk of death correlated with elevated D-dimer values.
Conclusion

As CT scan is available easily and can be performed rapidly, it can be used as a screening tool in predicting the prognosis and mortality at the time of presentation to the emergency room. Our study could prove that patients with CT severity score ≥15 had a high risk of mortality and required prolonged ICU stay of >5 days. CT severity score helps the primary care physicians to predict probable outcome and length of hospital stay at the time of admission itself and allocate the limited resources appropriately. CT severity score also correlates well with values of D-dimer and serum CRP, which adds value in prognostication and risk stratification for mortality in COVID-19.

Limitation

Our study was done retrospectively in a single center with limited cohort patients. Ours being a tertiary care center, most of the patients were showing severe illness at the time of presentation itself.

Abbreviations

CT: Computed tomography
CKD: Chronic kidney disease
CAD: Coronary artery disease
CLD: Chronic liver disease
NIV: Noninvasive ventilation
MV: Mechanical ventilation
CRP: C-reactive protein.

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Conflicts of interest

There are no conflicts of interest.

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Table 6: Mean values

| Variables | CT severity score | P |
|-----------|------------------|---|
|           | Mild (n=44) | Moderate (n=98) | Severe (n=52) |
| D-dimer   |             |               |               |
| Normal    | 24 (54.5%)   | 38 (38.8%)    | 6 (11.5%)     |
| Elevated  | 20 (45.5%)   | 60 (61.2%)    | 46 (88.5%)    |
| CRP       |             |               |               |
| Elevated  | 34 (77.3%)   | 91 (92.9%)    | 52 (100%)     |
| Normal    | 10 (22.7%)   | 7 (7.1%)      | 0 (0.0%)      |
| Mean value|   |               |               |
| D-dimer   | 876.12      | 1326.34      | 2273.67      |
| CRP       | 21.31        | 50.88        | 75.04        |

CRP=C-reactive protein, CT=computed tomography