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Development of a Severity Assessment score for COVID-19: COVID Severity Score (CSS) at the time of admission to Hospital

Alsa Hussain✉, **Hina Sabir, Syed Ali Abbas**

Department of Pulmonology, Dr Ziauddin University Hospital, Karachi - Pakistan

Corresponding Author
Alsa Hussain
Department of Pulmonology,
Dr Ziauddin University Hospital,
Karachi - Pakistan
E-mail: alsahussain7@gmail.com

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The authors declare that there is no conflict to interest.

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A B S T R A C T

Background: As of mid-2022, more than 650 million people have been infected with COVID-19 worldwide. With ongoing outbreaks and varying degrees of severity in different regions of the globe, we continue to battle against this global health crisis after 3 years of discovery of Sars-CoV-2. It is crucial for clinicians to utilize the information collected over this time period to combat any upcoming wave in the future. One approach to this is the development of a scoring system that can assess the severity of COVID-19 patients at the time of admission. Although much is known about the course of its clinical disease, much more is yet to be discovered in terms of its optimal management to yield favorable outcomes. Recognizing key risk factors and biochemical parameters can assist in an early assessment of the severity of COVID-19, thus leading to a timely management reducing morbidity and mortality.

Objective: To predict the extent of COVID-19 disease severity upon admission using readily available means of assessment in a city with a lower socioeconomic status.

Methodology: This retrospective analysis was conducted at the Department of Pulmonology, Dr. Ziauddin University Hospital in Karachi. The study spanned from June 2021 to June 2022. A total of 102 patient records were included in this research. These patients had tested positive for SARS-CoV-2, either through a reverse transcription polymerase chain reaction (RT-PCR) test or a rapid antigen detection test. Data for this study was collected from electronic medical records (EMR) and chart reviews, and the analysis was performed using SPSS version 26.0.

Results: The COVID-19 Severity Score (CSS) is a cumulative score derived from nine parameters and was developed by closely observing 102 COVID-19 patients. Parameters incorporated are Age, Comorbidities, Ferritin, LDH, D-dimer, Neutrophil to Lymphocyte Ratio (NLR), Chest X-ray, Creatinine, and Platelet Count. Each parameter is assigned a score according to predefined cutoff ranges, which include a semi-quantitative method for interpreting chest X-rays. A patient's total score is calculated by summing individual parameter scores, with a maximum possible score of 29. The CSS grading system categorizes patients into four "severity risk" groups. The study assessed the CSS's effectiveness in predicting the risk of severe COVID-19 by considering four key factors: hospital stay duration, need for mechanical ventilation, oxygen requirements, and mortality at discharge.

Conclusion: In conclusion, this study's findings strongly advocate for the use of CSS scores as a valuable tool in risk stratification for severe COVID-19 cases. Early identification of patients with high CSS scores should prompt intensified medical care, including extended hospital stays, mechanical ventilation, and oxygen support, to improve patient outcomes and reduce mortality in this vulnerable population.

Keywords: Severity Assessment Score; COVID-19: COVID Severity Score; CSS; Karachi

Introduction

As of mid-2022, more than 650 million people have been infected with COVID-19 worldwide. With ongoing outbreaks and varying degrees of severity in different regions of the globe, COVID-19 has persistently challenged healthcare systems, precipitating an unprecedented global health crisis. It is crucial for clinicians to utilize the information collected over this time period to combat any upcoming wave in the future. One approach to this is the development of a scoring system that can assess the severity of COVID-19 patients at the time of admission. Severe Acute Respiratory Syndrome Coronavirus 2 or Sars-Cov-2 is an enveloped positive sense RNA virus. The spike glycoprotein (S) present on its surface is considered the main virulence factor. It binds to the ACE-2 receptors on target cells to gain entry into the host cells. Once bound, the type 2 transmembrane serine protease(TMPRSS2) cleaves ACE-2 and activates the spike glycoprotein promoting the viral uptake by host cells. Both ACE-2 and TMPRSS2 are abundantly found in bronchial and alveolar epithelial lining, owing to the pulmonary habitat and spread of COVID-19 disease.[1,2]

COVID-19 can manifest as a completely asymptomatic disease to a very complicated illness. Most commonly presenting symptoms are fever, cough, fatigue, anosmia, shortness of breath, etc. A wide range of pulmonary and extra pulmonary complications include pneumonia, acute respiratory distress syndrome, acute myocardial infarction, hepatic injury, acute kidney injury, thrombosis, stroke, multi organ failure, sepsis and death.[3-5]

Although COVID-19 causes mild symptoms in the majority of the population, certain risk factors can lead to advancement of the disease with these grave complications. Some key risk factors, linked to an increased severity, are summarized in Figure 1.

While considerable knowledge has been gained regarding the course of its clinical disease, much more is yet to be discovered concerning the most effective approaches to its treatment, aiming to yield favorable outcomes. Recognizing key risk factors and biochemical parameters can assist in an early assessment of the severity of COVID-19, thus leading to a timely management reducing morbidity and mortality.

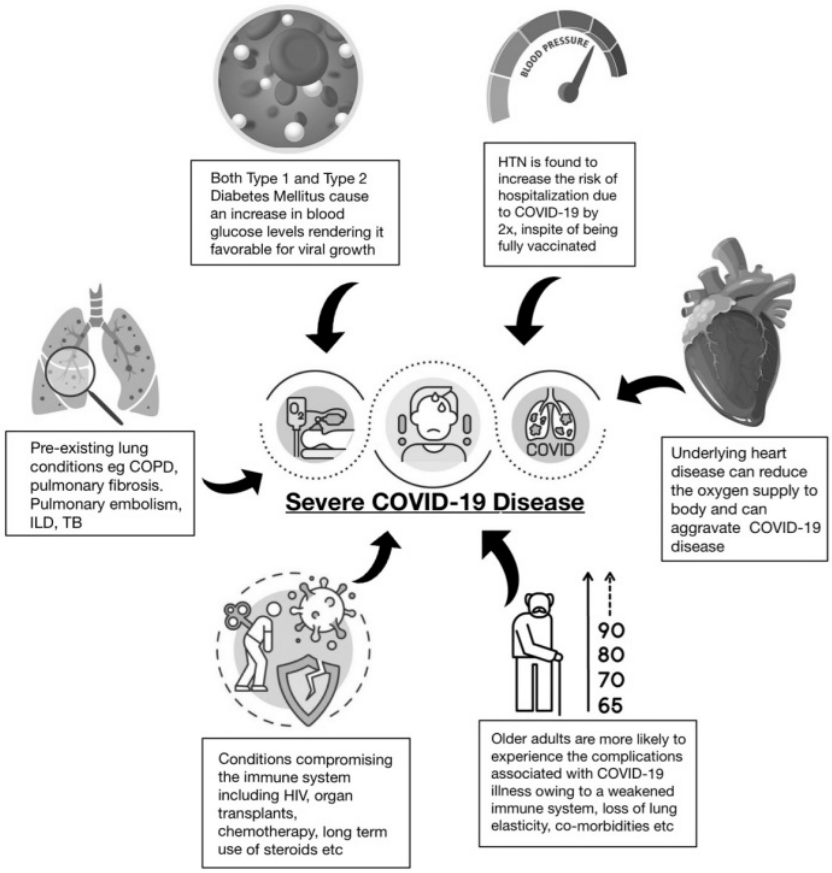


Figure 1: Risk Factors of Developing Severe COVID-19 Disease[14]

Objective

We developed a scoring system, COVID-19 Severity Score or CSS, to predict the severity of the disease at the time of admission. The purpose of this score is to identify high risk patients who have an increased probability of developing poor outcomes including admission to ICU, increased oxygen requirement, requirement of mechanical ventilation, and in-hospital mortality.

Methodology

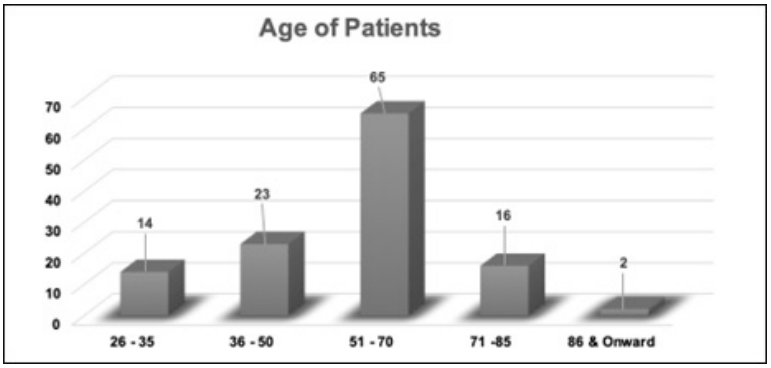
A retrospective study of 102 patients was conducted at a tertiary care hospital, Dr. Ziauddin University Hospital (North Campus), Karachi. Patients included in this study tested positive on reverse transcription polymerase chain reaction (RT-PCR) test or rapid antigen detection test for SARS-CoV-2. Data was collected through EMR and chart reviews, and analyzed using SPSS v. 26.0.

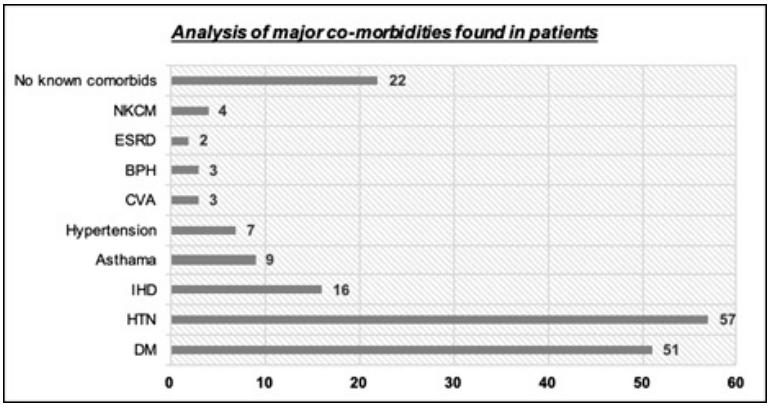
Score description: CSS is a cumulative score of 9 parameters: Age, Comorbidities, Ferritin, LDH, D-dimer, Neutrophil to Lymphocyte Ratio, Chest X-ray, Creatinine, and Platelet Count. This score was established after careful monitoring of 102 COVID-19 patients from the time of admission to their discharge. Each parameter was assigned a score based on cut-off ranges decided after careful evaluation of all participants (Table 1).

Parameter	Range	Score
Age	<40	0
	40-60	1
	>60	2
Cr	Normal	0
	Raised	1
PLT Count	Low	1
	Normal	0
	High	1
NLR	<3	0
	>3	1
LDH	Normal	0
	Up to 1000	1
	>1000	2
Ferritin	Normal	0
	Up to 1000	1
	>1000	2
D dimer	Normal	0
	Up to 15000	1
	>15000	2

Comorbidities that were linked to a severe illness were given 1 point each. Most common comorbidity was found to be Hypertension (n=66.67%) followed by Diabetes Mellitus (n=46.07%). Remaining included Chronic Kidney Disease, Ischemic Heart Disease, Cerebrovascular Accident, Acute Coronary Syndrome. Rheumatoid arthritis, Hypo/Hyperthyroidism and Carcinoma of breast were also given 1 point each taking into account immunosuppressant and chemotherapeutic drugs prescribed to the patients. Asthma and psychiatric illnesses such as depression and psychosis were not given any points.[6]

Chest X-rays were scored based on a study conducted in Italy, 'CXR severity score in COVID 19 patients on emergency department admission: A two-center study' which derived a CXR score using a semi-quantitative method.[7] The study classified each lung into three zones: upper zone (from the lung apex to the aortic arch profile), middle zone (from the aortic arch profile to the lower margin of the left pulmonary hilum), and lower zone (from the lower margin of the left pulmonary hilum to the diaphragm). The zones were then evaluated using a scoring system ranging from 0 to 3 based on specific criteria. A score of 0 indicates normal lung parenchyma, 1 indicates interstitial involvement only, 2 indicates the presence of radio-opacity for less than 50% of the visible lung parenchyma, and 3 indicates the presence of radio-opacity for 50% or more of the visible lung parenchyma. The highest possible cumulative score for both lungs was 18.





The individual scores of the parameters were added together to obtain a total score for each patient, with a maximum possible score of 29. The grading system for determining the "risk of severity" was optimized and divided into four groups based on prognostic scores: <9 indicating no significant risk, 10-14 indicating mild risk, 15-19 indicating moderate risk, and >20 indicating high risk. The study evaluated the effectiveness of CSS in determining the risk of a severe course of COVID-19 disease at the time of admission. Severity of COVID-19 was determined based on four key parameters: length of hospital stay, need for mechanical ventilation, amount of oxygen administered, and mortality outcome at the time of discharge.

Results

Length of hospital stay: Hospital stays were divided into three categories based on duration: <5 days, 6-10 days, and >11 days, representing mild, moderate, and severe illness, respectively. The shortest stay was 1day, while the longest was 26 days.

Numerous studies have demonstrated that the majority of COVID-19 patients experience a mild to moderate disease course.[8] In our study, 56.86% of patients were hospitalized for less than five days. 14.7% had a longer stay of more than 11 days, of these 46.6% had a CSS score above 20.

There was a gradual rise in the proportion of patients remaining hospitalized for five or more days across the different CSS groups. Specifically, the number of patients in CSS groups <9, 10-15, 16-19, and >20 who stayed for at least five days increased in a progressive manner from 4, 10, 14, and 30, respectively.

Mechanical Ventilation: Patients with severe COVID-19 are at high risk of developing acute respiratory distress syndrome (ARDS), which may require mechanical ventilation. Mechanical ventilation provides life-saving oxygenation support to critically ill COVID-19 patients, however, it is also associated with high morbidity and mortality rates. A recent meta-analysis of 32 studies reported that 80% of critically ill COVID-19 patients required mechanical ventilation and had a mortality rate of 40-50%. Additionally, prolonged mechanical ventilation has been associated with the risk of ventilator-associated lung injury, which can exacerbate lung damage and prolong the recovery period of COVID-19 patients. Therefore, early recognition of COVID-19 patients at high risk of developing severe respiratory distress and timely implementation of mechanical ventilation may improve clinical outcomes and reduce mortality rates.[9,10]

Patients belonging to the CSS group above 20 exhibited a notable rise in the need for mechanical ventilation.13.7% of patients required mechanical ventilation to maintain adequate pulmonary function. Out of those 71.42% of the

patients had a CSS score of more than 20.

Amount of Oxygen required: The severity of patients' COVID-19 infection was significantly linked to their oxygen requirement, which was classified into five groups ranging from low to high demand: 2-5 liters, 10-15 liters, 20-30 liters, 30-40 liters, and 50-60 liters. As the CSS score increased, there was a proportional rise in oxygen requirement. In particular, the number of patients requiring oxygen substantially increased across all O_2 groups as the CSS score increased. Patients with CSS scores less than 5 did not require more than 10-15 L of oxygen, whereas those with CSS scores above 20 accounted for 73.33% of patients requiring 50-60 L of oxygen.

Mortality: The study outcomes were categorized into three groups including patients who completed the treatment and were discharged (70.5%), patients who were discharged based on their request (12.7%), and patients who died (16.67%). The majority of deaths occurred in patients belonging to the CSS group above 20, accounting for 76.47% of total deaths. The percentage of patient survived after treatment was found to be more than 80% in CSS groups <9 and 10-14, 73.1% in CSS group 15-19, while it dropped to 63.63% in CSS group >20.

Discussion

Risk stratification upon admission can help identify patients at risk of experiencing severe outcomes from COVID-19. This process can guide healthcare providers in tailoring targeted treatment plans for these individuals. An example of such a scoring system is CoVA, which serves as an outpatient screening tool predicting COVID-19 prognosis[15] CoVa considered 30 parameters as potential predictors of adverse events and also identified 4 specific predictors that substantially raise the predicted probability of adverse events when they are present. Among the 30 parameters considered in CoVA, there are some parameters complex to obtain in our setting, such as intracranial and subarachnoid hemorrhage. On the contrary, CSS relies on just nine parameters. It was deliberately designed to depend on these easily accessible parameters, taking into consideration affordability and the socioeconomic status of the city's population.

However, CSS lacks the ability to distinguish individual parameters that may independently contribute to predicting unfavorable results. Both CoVa and CSS use Chest Xray for radiological evaluation, however, the usefulness of chest x-rays has been doubted because pulmonary symptoms may persist even when the images appear normal.[16] CoVa emerges as the superior score due to its development through comprehensive data analysis

Several factors contribute to the potential for future waves of COVID-19, including vaccination rates, public health policies, and individual behaviors. Variations in these factors can lead to differing levels of transmission and severity of the disease.

Factors Contributing to Future Waves of COVID-19 and the Significance of COVID Severity Score (CSS): According to recent estimates, the population of Pakistan stands at approximately 231million, with only 132.5 million individuals having received vaccinations against COVID-19, leaving an unvaccinated population of around 100 million.[11] Given that the virus continues to evolve and produce more virulent and intricate variants each year, it is highly probable that our healthcare systems may become overwhelmed once the next wave of COVID-19 strikes.

The latest COVID variant XBB or Kraken, a derivative of Omicron, has now become the dominant variant in the US. XBB has acquired a mutation in its spike protein that not only helps it evade the immunity conferred by past infections or vaccination, but also lets it bind to the ACE receptors more tightly, making it exceedingly infective.[12]

The emergence of XBB serves as a stark reminder that the SARS-CoV-2 virus is continually evolving, with the potential to become more transmissible and virulent. Based on current data indicating the swift transmission of XBB, there is a significant likelihood that we may encounter another wave of COVID-19 during the winter months.

Therefore, it is essential to maintain our vigilance and focus on protecting vulnerable populations, including the elderly, immunocompromised, unvaccinated individuals, and those with underlying health conditions.

The implications of having a scoring system for assessing the severity of COVID-19 patients at the time of admission are significant. As established by the data presented above, the COVID Severity Score (CSS) can be used to monitor the progress of patients and adjust their treatment plans accordingly. This can help to prevent complications and ensure that patients receive the appropriate care at every stage of the disease. This diagnostic tool can also be especially helpful to secondary and tertiary care hospitals in Low-and-middle income countries (LIMCs) where resources such as quarantine beds, ventilators and oxygen, are in limited supply and the decision for allocation of these resources by the hospitals requires prompt and precise management. In addition to providing an estimate of critical COVID-19 cases at the time of admission, CSS can also help determine the demand for ambulatory care, supportive treatment for mild and moderate cases and isolation units, leading to precise planning and minimizing strains on healthcare system amid an overwhelming surge of COVID-19 wave.

Limitations

Given the low socio-economic status of our patient population, we elected to use chest X-ray (CXR) as the primary modality for imaging the chest. CT scan was reserved for cases where the patient's condition was worsening and initial CXR was inadequate to evaluate the extent of pulmonary involvement. As a result, we were unable to employ the more standardized CORADS score for our CSS.

Conclusion

While further research is needed to fully validate these scoring systems, they hold promise as a valuable tool for healthcare professionals during the COVID-19 pandemic. It is our belief that the CSS can be an asset to hospitals during such decision-making moments.

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