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Evaluation of PORT/PSI and SOFA scores in predicting in-hospital mortality of patients with COVID-19

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Abstract

Introduction: There is limited information analyzing the utility of different prognostic scores in predicting in-hospital mortality among patients with COVID-19. This study aimed to evaluate the performance of PORT/PSI and SOFA scores in predicting the in-hospital mortality of patients with COVID-19. **Material and methods**: This was an observational, analytical, and retrospective study that included consecutive patients hospitalized for COVID-19 from April 1, 2020, to May 31, 2020. The study population was characterized, and ROC analysis was performed and used to calculate the area under the curve of PORT/PSI and SOFA scores as well as the sensitivity, specificity, and predictive values. **Results**: A total of 151 patients were included, with a median age of 52 years (IQR 45-64); 69.5% were men, with a median BMI of 29.3 kg/m^2 (IQR 25.5-34.7). Of the total, 102 patients died during hospitalization (67.5%). The areas under the ROC curves for predicting in-hospital mortality were 0.74 (95% CI 0.67-0.81) for the SOFA score and 0.85 (95% CI 0.78-0.90) for the PORT/PSI score. When compared, the PORT/PSI score predicted mortality significantly better than the SOFA score (p: 0.01). **Conclusions**: The PORT/PSI score is a good tool to predict in-hospital mortality in patients with COVID-19.

Key word: COVID-19, PORT, PSI, SOFA, in-hospital mortality.

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Introduction

Since the emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in Wuhan, China, in December 2019, viral pneumonia has become a significant public health issue (1). The disease caused by this virus, called coronavirus disease 2019 (COVID-19), is characterized by a wide range of symptoms, from mild to severe, with acute respiratory distress syndrome being its main complication (2). Therefore, assessing the severity of COVID-19 at the time of hospital admission acquired fundamental importance during the pandemic (1).

Identifying patients with a poor prognosis at hospital admission is essential to help guide rapid treatment and optimize the use of a medical unit's resources. Several prognostic scales have been used to identify a high risk of mortality in patients with community-acquired pneumonia [CAP] (2).

The PORT/PSI score (Pneumonia Severity Index) is a prediction score that determines the prognosis of CAP. Patients are stratified into five classes according to their score. All patients with a score > 90 should be hospitalized, while patients with a score > 130 require intensive care to obtain better outcomes [Table 1] (1,3).

Table 1. PORT/ PSI score

Factor	Score
Age	
Male	Age (years)
Female	Age (years) -10
Long-term care facility resident	10
Coexisting illnesses	
Neoplastic disease	30
Liver disease	20
Congestive heart failure	10
Cerebrovascular disease	10
Renal disease	10
Physical-examination findings	
Altered mental status	20
Respiratory rate ≥30/ min	20
Systolic blood pressure <90 mmHg	20
Temperature <35°C o >39.9°C	15
Pulse ≥125 / min	10
Laboratory and radiographic findings	
Arterial blood pH <7.35	30
Blood urea nitrogen ≥30 mg/dl	20
Serum sodium <130 mmol/L	20
Serum glucose ≥250 mg/dl	10
Hematocrit <30%	10
Partial pressure of oxygen <60 mmHg	10
Pleural effusion	10

PORT/PSI Group	PORT/PSI Score	Risk
I	Age <50 years, none from comorbidities, physical and laboratory findings	Low risk
II	≤70 points	
III	71-90 points	
IV	91-130 points	High risk
V	>130 points	

Adapted from Satici C, Demirkol MA, Sargin Altunok E, Gursoy B, Alkan M, Kamat S, et al. Performance of pneumonia severity index and CURB-65 in predicting 30-day mortality in patients with COVID-19. Int J Infect Dis. 2020 Sep; 98:84-89.

The SOFA (Sequential Organ Failure Assessment) score assesses the level of dysfunction of six organ systems: the respiratory, circulatory, renal, hematological, hepatic, and nervous systems. The tool uses six criteria that reflect the function of each system, and scores from 0 to 4 are assigned [Table 2] (4-8). A SOFA score ≥ 2 reflects significant organ dysfunction and an increased risk of adverse outcomes in patients with sepsis (9).

In a literature review, information is limited on the application of prognostic scores to predict in-hospital mortality in patients with COVID-19 or other pneumonias of viral etiology. Therefore, in this study, our objective was to compare the accuracy of the PORT/PSI and SOFA scores to predict mortality in hospitalized patients with COVID-19.

Material and methods

This is a retrospective cohort study from a hospital in Mexico City. Our hospital has operated as a COVID-19 hospital since March 2020. During the study period, the ICU capacity was only seven beds, but the capacity of the hospital's units was expanded from 36 to 72 beds (all equipped for invasive mechanical ventilation). In our unit, any patient suspected of having COVID-19 with respiratory distress (> 30 breaths/minute) or oxygen saturation lower than <90% in ambient air was hospitalized.

Consecutive hospitalized patients diagnosed with SARS-CoV-2 pneumonia between April 1, 2020, and May 31, 2020, were included in this study. The inclusion criteria were as follows: (1) patients older than 18 years; (2) patients with SARS-CoV-2 infection confirmed by PCR and with alterations in radiographic studies (infiltrates and/or ground glass pattern); (3) patients treated exclusively by the internal medicine service; and (4) patients discharged from the hospital due to either death or clinical improvement. The exclusion criteria were as follows: (1) pregnancy, (2) incomplete clinical records, and (3) incomplete information for calculating the SOFA and PORT/PSI scores. The following were collected from the medical records: demographic characteristics, comorbidities, days of hospitalization, and time until discharge. We retrospectively calculated the PORT/PSI and SOFA scores and compiled the results in a database.

Table 2. SOFA score

Factor	Score
Respiration (PaO_2/FiO_2 -mmHg-)	
≥400	0
<400	1
<300	2
<200 with respiratory support	3
<100 with respiratory support	4
Coagulation (Platelets -x10^3/mm-)	
≥150	0
<150	1
<100	2
<50	3
<20	4
Liver (Bilirrubin -mg/dl-)	
<1.2	0
1.2-1.9	1
2-5.9	2
6-11.9	3
≥12	4
Cardiovascular	
Mean arterial pressure ≥70 mmHg	0
Mean arterial pressure <70 mmHg	1
Dopamine ≤ 5 mcg/kg/min o dobutamine (any dose)	2
Dopamine >5 mcg/kg/min o epinephrine ≤0.1 mcg/kg/min o norepinephrine ≤0.1 mcg/kg/min	3
Dopamine >15 mcg/kg/min o epinephrine >0.1 mcg/kg/min o norepinephrine >0.1 mcg/kg/min	4
Central nervous system (Glasgow Coma Scale score)	
15	0
13-14	1
12-10	2
9-6	3
<6	4
Renal (Creatinine -mg/dl- or urine output)	
<1.2 mg/dl	0
1.2-1.9 mg/dl	1
2-3.4 mg/dl	2
3.5-4.9 mg/dl or urine output <500 ml/day	3
>5 mg/dl or urine output <200 ml/day	4

Adapted from Monares Zepeda E, Rodriguez Guillen JH, Vales Guerrero A, Galindo Martin CA, Corrales Brenes EJ, Suarez Cruz A. Validación de la "escala evaluación de fallo orgánico secuencial" (SOFA) con modificación del componente cardiovascular en la Unidad de Terapia Intensiva del Hospital San Angel Inn Universidad. Med Crit 2016 Mar;30(5):319-323

The study's primary outcome was in-hospital mortality, defined as documented death from any cause during hospitalization. In addition, the patients were classified into subgroups: survivors vs. nonsurvivors.

Statistical analysis was performed using the IBM SPSS Statistics 22 system. Categorical data were reported as proportions and counts, and continuous data were presented as medians and interquartile ranges (IQRs) unless the data were normally distributed. We compared the differences between the categorical variables using the chi-square test, and we evaluated the continuous variables using Student's t-test or analysis of variance.

The ROC curve was used to assess the predictive value of each scoring system, and the Z test was used for the area under the ROC curve (AUC). An AUC > 0.8 was considered a good performance. To evaluate the precision of each prognostic score, the cutoff point with the best results of the ROC curves was selected to determine the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). A value of p <0.05 was accepted as statistically significant.

The study was conducted following the Declaration of Helsinki. The Institutional Ethics Committee approved the study protocol (501-010-01-21, CEI-1-2021), with an exemption from the requirement of informed consent, as it was a risk-free and retrospective investigation. Furthermore, patients' privacy and personally identifiable information were protected, and data collection did not harm the patient.

Results

A total of 151 patients were included in this study. Epidemiolo-gical and clinical data are shown in Table 3.

The median age was 51 years (IQR 45-64), 69% (n = 105) were men, the median BMI was 29.3 kg/m^2 (IQR 25.5-34.7), and the median years of schooling was 9 (IQR: 6-9). Twenty-five percent of patients (n = 38) had a history of smoking. Sixty percent (n = 91) had comorbidities; diabetes (37.7%) and hypertension (37%) were the most frequent. Ninety-nine percent of patients (n = 150) received oxygen therapy. Acute kidney injury occurred in 37.1% of the patients (n = 56). A total of 67.5% (n = 102) of the patients required invasive mechanical ventilation, and 33% (n = 50) required vasopressor support.

Table 3.- Characteristics of hospitalized patients with COVID-19

Variable	Total (n=151)	Survivors (n= 49)	Nonsurvivors (n=102)	p-value
Demographic and clinical characteristics				
Age, median (IQR) -years-	52 (45-64)	48 (38-54)	55 (47-66.8)	<0.001
Male gender, n (%)	105 (69%)	30 (61.2%)	75 (73.5%)	0.1
BMI, median (IQR) -kg/m^2-	29.3 (25.5-34.7)	28.6 (25.9- 34)	30.2 (25.5-36.5)	0.3
Schooling, median (IQR) -years-	9 (6-9)	9 (6-12)	7 (6-9)	0.01
Smoking, n (%)	38 (25%)	17 (34.7%)	21 (20.6%)	0.09
Alcoholism, n (%)	34 (22.5%)	18 (36.7%)	16 (16%)	0.007
Drug use, n (%)	3 (2%)	1 (2%)	2 (2%)	1
Comorbidities, n (%)	91 (60%)	25 (51%)	66 (64.7%)	0.1
COPD, n (%)	5 (3.3%)	1 (2%)	4 (3.9%)	0.9
Diabetes, n (%)	57 (37.7%)	10 (20.4%)	47 (46%)	0.004
Hypertension, n (%)	56 (37%)	14 (28.5%)	42 (41%)	0.1
Coronary heart disease, n (%)	2 (1.3%)	1 (2%)	1 (1%)	1
Chronic kidney disease, n (%)	6 (4 %)	1 (2%)	5 (5%)	0.6
Hypothyroidism, n (%)	6 (4 %)	2 (4%)	4 (4%)	1
Asthma, n (%)	6 (4 %)	5 (10.2%)	1 (1%)	0.02
Treatments, complications and clinical outcomes				
Supplemental oxygen, n (%)	150 (99%)	48 (98%)	102 (100%)	0.7
Invasive mechanical ventilation, n (%)	102 (67.5%)	5 (10.2%)	97 (95.1%)	<0.001
Renal replacement therapy, n (%)	1 (0.6%)	1 (2%)	0	0.7
Use of vasopressor, n (%)	50 (33%)	2 (4.1%)	48 (47.1%)	<0.001
Acute kidney injury, n (%)	56 (37.1%)	6 (12.2%)	50 (49%)	<0.001
Hospital stay, median (IQR) -days-	7 (4-11)	10 (7-15)	6 (4-9)	<0.001
Prognostic scores				
PORT/ PSI, median (IQR)	83 (60-108)	58 (46-67)	93 (75-119)	<0.001
SOFA, median (IQR)	2 (2-3)	2 (2-2)	3 (2-3)	<0.001

Abbreviations: BMI: body mass index, COPD: chronic obstructive pulmonary disease.

Of this population (n = 151), 49 patients were discharged due to clinical improvement (33%), and 102 (67%) died during hospitalization. The patients had a median hospital stay of 7 days (IQR: 4-11). As expected, the patients who died were older, less educated, more likely to have diabetes, and experienced more complications. The values of the prognostic scores were higher in the deceased patients, as shown in Table 3. The patients who died also had shorter hospital stays than the survivors (6 (IQR 4-9) vs. 10 (IQR 7-15), p <0.001).

SOFA score

Of the study population, 15 patients (9.9%) had a SOFA score of 0 to 1, 110 patients (72.8%) had a score of 2-3, 19 patients (12.6%) had a score of 4-5 and 7 patients (4.7%) had a score ≥ 6. Mortality was 20% among those with a score of 0 to 1, 62.3% among those with a score of 2-3, 94.7% among those with a score of 4-5 and 100% among those with a score ≥6.

To calculate the sensitivity, specificity, and predictive values, a cutoff point of >2 points was used (the best results were obtained with this cutoff point). A SOFA score >2 at hospital admission had an average performance in predicting in-hospital mortality, with a sensitivity of 55.8%, specificity 81.6%, PPV of 43.2% and NPV of 88.1% (AUC: 0.74, CI 95% 0.67-0.81; p <0.001) (Table 4).

PORT/PSI score

In this population, 22 patients (14.6%) were placed in group I, 39 patients (25.8%) in group II, 26 patients (17.2%) in group III, 46 patients (30.5%) in group IV, and 18 patients (11.9%) in group V. Mortality was 13.6% for those in group I, 48.7% for those in group II, 84.6% for those in group III, 91.3% for those in group IV and 88.8% for those in group V.

The cutoff point with the best results in ROC curves was > 70 points. A PORT/PSI score ≥71 (group III) had good performance in predicting in-hospital mortality, with a sensitivity of 78.4%, specificity 79.5%, PPV of 49% and NPV of 93.7% (AUC: 0.85, 95% CI 0.78-0.90; p <0.001) (Table 4).

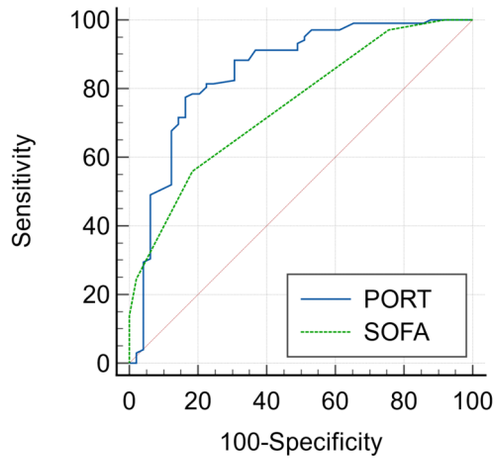
Table 4. Discriminative accuracy of the PORT/PSI and SOFA scores in predicting in-hospital mortality

Value % (95% CI)	SOFA[a]	PORT/PSI[b]
Sensitivity	55.8 (45.7-65.7)	78.5 (69.2-86)
Specificity	81.6 (68-91.2)	79.5 (65.7-89.8)
Positive predictive value	43.2 (29.1-58.5)	49 (35.4-62.8)
Negative predictive value	88.1 (85.1-90.5)	93.7 (90.9-95.6)
AUC	0.74 (0.67-0.81)	0.85 (0.78-0.9)

Abbreviations: CI: confidence interval, AUC: area under curve.
[a] SOFA score ≤2 versus >2.
[b] PORT/PSI score ≤70 versus >70.

A comparison of AUCs for the prediction of in-hospital mortality showed that the PORT/PSI model predicted mortality significantly better than the SOFA model (difference AUC 0.1, 95% CI 0.02-0.18; p: 0.01) (Figure 1).

Figure 1.- ROC curve for PORT/PSI and SOFA in predicting in-hospital mortality



Discussion

To our knowledge, this is the first study in Mexico that evaluates two specific predictive scores for CAP to predict mortality in patients hospitalized with COVID-19. Hospital mortality in our study was high (67%), which was higher than that reported in other studies (10-14). This could be because during the study period, the criterion for hospital admission was supplemental oxygen requirement, which is why our research concentrates on a higher number of seriously or critically ill patients than previous studies.

We observed that the PORT/PSI score underestimated the severity of disease in patients with COVID-19; therefore, we lowered the cutoff point to obtain better results. This phenomenon could be explained by the so-called "silent hypoxemia" observed in patients with SARS-CoV-2 pneumonia, where severe hypoxemia with low respiratory rates could mask the severity of pneumonia (15).

A PORT/PSI score ≥ 71 points showed better sensitivity (78.4% versus 55.8%), positive predictive value (49% versus 43.2%) and negative predictive value (93.7% versus 88.1%) but lower specificity (79.3% versus 81.6%) in the prediction of in-hospital mortality than a SOFA score >2. When evaluating the performance of PORT/PSI and SOFA to predict in-hospital mortality, the PORT/PSI scale performed significantly better than SOFA (difference AUC 0.1, 95% CI 0.02-0.18; p: 0.01).

In our study, the performance of PORT/PSI was slightly superior to that shown by Artero et al. in a study with 10,238 patients, with an AUC of 0.83 for in-hospital mortality (2). Our results were similar to those found by Fan et al. in their study of 654 hospitalized patients with COVID-19 in Wuhan, China (AUC 0.85), in which the primary outcome was death (16). Our results were also similar to those of a retrospective study of 681 patients in Istanbul, Turkey [AUC 0.85] (17). Esteban Ronda et al., in a study with 208 patients, showed an AUC of 0.82 for the primary outcome of mortality at day 30 (18). Our findings are consistent with those of previous studies and confirm that the PORT/PSI is a fairly accurate score

by which to assess the risk of in-hospital mortality in patients with COVID-19.

Information is scarce regarding the application of the SOFA score in COVID-19 patients. Raschke et al., in a retrospective study of 675 patients with COVID-19 requiring mechanical ventilation, reported an AUC of 0.59 for hospital mortality (19). Our AUC was higher than that of Raschke et al.; nevertheless, we showed that the SOFA score possesses inadequate discriminant accuracy to be used in COVID-19 patients.

The study has some limitations: 1) The sample size is small compared to those of previous studies; thus, our study has a greater probability of sampling error. 2) The study is a single-center study that is not externally validated and is retrospective and observational in its design. 3) Due to problems of limited logistics and resources, patient follow-up was limited only to hospitalization, so the association of prognostic scores with mortality after patient discharge due to clinical improvement was not evaluated.

Conclusions

The PORT/PSI score performed better than the SOFA score in predicting in-hospital mortality in patients with COVID-19. The PORT/PSI score could underestimate the severity of disease in patients with COVID-19, but it is a good tool with which to predict in-hospital mortality upon admission to the hospital.

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Authors' contribution: All authors have contributed in all stages of the investigation and have approved the final version.

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