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Review Article

The various prognostic scoring system used for predicting COVID-19 mortality

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ABSTRACT

The widespread pandemic of Coronavirus disease 2019 (COVID-19) has been reported to affect most countries all over the world, and burden all of the affected healthcare systems. COVID-19 has first emerged in December 2019 within the district of Wuhan which is located in China. Many prognostic scoring systems have been developed to predict severe disease and death for patients with COVID-19. In this literature review, the aim to discuss the various prognostic scoring system used for predicting COVID-19 mortality. It has mainly approached the prognostic scoring systems in two main ways: The clinical and biochemical ways. In addition, the research also investigates the chest X-ray imaging findings based on scoring systems for predicting mortality for patients with COVID-19. Many scoring systems have been reported based on the biochemical and clinical parameters as age, D-dimer, presence of comorbidities, procalcitonin, C-reactive protein (CRP) and other features. Some of the reported scoring systems were recently developed in the COVID-19 pandemic while others were just modified based on the fact that patients with COVID-19 are critically ill, and usually require the same medical attention as other conditions. These scoring systems should be considered by clinicians to early predict and intervene against severe COVID-19 that might cause death. As for the imaging modalities, we have also reported many of the reported systems in the literature, including the ones that are based on chest computed tomography and X-ray findings, and are discussed in detail within this study.

Keywords: Diagnosis, Mortality, Prognosis, COVID-19

INTRODUCTION

The widespread pandemic of Coronavirus disease 2019 (COVID-19) has been reported to affect most countries all over the world, and burden all of the affected healthcare systems. COVID-19 has first emerged in December 2019 within the district of Wuhan which is located in China.[1] Many pulmonary and extrapulmonary features were observed in patients with COVID-19 infections. All of the reported features might be life-threatening and can require

hospitalization to intervene against mortality.[1-4] At first, many patients died from a pulmonary affection. After that, many studies have reported that the involvement of many biochemical and clinical parameters can significantly be associated with death more than the pulmonary features. For instance, previous studies have demonstrated that the presence of clinical comorbidities was significantly correlated with worsened COVID-19 and mortality.[5,6] Others reported that clinical parameters as D-dimer levels, procalcitonin and C-reactive protein (CRP) were all significant predictors for the severity of the disease and death.[7-9] However, this does not underestimate the role of pulmonary manifestations as previous studies have demonstrated the significant roles that chest imaging modalities might play in the prognosis as well as the follow-up and the diagnosis of the disease.[10,11] Many scoring systems have been developed to predict severe disease and death for patients with COVID-19. In this literature review, the aim to discuss the various prognostic scoring systems used for predicting COVID-19 mortality.

METHODS

This literature review is based on an extensive literature search in Medline, Cochrane and EMBASE databases on 8th June 2021 using the medical subject headings (MeSH) and a combination of all possible related terms. This was followed by the manual search for papers in Google Scholar and the reference lists are included at the end of this research.[12,13] This research discusses various prognostic scoring systems used for predicting COVID-19 mortality were screened for relevant information. There are no limits on date, language, age of participants or publication type.

DISCUSSION

Biochemical-related scoring systems

Many studies have previously demonstrated the ability of many biochemical markers in making prognostic decisions to COVID-19 infections and predicting mortality in these patients. For instance, CRP, D-dimer, and the presence of comorbidities. Also, there are many other factors that were previously reported to be used as significant predicting factors of death in COVID-19 confirmed infected cases (Figure 1). For instance, a previous investigation by Shang et al innovated the scoring system of COVID-19 (CSS) based on the significance of many factors in the multivariate regression model including old age, lymphopenia, coronary heart diseases, procalcitonin, and D-dimer as significant predictors for mortality in patients with severe COVID-19 disease status.[14] The results were validated in 2529 patients and were divided into two groups including the high and low-risk groups. Richardson et al previously validated the National Early Warning Score 2 in predicting mortality among patients hospitalized with COVID-19.[15] He reported that the scoring systems can significantly be used to monitor these patients and can predict mortality along with the different time intervals from hospital admission. Additionally, previous investigations have also reported that D-dimer levels can significantly predict the outcomes in patients with COVID-19 infections, as elevated levels are usually associated with an increased risk of mortality.[7-9] It has also been reported that procalcitonin, white blood cell counts, neutrophil counts, and CRP were all significant predictors for mortality in patients with COVID-19.[16] In the same context, it has also been previously reported that elevated creatinine kinase, hypertension, reduced lymphocytic counts, and prolonged prothrombin time were all associated with severe COVID-19 infections and mortality.[17] Another prediction model was also developed in a large cohort study in Spain by Berenguer et al that reported that many laboratory and clinical factors were used to predict the 30-day all-cause mortality among their cohorts.[18] A scoring system was then stratified from 0-30 ,and patients have evaluated accordingly as follows: 1) 0-2 points= low risk (0%-2.1%), 2) 3-5 points= moderate risk (4.7%-6.3%), 3) 6-8 points= high risk (10.6%-19.5%), and 4) 9-30= very high risk (27.7%-100%). The Acute Physiology and Chronic Health Evaluation II score was also reported for validating its ability to predict mortality among patients hospitalized for COVID-19 infections. Moreover, a previous investigation by Zou et al reported that it was an effective approach to predict mortality among these patients with the estimated sensitivity and specificity rates of 96.15%, and 86.27%, respectively.[19] Furthermore, Sourij et al previously validated a scoring system based on age, CRP, glomerular filtration rate, arterial occlusive disease, and AST levels at admission to predict mortality with diabetic patients with COVID-19 infections, and reported that the scoring system was significantly able to predict mortality with these patients.[20]

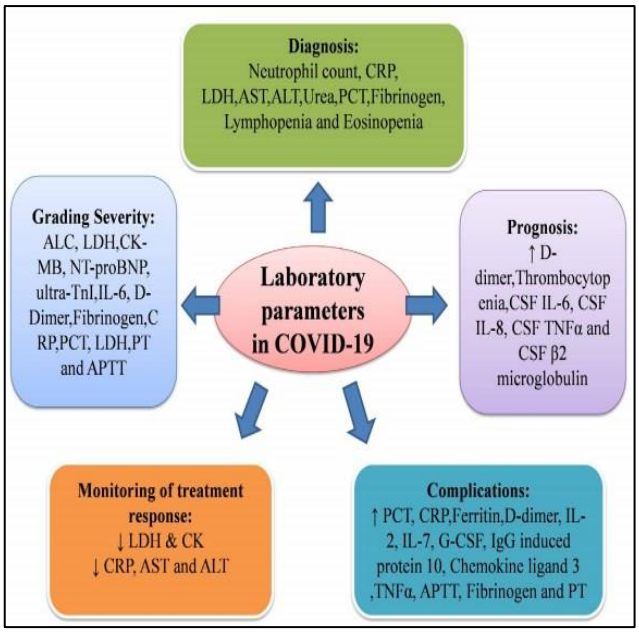

Figure 1: Several factors are associated with the diagnosis, follow-up, and prognosis of COVID-19 infections.[35]

X-ray imaging-related to scoring systems

The scoring systems based on the findings of COVID-19 patients' chest X-ray imaging results constitute a major factor that can significantly predict the prognosis of severe cases suffering from COVID-19. Many scoring systems have been previously validated including systems for computed tomography (CT) and chest X-ray (CXR) that are discussed as the following.

Scoring systems for chest CT imaging

CT imaging of the chest has been previously validated as the most reliable tool in the detection, and deciding the prognosis of the disease in burdened areas with COVID-19.[21] Although it has been reported that CT imaging of the chest is very sensitive in detecting chest abnormalities, it was previously reported that the findings are not specific. Therefore, it should not be used alone to diagnose COVID-19 infections.[22] However, the reported high sensitivity of the modality qualifies it for detection and assessment of the severe cases that have been already diagnosed with COIVD-19 infections. Accordingly, during the era of COVID-19, many assessment algorithms were developed by physicians all over the globe to facilitate the prediction and management of severe cases and enhance the prognosis. Among the reported severity scoring systems, Yang et al reported the chest CT severity score (CT-SS) to adequately identify patients at baseline that require hospital admission since the time they were diagnosed with the infection, which is similar to a previous system that was developed during the 2005 SARS epidemic.[23,24] Lung opacities are used to assess the severity of the affected cases. The authors divided the lung into 20 regions, where the opacities of each were assessed and were given a score from 0-2 based on the degree of affection, including 0%, 1-50%, or 51-100%, respectively. The overall score was then obtained by summing up all of the scores of the 20 regions, which ranged between 0 and 40. In their prospective study, the authors reported that the optimal threshold for the system to detected severe COVID-19 cases was 19.5 points with estimated specificity and sensitivity of 94% and 83.3%, respectively. Kunwei et al also reported the total severity score (TSS) by evaluating the five lobes of the lungs for the potential presence of inflammatory markings and accordingly giving a score for each lobe from 0-4 points based on the degree of affection, as 0= 0%, 1= 1-25%, 2= 26-50%, and 3= 51-75%, and 4= 76-100%.[25] The overall score was then obtained by gathering all the scores for each lobe with an estimated cut-off point of 7.5 for determining the severe cases as the estimated specificity and sensitivity rates were 100%, and 82.6%, respectively. The severity status of the included COVID-19-confirmed cohort was accordingly subdivided into four groups (n=78), including patients with minimal (n=24), common (n= 46), severe (n=6), and critical diseases (n=2), and all the radiological findings were assessed by two experienced radiologists. Wasilewski et al furtherly modified the modality into the mTSS to include the characters of abnormalities that are usually observed during CT imaging of the chest.[10] They have added letters to the overall score of the previous TSS system to indicate the most frequent abnormality in each lobe. The letters included A which refers to ground-glass opacity. B which refers to crazy-paving patterns. C which refers to consolidations, and X which refers to other characteristics. The chest CT score was also previously validated in the study by Li et al which reported that the two lungs were subdivided into 5 lobes and the single lobe was evaluated alone.[26] The significant CT findings that could be observed within each lobe included ground-glass opacities, nodules, consolidations, reticulations, crazy-paving patterns, interlobular septal thickening, linear wall thickening, curvilinear subpleural line, pleural and pericardial effusions, linear opacities ,and potential enlargement of the lymph nodes. The overall score ranged between 0-25 as each lobe could be given a score from 5 based on the severity and affection of this lobe. The gradings and scores are interpreted as follows: 0= 0% affection, 1<5% affection, 2=5%-25% affection, 3=26%-49% affection, 4=50%-75% affection, and 5>75% affection. The reported sensitivity and specificity for the modality were 80% and 82.8% with an estimated cutoff point for estimating the severity of COVID-19 disease of 7. All the results of the CT imaging were assessed by two independent radiologists to obtain better outcomes and validated results. Furthermore, other classification systems were also proposed as COVID-19 Reporting and Data System (CO-RADS) to effectively evaluate and predict the severity and death among patients with COIVD-19 infections.[27] Other initiatives of scoring systems were also developed and reported as the ones reported by the Radiological Society of North America (RSNA) and the British Society of Thoracic Imaging (BSTI) and were all considered valid for predicting severe COVID-19 cases.[28,29]

Scoring systems for chest X-ray imaging

Although the estimated sensitivity of CXR is significantly lower than that estimated for CT imaging, it still can be used for deciding the prognosis and evaluation of the later stage and detection of severe COVID-19 cases. Many severity assessment scores based on the findings of CXR were also reported in the literature. SARI CXR severity scoring system was first developed by Taylor et al in 2015 and aimed to assess the severity of respiratory tract illnesses to be used by non-radiologists in the assessment of such diseases in their patients.[30] Patients with acute respiratory tract infections were divided into five main categories as the following: normal, patchy atelectasis and/or bronchial wall thickening and/or hyperinflation, focal consolidations, multifocal consolidations, and significantly diffuse alveolar changes. During the COVID-19, the system was reported by Yoon et al indicating the validity of the modality in the assessment of COVID-19 patients and evaluation of the prognostic outcomes.[31] The Radiographic Assessment of Lung Edema (RALE) classification system was also developed by Wong et al

that aimed to assess the severity of COVID-19 infections in association with the results of the RT-PCR for the corresponding patients, which was first proposed in 2018 by Warren et al.[32,33] Each of the two lungs was assessed and graded from 0-4 based on the severity and extension of the ground-glass opacities and consolidations and the overall score was used to assess the status of the whole lung and the severity of the disease. The grading was interpreted as follows: 0=no involvement, 1<25% involvement, 2=25%-50% involvement, 50%-75% involvement, and >75% involvement. The authors reported that among the 64 patients that were included in their observational study, the highest score was 8, while the median was 3. The CXR score is the only system score that was developed specifically for patients with COVID-19 to assess the severity of the disease and was first reported by Borghesi et al.[34] The scoring system was based on two steps to assess the severity of the status and lung affection in patients with COVID-19. The first was to divide each lung into three zones that can be obtained on frontal chest projections and each zone of the right lung was marked by three letters including A, B, and C while D, E, and F were used for the corresponding zones of the opposite lung, which divided the lung into three zones including upper, inferior and middle levels. The second step was to grade each zone from 0-3 according to the observation of abnormalities and the severity of COVID-19 infections. The scores were interpreted as follows: 0=no abnormal lung findings, 1=the presence of significant interstitial infiltrations, 2=the presence of significant alveolar and interstitial infiltrations with the observation of predominance in the interstitium, and 3=the presence of significant alveolar and interstitial infiltrations with the observation of predominance in the alveoli. The authors reported that the scores of the done CXR to their patients were noticed to be much higher in COVID-19 cases that were dead than other cases, and the estimated scores ranged from 0 to 16 with a maximum total score of 18 and a median of 6.5.

CONCLUSION

In this literature review, the discussion was around the various prognostic scoring system used for predicting COVID-19 mortality. it has mainly approached the prognostic scoring systems in two main ways: the clinical and biochemical way. In addition, the research also investigates the chest X-tray imaging findings based on scoring systems for predicting mortality for patients with COVID-19. Many scoring systems have been reported based on the biochemical and clinical parameters as age, D-dimer, presence of comorbidities, procalcitonin, CRP and other features. Some of the reported scoring systems were recently developed in the COVID-19 pandemic while others were just modified based on the fact that patients with COVID-19 are critically ill, and usually require the same medical attention as other conditions. These scoring systems should be considered by clinicians to early predict and intervene against severe COVID-19 that might cause death.

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