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Original article

Pneumonia severity indices predict prognosis in coronavirus disease-2019



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ABSTRACT

Background. – Early recognition of the severe illness is critical in coronavirus disease-19 (COVID-19) to provide best care and optimize the use of limited resources.

Objectives. – We aimed to determine the predictive properties of common community-acquired pneumonia (CAP) severity scores and COVID-19 specific indices.

Methods. – In this retrospective cohort, COVID-19 patients hospitalized in a teaching hospital between 18 March–20 May 2020 were included. Demographic, clinical, and laboratory characteristics related to severity and mortality were measured and CURB-65, PSI, A-DROP, CALL, and COVID-GRAM scores were calculated as defined previously in the literature. Progression to severe disease and in-hospital/overall mortality during the follow-up of the patients were determined from electronic records. Kaplan-Meier, log-rank test, and Cox proportional hazard regression model was used. The discrimination capability of pneumonia severity indices was evaluated by receiver-operating-characteristic (ROC) analysis.

Results. – Two hundred ninety-eight patients were included in the study. Sixty-two patients (20.8%) presented with severe COVID-19 while thirty-one (10.4%) developed severe COVID-19 at any time from the admission. In-hospital mortality was 39 (13.1%) while the overall mortality was 44 (14.8%). The mortality in low-risk groups that were identified to manage outside the hospital was 0 in CALL Class A, 1.67% in PSI low risk, and 2.68% in CURB-65 low-risk. However, the AUCs for the mortality prediction in COVID-19 were 0.875, 0.873, 0.859, 0.855, and 0.828 for A-DROP, PSI, CURB-65, COVID-GRAM, and CALL scores respectively. The AUCs for the prediction of progression to severe disease was 0.739, 0.711, 0.697, 0.673, and 0.668 for CURB-65, CALL, PSI, COVID-GRAM, A-DROP respectively. The hazard ratios (HR) for the tested pneumonia severity indices demonstrated that A-DROP and CURB-65 scores had the strongest association with mortality, and PSI, and COVID-GRAM scores predicted mortality independent from age and comorbidity.

Conclusion. – Community-acquired pneumonia (CAP) scores can predict in COVID-19. The indices proposed specifically to COVID-19 work less than nonspecific scoring systems surprisingly. The CALL score may be used to decide outpatient management in COVID-19.

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1. Introduction

In December 2019, a novel coronavirus, soon named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was announced as the causative agent of clusters of unknown pneumonia in China [1]. The infection was called coronavirus disease 2019 (COVID-19) and the World Health Organization (WHO) declared COVID-19 a pandemic on 11 March 2020 [2].

The course in COVID-19 is usually mild or moderate (81%), however severe (14%) and critical illness (5%) have also been reported [3]. The patients who have mild signs and symptoms generally

recover at home and moderate and/or severe cases are hospitalized for observational and supportive care [4]. Some clinical predictors of poor prognosis have been identified as the evolving knowledge of COVID-19. These well-established risk factors for severe COVID-19 are; older age, cardiovascular disease, diabetes mellitus, obesity, chronic lung disease (especially chronic obstructive lung disease and interstitial lung disease), immunocompromised state, end-stage renal disease, and liver disease [4]. These previously suggested risk factors were determined mostly by single-center and univariate analysis-based studies and establishing an accurate prediction of progression depending on multivariate analysis of COVID-19 would be appreciated. Ji et al. [5], developed a prediction model called CALL score (comorbidity, age, lymphocyte, and lactate dehydrogenase (LDH)), which scores from 4 to 13 points (4–6 points = Class A; low progression risk, 7–9 points = Class B; intermediate progression risk, 10–13 points = Class C; high progression risk). They tested the model along with CURB-65 (confusion, urea, respiratory rate, blood pressure) pneumonia severity score and reported the area under the curve (AUC) was 0.91 and a cut-off of 6 points, the positive and negative predictive values were 50.7% and 98.5% respectively. The scoring model was later tested in a group of Italian COVID-19 patients. Among these 210 patients, the median CALL score was 10 (interquartile range (IQR): 8–12) and progression to severe COVID-19 prediction of CALL score was low AUC of 0.622 however in-hospital mortality prediction was good (AUC: 0.768) [6]. Soon after, another COVID-19 specific score was proposed called COVID-GRAM score [7]. Ten independent predictors were identified to predict the development of critical illness including chest radiography abnormality, age, hemoptysis, dyspnea, unconsciousness, number of comorbidities, cancer history, neutrophil-to-lymphocyte ratio, lactate dehydrogenase, and direct bilirubin (<http://118.126.104.170/>).

CURB-65 (new-onset confusion; urea > 7 mmol/L; respiratory rate \geq 30/minute, systolic blood pressure < 90 mmHg and/or diastolic blood pressure \leq 60 mmHg; and age \geq 65 years; attributing 1 point for each item) [8] and Pneumonia Severity Index (PSI) [9] are common prognostic scales and have been used widely in community-acquired pneumonia (CAP) to predict 30-day mortality. However, both are not sufficient enough to identify patients who need intensive care triage [10]. PSI is highly discriminative but underestimates disease severity in young patients with no comorbidity <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6167349/> CR3 and CURB-65 could not identify patients at low risk of mortality [11]. The A-DROP score, consisting of age \geq 70 years in males or \geq 75 years in females, blood urea nitrogen \geq 21 mg/dL or dehydration, oxyhemoglobin saturation measured by pulse oximetry \leq 90% or partial oxygen pressure in arterial blood \leq 60 mmHg, confusion, and systolic blood pressure \leq 90 mmHg, is a modified version of the CURB-65 score proposed by the Japanese Respiratory Society in 2006. Its predictive power is similar to that of the CURB-65 and PSI [12]. A recent study, examining the utility of pneumonia severity indices in viral pneumonia, reported that PSI was an important tool for assessing the prognosis of patients with community-acquired pneumonia, whether the causative agent was a respiratory virus or not [13].

As well as for the management of CAP, assessment of disease severity is crucial to decide hospitalization, intensive care need, and prognosis in COVID-19. Therefore, we aimed to investigate the prognostic values of common pneumonia severity indices, as well as COVID-specific scores such as CALL and COVID-GRAM score in COVID-19.

2. Methods

2.1. Study Population and Setting

Following the announcement of the first COVID-19 patient on March 11, 2020, in Turkey, the first COVID-19 patient was determined on March 18, 2020, by a positive real-time polymerase chain reaction (RT-PCR) test for SARS-CoV-2 in our teaching hospital which was organized as a pandemic hospital immediately at the beginning of the pandemic.

In this retrospective cohort study, patients older than 18, who admitted to pandemic clinics of our hospital between 18 March and 20 May 2020 were screened. The patients hospitalized with probable and/or definite COVID-19 diagnosis were included. The patients with negative SARS-CoV-2 PCR results and diagnosed with medical conditions other than COVID-19, and the patients who did not have radiologically confirmed COVID-19 pneumonia were excluded. Medical records were obtained from the electronic charts of the hospital database.

The study was approved by the local ethical committee (No: 2020/20-21) and the Ministry of Health Scientific Research Approval Department.

2.2. Case Definition

Probable COVID-19 was defined as a patient with respiratory system symptoms and/or fever and history of travel abroad or contact with a confirmed COVID-19 patient within the previous 14 days or severe acute respiratory infection (SARI), according to the Republic of Turkish Ministry of Health guidelines, version March, 2020. The definition was updated as the guidelines updated [14].

Definite COVID-19 was defined as a patient with respiratory system symptoms and/or fever and a positive SARS-CoV-2 PCR test.

2.3. Severe COVID-19 Definition

Severe COVID-19 was defined by at least one of the following: respiratory distress (respiratory rate \geq 30/minute), SpO₂ < 90%, requirement of noninvasive (NIV), or invasive mechanical ventilation (IMV) or admission to the intensive care unit (ICU) [14].

2.4. Hospitalization criteria

Any probable COVID-19 patient over 50-years old, and/or had any comorbidity, and/or SARI (fever, cough, dyspnea, tachypnea (respiratory rate > 22/minute), hypotension (< 90/60 mmHg), hypoxemia (peripheral oxygen saturation (SpO₂) < 93%), confusion and extensive radiological involvement) were hospitalized [14].

All hospitalized patients received standard treatment protocol according to the national guidelines including hydroxychloroquine, azithromycin, favipiravir, and low molecular weight heparin. The patients having a SpO₂ < 93% were given supplementary oxygen therapy including high flow oxygen therapy (HFNO) and non-invasive or invasive ventilation (NIV) as needed. In case of macrophage activation syndrome, tocilizumab an interleukin-6 blocker was administered [14].

2.5. Diagnostic tests

The diagnostic testing included, upon sample receipt, a rapid molecular test for SARS-CoV-2 testing based on the protocol released by the World Health Organization [15]. SARS-CoV-2 RNA

was tested by a one-step real-time RT-PCR assay targeting viral RdRp (Biospeedy SARS CoV-2 qPCR detection kit, Bioeksan, Turkey) provided by MoH. The test was performed on the RotorGene Q5plex HRM. Human RNase P gene amplification was used as an internal control.

2.6. Pneumonia Severity Indices

CURB-65 [8], PSI [9], A-DROP [12], and CALL [5], COVID-GRAM [7] scores were calculated as defined previously in the literature.

Basal demographic, clinical, and laboratory data of the included patients were recorded. The presence of hypertension, diabetes, cardiovascular disease, chronic lung disease, malignancy, chronic renal disease, cerebrovascular disease, or prior immunosuppression for at least 6 months were accepted as having comorbidity. Severe disease-related parameters including NIV/IMV requirement and/or ICU admission were collected from electronic records. The follow-up period lasted till July 2020, and survival data were obtained from the national electronic records.

The patients presented with severe COVID-19 within 24 hours after admission were excluded from the severity prediction analysis.

2.7. Statistical analysis

Data were analyzed with SPSS software (Statistical Package for the Social Sciences, version 22.0 SPSS Inc., Chicago, IL). Mean and standard deviation or median and IQR were used according to the distribution of the data. For parametric evaluations, student t-test was performed. Categorical data were evaluated by chi-square or Fisher's exact test. The survival analysis was performed by using Kaplan–Meier, log-rank test, survivor/non-survivor groups were categorized according to overall survival. The discrimination capability of pneumonia severity indices was evaluated by receiver-operating-characteristic (ROC) analysis and AUCs were compared. Cox proportional hazard regression model was used to calculate hazard ratios (HR) and 95% confidence intervals (95%CI) for pneumonia severity indices to predict mortality and unadjusted and adjusted models were produced since different scores included different variables. A *P*-value < 0.05 was considered significant.

3. Results

A total number of 4967 patients were admitted to pandemic clinics of our center between 18 March and 20 May 2020, and 359 patients were hospitalized with a probable/definite diagnosis of SARS-CoV-2 infection. SARS-CoV-2 infection was ruled out in 35 patients and 26 patients were excluded due to COVID-19 infection without pneumonia. Finally, 298 hospitalized patients with probable or definite COVID-19 infection were included in the analysis. Two hundred two (67.8%) were accepted as definitive COVID-19 either by PCR (*n* = 192, 64.4%) and/or serology. All patients were followed-up for a median of 108 days (IQR: 87.75–118.00) beginning from the hospitalization date.

The mean age of the study population was 61.85 ± 20.01 years, slightly more than half (50.4%) were female, and 185 (62.1%) had at least one underlying comorbidity. Sixty-two (20.8%) patients presented with severe COVID-19 at the time of the admission, while 31 (10.4%) developed severe COVID-19 in the follow-up. Thirty-seven patients (12.4%) were transferred to the ICU among whom 33 (11.1%) were treated with IMV during the follow-up. The median length of ICU transfer time was similar between survivors and non-survivors [4.5 days (Q1–Q3, 2.0–5.0) vs. 3.0 days (Q1–Q3, 1–9)], (*P* = 0.288), while the median length of the stay (LOS) was significantly longer among the non-survivors [5.0 days (Q1–Q3, 3.0–8.0) vs. 8.0 days (Q1–Q3, 4.0–19.8)], (*P* = 0.001). In-hospital mortality

was 39 (13.1%), while overall mortality was 44 (14.8%). During this period, the overall mortality in the total COVID-19 patient population of our hospital was 4%.

The basal demographic, clinical, and laboratory characteristics of the overall survivor and non-survivor groups are presented in Table 1. The non-survivor group was older and had more comorbidities than the survivor group (*P* < 0.001, for both). Vital signs except systolic blood pressure were not different between the overall survivor and non-survivor groups (*P* = 0.02). However, laboratory parameters such as ferritin, C-reactive protein (CRP), troponin, d-dimer, lactate dehydrogenase (LDH), neutrophil, and neutrophil/lymphocyte ratio were significantly higher in the non-survivor group (Table 1).

All hospitalized patients received standard treatment protocol recommended at that time [14]. Of 298, 262 (87.9%) patients were treated with hydroxychloroquine, and 58 (19.5%) were treated with hydroxychloroquine and azithromycin, which did not make any difference for overall mortality (*P* = 0.246 vs. *P* = 0.214, respectively). Favipiravir was administered in 50 (16.8%) patients and more common in the non-survivor group since it had been used in severe disease (*P* < 0.001), low molecular weight heparin was also used significantly more in the non-survivor group with the same reason (*n* = 41, 93.2%) (*P* < 0.001).

The overall mortality of the study population according to CAP pneumonia scores and specific COVID-19 indices increased as the scores increased (Table 2, Fig. 1). The mortality in low-risk groups that were identified to manage outside the hospital was 0 in CALL Class A, 1.67% in PSI low risk, and 2.68% in CURB-65 low-risk.

The AUCs for the prediction of overall mortality in COVID-19 were highest for A-DROP (0.875) and PSI (0.873) scores, although the 95%CIs of all severity indices were in a similar range (Table 3, Fig. 2A). The AUCs for the prediction of progression to severe COVID-19 were low (0.660–0.739) for all indices, again having similar 95%CI ranges (Table 3, Fig. 2B).

The hazard ratios (HR) for the tested pneumonia severity indices for the unadjusted model demonstrated that A-DROP HR: 3.01 (95% CI, 2.39–4.01) and CURB-65 HR: 3.01 (95% CI, 2.26–3.40) scores had the strongest association with mortality, the CALL score HR: 1.71 (1.45–2.03), and PSI HR: 1.03 (95% CI, 1.02–1.04), COVID-GRAM HR: 1.03 (95% CI, 1.02–1.04) scores were the following. Adjusted associations still existed although comorbidity was not included in the A-DROP and CURB-65 scores (*P* < 0.001 for both).

4. Discussion

Early recognition of severe disease is one of the critical points in the management of COVID-19 to optimize the use of limited resources. Therefore, we aimed to analyze the utility of the well-known CAP severity indices; CURB-65, PSI, and A-DROP as well as CALL and COVID-GRAM scores introduced for COVID-19 in predicting mortality and progression to severe disease. We found that common CAP scores worked slightly better for mortality than the proposed COVID-19 specific prediction tools. For the prediction of progression to severe COVID-19, all scores worked approximately similarly with low predictivity.

We found that demographic characteristics such as age and comorbidity significantly differed between the survivor and non-survivor groups in favor of survivors. Although the mean age of our study population was 61.9 ± 20.1 years, at the beginning of the pandemic, we had considerably high numbers of nursing home residents. The gender distribution was nearly equal for both sexes, against the male dominance in the literature [3,16]. Comorbidity was present in more than half of our patients (62.1%) hypertension being the most common one as reported in the previous studies [16].

Table 1

The basal demographic characteristics, vital signs and laboratory parameters of the study population classified by overall mortality.

	All participants n = 298	Non-survivor n = 44	Survivor n = 254	P	
Age, years, mean ± SD	61.85 ± 20.01	81.05 ± 14.05	58.52 ± 19.01	< 0.001	
Sex, female, n (%)	150 (50.3)	25 (56.8)	125 (49.2)	0.352	
COVID-19 contact	138 (54.1)	21 (52.5)	117 (54.4)	0.823	
Comorbidities, n (%) ^a	185 (62.1)	40 (90.9)	145 (57.1)	< 0.001	
Hypertension	136 (45.6)	30 (68.2)	106 (41.7)	0.001	
Coronary artery disease	28 (9.4)	7 (15.9)	21 (8.3)	0.155	
Congestive heart failure	18 (6.0)	6 (13.6)	12 (4.7)	0.034	
Diabetes	50 (16.8)	9 (20.5)	41 (16.1)	0.480	
COPD	18 (6.0)	4 (9.1)	14 (5.5)	0.318	
Asthma	18 (6.0)	2 (4.5)	16 (6.3)	1.000	
Chronic renal failure	24 (8.1)	9 (20.5)	15 (5.9)	0.004	
Cerebrovascular disease	14 (4.7)	6 (13.6)	8 (3.1)	0.009	
Malignant disease					
Remission	10 (3.4)	3 (6.8)	7 (2.8)	0.171	
Active cancer	12 (4.0)	3 (6.8)	9 (3.5)	0.395	
PCR positivity, n (%)	192 (76.8)	34 (85.0)	158 (75.2)	0.180	
Vital signs and laboratory					
	n	All participants n = 298	Non-survivor n = 44	Survivor n = 254	P
Vital signs ^b					
Heart rate, bpm	250	92 (82-106)	90 (80-105)	93 (82-106)	0.555
Respiratory rate, (min)	298	20 (16-22)	21 (18-24)	20 (16-22)	0.001
SBP, mm Hg	256	132 (120-148)	126 (120-137)	134 (121-149)	0.024
Laboratory values ^b					
Neutrophil, 10 ³ /UI	295	4.3 (3.0-6.4)	6.2 (4.3-7.9)	4.0 (2.9-6.1)	< 0.001
Lymphocytes, 10 ³ /UI	295	1.2 (0.9-1.7)	1.1 (0.7-1.6)	1.2 (0.9-1.7)	0.0198
NLR	294	3.4 (2.2-6.0)	5.4 (3.0-10.0)	3.2 (2.2-5.5)	< 0.001
CRP, mg/L	285	32.4 (11.3-86.4)	85.1 (39.3-150.1)	23.7 (10.6-74.4)	< 0.001
Procalcitonin, ng/ml	261	0.05 (0.03-0.10)	0.14 (0.07-0.31)	0.05 (0.03-0.08)	< 0.001
LDH, U/L	236	233 (184-327)	343 (248-449)	223 (182-303)	< 0.001
Ferritin, ng/ml	210	170 (75-345)	355 (153-719)	144 (63-307)	< 0.001
Troponin, ng/L	276	6.1 (5.5-14.7)	24.0 (9.7-56.6)	5.5 (5.5-10.2)	< 0.001
ALT, U/L	280	22.0 (14.0-35.0)	20.0 (11.5-33.5)	22.0 (15.0-36.0)	0.462
D-dimer, µg/ml	262	0.7 (0.4-1.4)	1.4 (0.8-3.1)	0.6 (0.4-1.2)	< 0.001

Data are expressed as median and interquartile range (IQR) otherwise mentioned. COVID-19: Coronavirus disease 2019. COPD: Chronic Obstructive Pulmonary Disease. PCR: Polymerase Chain Reaction. SBP= Systolic Blood Pressure. NLR: Neutrophil/Lymphocyte Ratio. CRP: C-reactive protein. LDH: Lactate dehydrogenase. ALT: Alanine aminotransferase. COVID-19: Coronavirus disease 2019. COPD: Chronic Obstructive Pulmonary Disease. PCR: Polymerase Chain Reaction. SBP= Systolic Blood Pressure. NLR: Neutrophil/Lymphocyte Ratio. CRP: C-reactive protein. LDH: Lactate dehydrogenase. ALT: Alanine aminotransferase.

^a Number of cases that have at least one comorbidity.

^b The vital signs and laboratory values were evaluated at the time of admission.

Table 2

Survival status by overall mortality of the study population according to the CAP pneumonia severity and specific COVID-19 indices.

	All participants n = 298	Non-survivor n = 44	Survivor n = 254	P
CALL score, mean ± SD ^a	8.28±2.67	10.84±1.41	7.83±2.58	< 0.001
CALL Class, n (%)				< 0.001
Class A	84 (28.2)	0 (0.0)	84 (33.1)	
Class B	108 (36.2)	9 (20.5)	99 (39.0)	< 0.001
Class C	106 (35.6)	35 (79.5)	71 (28.0)	
GRAM Score, mean±SD ^{b,c}	112.09 ± 36.01	152.50±33.13	104.01 ± 30.80	
PSI ^d , mean±SD	76.35 ± 40.27	123.68±32.66	68.15 ± 35.57	< 0.001
PSI, risk groups, n (%)				< 0.001
≤ 70, low risk	125 (41.9)	2 (4.5)	123 (48.4)	
71–90, low risk	55 (18.5)	3 (6.8)	52 (20.5)	
91–130, moderate risk	55 (18.5)	14 (31.8)	41 (16.1)	
> 130, high risk	63 (21.1)	25 (56.8)	38 (15.0)	
CURB-65 ^e , mean±SD	0.96 ± 1.06	2.16 ± 0.83	0.75 ± 0.95	< 0.001
1, low risk	203 (68.1)	8 (23.2)	195 (76.8)	
≥ 2, high risk	95 (31.9)	36 (81.8)	59 (18.2)	
A-DROP ^f , mean±SD	0.85 ± 1.07	2.18 ± 0.99	0.62 ± 0.90	< 0.001

CAP: Community acquired pneumonia. COVID-19: Coronavirus disease 2019. SD= Standard deviation.

^a CALL score was calculated based on the findings of the study by Ji et al. [5], 2020. Class A = 4–6 points, Class B = 7–9 points, Class C = 10–13 points.

^b COVID-GRAM score was proposed by Liang et al. [7], 2020.

^c Data was available for 240 subjects.

^d PSI was calculated based on the findings of the study by Fine et al. [9], 1997.

^e CURB-65 was calculated based on the findings of the study by Lim et al. [8], 2003.

^f A-DROP score was proposed by Shindo et al. [12], 2008.

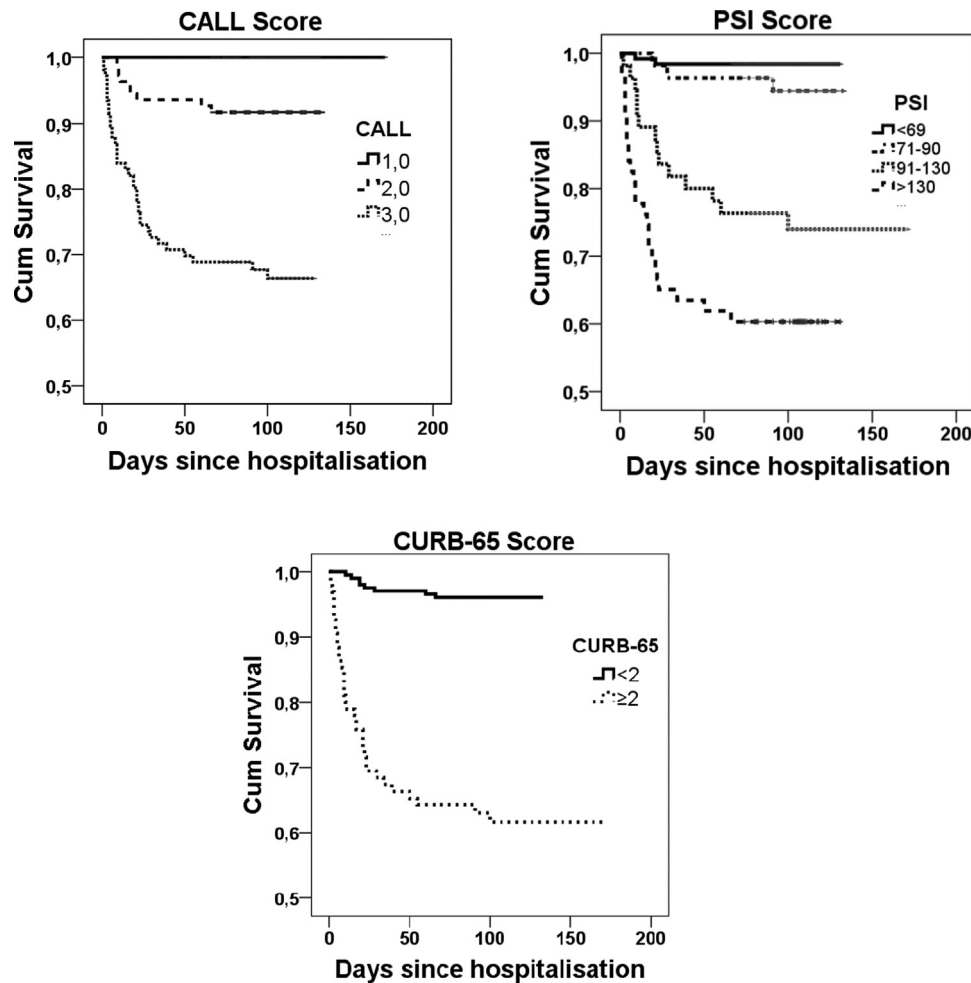


Fig. 1. Kaplan–Meier survival plots for overall mortality (n = 44), by PSI, CURB-65, and CALL scores.

Table 3

Prediction of overall mortality (n = 40/240) and progression to severe COVID-19 (n = 23/230) risk of the study population according to CAP pneumonia severity and specific COVID-19 indices.

Severity indices	Overall mortality		Progression to severe COVID-19	
	AUC	95% CI	AUC	95% CI
PSI ^a	0.873	0.820–0.925	0.697	0.602–0.793
CURB-65 ^b	0.859	0.804–0.914	0.739	0.639–0.839
A-DROP ^c	0.875	0.822–0.937	0.660	0.554–0.767
CALL score ^d	0.828	0.773–0.882	0.711	0.616–0.806
COVID-GRAM score ^e	0.855	0.801–0.909	0.673	0.572–0.774

CAP: Community acquired pneumonia. COVID-19: Coronavirus disease 2019. AUC: Area under the receiver operating characteristic curves. CI: Confidence interval.

^a PSI was calculated based on the findings of the study by Fine et al. [9], 1997.

^b CURB-65 was calculated based on the findings of the study by Lim et al. [8], 2003.

^c A-DROP score was proposed by Shindo et al. [12], 2008

^d CALL score was calculated based on the findings of the study by Ji et al. [5], 2020.

^e COVID-GRAM score was proposed by Liang et al. [7], 2020.

Our overall mortality rate (14.8%) was high when compared with our national registry (2.3%) [17]. In a Chinese Center for Disease Control and Prevention report including 72314 COVID-19 cases, the fatality rate was reported 2.3%, this rate was 14.8% for patients over 80 years and 49% in critical cases [3]. Likewise, we interpreted the high mortality rate partially due to the nursing home profile of the study population and partially due to the high percentage of (one of five) disease presentation as a severe disease. In another study investigating risk factors for mortality of adult inpatients among 191 confirmed COVID-19 patients, 54 deaths were reported, reaching an in-hospital mortality rate of 28.3% [16]. In a meta-analysis

consisting of 10 studies that were conducted in China, the pooled fatality rate was reported 5% [18], including studies with a fatality rate of 14.6% as ours [19].

Among the vital signs only low systolic blood pressure associated with critical disease was observed more in survivors. Some previously well-defined laboratory parameters including ferritin, CRP, troponin, d-dimer, LDH, and neutrophil/lymphocyte were found to increase in non-survivors concordant with the literature.

The 30-day mortality in CAP has been reported 0.7–2.1% for CURB-65 (score < 2) [20] and 0.1–2.8% for PSI [9] low-risk groups. In our study, we found this rate 2.7% for CURB-65 and 1.7% for PSI

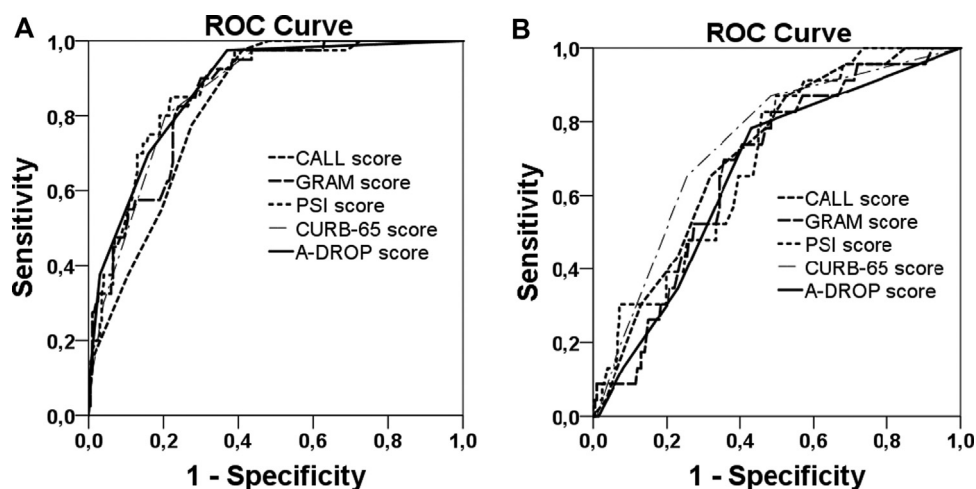


Fig. 2. Receiver operating curves (ROC) of community acquired pneumonia severity and COVID-19 specific indices for predicting A: Overall mortality ($n=40/240$) B: Progression to severe COVID-19 ($n=23/230$).

low-risk groups similar to CAP. Surprisingly, in the CALL low-risk group, mortality was not observed. In a meta-analysis investigating common pneumonia severity indices for the prediction of 28-day mortality in CAP, the AUCs were reported 0.735, 0.701, and 0.730 for PSI, CURB-65, and A-DROP respectively [10]. There are a few studies that investigated the role of pneumonia severity indices predicting outcome in COVID-19. Nguyen et al. looked for CURB-65 and showed an association with an unfavorable outcome, in their study, the majority of the patients were in the low-risk group (61.3%), however, more than 20% of them had a poor outcome. Therefore, they suggested not to use CURB-65 to identify COVID-19 patients that would be outpatient managed [21]. Another study from Turkey reported an AUC of 0.91 for PSI and 0.88 for CURB-65 in COVID-19 and concluded that PSI performed better than CURB-65 in predicting mortality [22]. In our study, likewise, the AUC of A-DROP score (0.875) was the highest, PSI (0.873) was following. However, 95%CI of all indices were in a similar range, which means they had similar predictive properties for mortality. The predictive properties of all indices for progression to severe COVID-19 were lower than the predictive properties for mortality, CURB-65 (0.737) was the best, CALL score was following (0.693). This was again similar for all investigated severity indices, and that might be attributed to the lack of validation of these indices' for progression to severe disease. Previously, the AUC of CALL score for progression to severity has been reported 0.622 like our study [6].

CURB-65 and A-DROP scores were found to have the highest association with mortality which still existed when adjusted for comorbidity (HR: 2.01, 95% CI: 1.57–2.96 and HR: 2.31, 95%CI: 1.62–3.30), although both indices did not include the comorbidity variable. PSI and COVID-GRAM scores demonstrated a lower association with mortality (HR: 1.02 95%CI, 1.01–1.03, for both). The CALL score was better than PSI and COVID-GRAM scores in both unadjusted and age and comorbidity-adjusted models (HR: 1.48, 95%CI: 1.19–1.84). Similar to our findings, Fan and colleagues suggested that the A-DROP score better predicted in-hospital mortality for COVID-19 pneumonia when compared to other CAP scores [23]. However, to our knowledge, there isn't a study investigating the role of COVID-GRAM score for the prediction of mortality in COVID-19 pneumonia.

In conclusion, well-known CAP scores can predict mortality and progression in COVID-19, as well as a newly introduced score A-DROP. The indices proposed specifically to COVID-19 also work, but less than nonspecific scoring systems, surprisingly. For low-risk COVID-19 patients both PSI and CURB-65 demonstrated a mortality rate similar to CAP, however, in our cohort, there was no mortality

in the CALL score low-risk group. Therefore, it may be used to decide outpatient management in COVID-19, while the other indices of CAP to determine prognosis and mortality.

Limitations

First, as a single-center study, the results should be replicated in larger and more representative samples. As a major limitation, the accurate disease-specific mortality data was lacking in discharged patients due to pandemic conditions, therefore we had to use overall mortality. Another limitation is the study population consisting only of hospitalized patients, although hospitalization criteria were in a wide range at the time the study was performed, that only age and comorbidities were considered.

Statement of Ethics

The study was approved by the local ethical committee (No: 2020/20–21) and the Turkish Ministry of Health Scientific Research Approval Department.

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Authors' contributions

In the Author Contributions section, a short statement detailing the contributions of each person named as an author should be included. Contributors to the paper who do not fulfill the ICMJE Criteria for Authorship should be credited in the Acknowledgement section.

Disclosure of interest

The authors declare that they have no competing interest.

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