The BAS²IC Score: A Useful Tool to Identify Patients at High Risk of Early Progression to Severe Coronavirus Disease 2019

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We developed a score, with easily accessible data (age, sex, body mass index, dyspnea, inflammatory parameters), to predict the risk of rapid progression to severe coronavirus disease 2019. Using a cutoff of >6 points, the negative predictive value was 87%.

Keywords. body mass index (BMI); COVID-19; C-reactive protein; prognostic score; risk factors.

The coronavirus disease 2019 (COVID-19) was declared a pandemic by the World Health Organization (WHO) on March 13, 2020 [1]. On an average, less than 3% of infected individuals are hospitalized, among which 20% require intensive care. Overall, 0.5% of patients with COVID-19 died [2]. Rapid identification of patients at a high risk of developing severe COVID-19 appeared to be crucial to help clinicians closely monitor such patients and for triage. In a previous multicenter study involving 1045 hospitalized patients with confirmed COVID-19, we identified several independent risk factors, such as advanced age, obesity, and inflammation, associated with the early development of severe disease [3]. In the present study, we aimed to develop a practical score for estimating the risk of rapid progression to severe disease in a cohort of patients hospitalized for COVID-19.

MATERIALS AND METHODS

We used data collected from a prospective noninterventional cohort study, which included adult patients with confirmed COVID-19 hospitalized in March 2020 in Strasbourg University and Mulhouse hospitals (France) [3]. Severe disease was defined as admission to the intensive care unit (ICU) or death within 7 days after admission. Overweight and obesity were defined according to the WHO as a body mass index (BMI) of $\geq 25 \, \text{kg/m}^2$ and $\geq 30 \, \text{kg/m}^2$, respectively. Dyspnea was defined as a score >0 according to the modified Medical Research Council breathlessness scale. We chose an early time point at day 7 because the majority of ICU transfers or deaths occurred within the first week of hospitalization.

In the derivation cohort, we have performed a Bayesian logistic regression to identify risk factors for severe COVID-19. All demographic, clinical, and biological variables with a $\text{Pr}(\text{diff} > 0) < 0.025$ or a $\text{Pr}(\text{diff} > 0) > 0.975$ in the univariate analysis, or of clinical relevance, were included in the multivariate model. Variables collected were as follows: age, sex, BMI, comorbidities (hypertension, diabetes, chronic lung disease, immunosuppression, chronic kidney disease, chronic heart failure, chronic hepatic failure, cancer, hematological malignancy, active smoking), pregnancy, symptoms at admission (fever, dyspnea, headache, chills, cough, fatigue, myalgia, chest pain, diarrhea, abdominal pain, confusion, anosmia or ageusia, oxygen level at admission), biological markers (C-reactive protein, neutrophil count, lymphocyte count, aspartate aminotransferase, alanine aminotransferase, hemoglobin level, platelet count, serum creatinine, serum sodium, lactate), radiological findings (chest computed tomography [CT] described as typical, bilateral involvement, ground-glass opacities, micronodules), treatments in the previous month (nonsteroidal anti-inflammatory drugs, angiotensin-converting enzyme inhibitors, angiotensin-2 receptor antagonists, insulin, corticosteroids, hydroxychloroquine), and antibiotic in the 7 days before admission (beta-lactam, macrolide).

The factors associated with severe disease identified by multivariate analysis were as follows: advanced age (β coefficient = 0.4), male sex (β coefficient = 0.735), overweight (BMI ≥ 25 and $<30 \, \text{kg/m}^2$, β coefficient = 0.490; BMI $\geq 30 \, \text{kg/m}^2$, β coefficient = 0.776), dyspnea (β coefficient = 0.913), inflammatory parameters at admission (C-reactive protein level ≥ 100 and $<200 \, \text{mg/L}$, β coefficient = 0.489), C-reactive protein level $\geq 200 \, \text{mg/L}$ (β coefficient = 1.397), neutrophil count $\geq 8000/\mu L$ (β coefficient = 0.747), and lymphocyte

count <1000/μL (β coefficient = 0.364) [3]. To build the score, these coefficients have been multiplied by 4 and rounded to the nearest half-integer.

The score was evaluated (positive predictive value [PPV], negative predictive value [NPV], sensitivity, specificity) on the derivation cohort and clinically relevant cutoffs (NPV >85% and PPV >60%) were determined. Missing data were imputed using prior distributions derived from the observed data. The performance of this score was validated using an external cohort of 153 patients hospitalized for COVID-19 during the same period in Colmar Hospital, France.

Patient Consent Statement

The study was approved by the Ethics Committee of the University Hospital of Strasbourg (No. CE-2020-51). Written consent was waived in the context of an emerging infection. The patients who refused to participate in this study were not included.

RESULTS

In the derivation cohort of 1045 patients, the mean age was 66 years (standard deviation [SD] = 16), and 612 patients (58.6%) were men (Supplementary Table 1). A total of 661 (63%) patients were overweight, with a BMI of ≥25 kg/m^2. The mean time between the onset of the symptoms and hospital admission was 7.2 days (SD = 5.3). Supplemental oxygen therapy was required in 769 (73.6%) patients. Finally, severe disease occurred in 424 (40.6%) patients. Based on previously identified prognostic factors [3], we then defined a prognostic BAS^{2}IC score including BMI, Age, Sex, Shortness of breath, and Inflammatory parameters to screen patients at a risk of developing early severe COVID-19 (Table 1).

In the receiver-operating characteristics analysis, the area under the curve was 0.76 (0.73–0.79) (Figure 1). Using a cutoff of >6 points, the NPV and PPV were 87% and 49%, respectively, with a sensitivity of 93% and a specificity of 32%. Using a cutoff of >14 points, the NPV was 66%, the PPV was 66%, sensitivity was 33%, and specificity of 88%.

In the validation cohort, including 153 adult patients, the mean age was 72 years (SD = 13). Among them, 97 (63.4%) were men and 103 (67.3%) were overweight. In this cohort, 45 (29%) patients have developed severe disease. Using a cutoff of >6 points, the NPV, PPV, sensitivity, and specificity were 88%, 38%, 87%, and 40%, respectively (Figure 1). Using a cutoff of >14 points, the NPV, PPV, sensitivity, and specificity were 73%, 58%, 16%, and 95%, respectively. A suggestion on management was proposed depending of these cutoffs (Table 2).

DISCUSSION

In this study, we established a new practical score, the BAS^{2}IC score, to easily evaluate the risk of developing early severe

Table 1. The BAS^{2}IC Score for Predicting Rapid Progression of COVID-19

Variables	Points Assigned
BMI ≥25 kg/m^2 and <30 kg/m^2	2
BMI ≥30 kg/m^2	3
Age >65 years	1.5
Sex, male	3
Shortness of breath (dyspnea) at admission	3.5
Inflammatory parameters at admission	
Neutrophil count ≥8000 per μL	3
Lymphocyte count <1000 per μL	1.5
CRP ≥100 mg/L and <200 mg/L	2
CRP ≥200 mg/L	5.5

Abbreviations: BMI, body mass index; COVID-19, coronavirus disease 2019; CRP, C-reactive protein.

NOTE: Patients with scores ≤6 points would be considered at a low risk of developing severe COVID-19 with a negative predictive value of 87%. Patients with scores >14 points would be considered at a high risk of developing severe COVID-19 with a positive predictive value of 66%.

**Table 2. Interpretation of the Score and Suggested Management**

≤6 points: low risk	Outpatient management may be possible.^{a}
>6 and ≤14 points: intermediate risk	Consider hospitalization.^{a}
	Outpatient management may be possible with close monitoring.
>14 points: high risk	Hospitalization required. Consider specific therapies (eg, dexamethasone, remdesivir).

^{a}Other parameters, such as need for oxygen, duration of symptoms, decompensation of underlying disease, extension of lesions on computed tomography, and others, should be taken into account to decide whether hospitalization is required.

COVID-19 among patients hospitalized due to severe COVID-19. The score was validated on an external cohort, providing a similar performance.

Patients with a score ≤6 points could be considered at a low risk of developing severe disease, with a NPV of 87%; hence, this score may help to decide which patients can be discharged. On the contrary, those with score >14 were considered to have a high risk, requiring rapid implementation of appropriate measures, such as hospitalization and consideration of specific therapeutics (eg, dexamethasone, remdesivir) [4, 5].

The BAS^{2}IC score has several advantages over previously published scores [4–6]. This score was based on a large multicenter prospective cohort. It can predict the development of early complications, and it relies on clinical and laboratory parameters, all of which are simple, inexpensive, and easily accessible. This score could be easily implemented in routine clinical practice to help clinicians classify patients at low risk and those at high risk, who should be closely monitored and thus might benefit quickly from the relevant therapy. This is particularly important in the context of a rapid increase in the number of cases saturating healthcare facilities and in cases where identifying patients
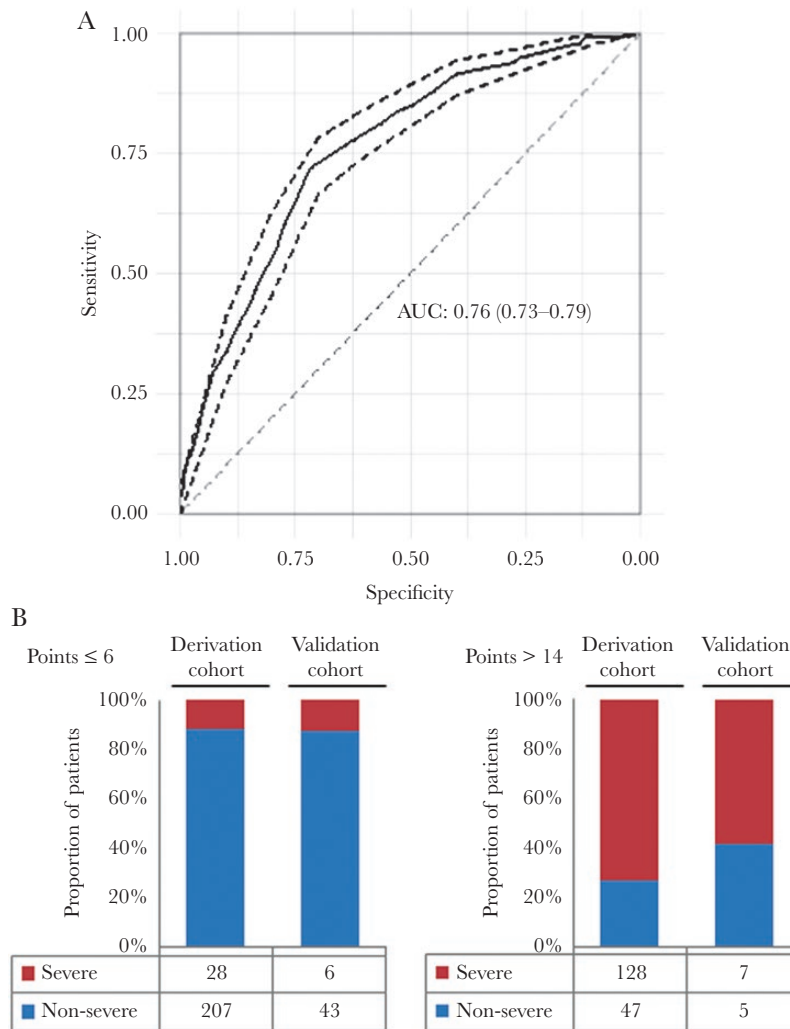
Figure 1. Performance of the BAS^{2}IC score developed to identify patients with coronavirus disease 2019 at a high risk of developing severe disease. (A) Receiver-operating characteristics analysis of the derivation cohort. (B) Number and proportion of patients from the derivation and the validation cohorts with points assigned ≤6 (left graph) and >14 (right graph) according to the severity of the disease. AUC, area under the curve.

at high risk of developing a severe disease might help optimize medical resources. Moreover, this score includes overweight parameter and certain inflammatory parameters, 2 important risk factors that have not been taken into account in previously published scores [6, 7]. The use of inflammatory parameters is of particular relevance in terms of the results of dexamethasone administration for COVID-19 treatment [5].

However, the BAS^{2}IC score has some limits. First, the performance level of this score is not very high. Some risk factors, such as high levels of D-dimer and interleukine-6, which are associated with a poor outcome, were not taken into account when elaborating our score [8, 9]. The efficacy of the score would probably have been even better if these parameters had been included. However, we believe that because these parameters are not tested for in routine clinical practice, adding them to the BAS^{2}IC score would have rendered the score difficult to use for clinicians. The etiology of

death or admission to the ICU among the elderly is multifactorial and often linked to the decompensation of underlying diseases. Comorbidities, such as diabetes, immunosuppression, and chronic kidney disease, were not associated with severe disease in our previous analysis but were associated with death alone [3]. Because this study was conducted in March 2020, the beginning of the outbreak in France, very few patients benefited from specific therapy, such as corticosteroids or immunomodulatory treatments. This could have had an impact on the number of patients with severe disease. Finally, this score is a helpful tool for clinicians, but it should not replace common clinical sense for deciding whether the patients require hospitalization or specific therapy. Other parameters, such as the duration of symptoms, decompensation of comorbidities, need for oxygen, extension of lesions on CT, and others, may be taken into account. Further studies are needed to confirm the performance of the BAS^{2}IC

score and validate our proposal for COVID-19 management depending on the score.

CONCLUSIONS

We developed the predictive BAS^{2}IC score, which is easy to implement and use in routine clinical practice, to help clinicians identify patients at high risk of developing early severe COVID-19. This simple score may be useful for triage of patients with COVID-19 and to identify those who should be closely monitored.

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