



Critical Review: COVID-19 Calculators During Extreme Resource-Limited Situations

Information about COVID-19 is changing rapidly. This review is based on incomplete data and reviews some newer calculators that have not yet been externally validated. As we learn more, this review may quickly become outdated. It is being published in order to provide potentially helpful information, even if incomplete, to clinicians at the frontlines of the pandemic.

Even well-validated calculators should never be used alone to guide patient care, nor should they substitute for clinical judgment.

SARS-CoV-2, also known as the 2019 novel coronavirus, was first reported in China in December 2019 as the pathogen behind the pattern of severe infectious pneumonias that were particularly fatal in the elderly. By January 2020, it was declared a global public health emergency.

In the near future, clinicians may face scenarios in which there are not have enough resources (ventilators, extracorporeal membrane oxygenation [ECMO] machines, etc) available for the number of critically sick COVID-19 patients. There may not be enough healthcare workers, as those who are positive for COVID-19 or those who have been exposed to the virus and need to be quarantined. During these worst-case scenarios, new crisis standards of care and thresholds for intensive care unit (ICU) admissions will be needed. Clinical decision scores may support the clinician's decision-making, especially if properly adapted for this unique pandemic and for the patient being treated.¹

This review will discuss the use of clinical prediction scores for pneumonia severity at 3 main decision points to examine which scores may provide value in this unique situation. Initial data from a cohort of over 44,000 COVID-19 patients in China, including risk factors for mortality, were compared with data from cohorts used to study the clinical scores, in order to estimate the potential appropriateness of each score and determine how to best

adjust results at the bedside. For example, age ≥ 60 years is a risk factor for mortality in bacterial pneumonia (odds ratio [OR] 5.2), but it is a considerably stronger risk factor for mortality in COVID-19 patients (OR 9.9-32). Other risk factors seem to confer even higher risk in COVID-19 patients than in typical bacterial pneumonia patients, including cardiovascular disease, diabetes, and lung disease. There is also a surprisingly large correlation between low lymphocyte counts and higher mortality in COVID-19 patients.¹⁻³ (See Table 1, page CD2.)

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There is evidence, based on a much smaller cohort of 191 patients, that a **SOFA score** > 5 (OR 5.5; 95% confidence interval [CI], 2.6-12.2; $P < 0.0001$) and D-dimer concentration > 1000 ng/mL on admission (OR 18; 95% CI, 2.6-128.6; $P < 0.0001$) confer significant mortality risk in COVID-19 patients.¹ In addition, prolactin levels have been found to be normal or even low; if levels are found to be high, this may suggest a bacterial coinfection necessitating administration of antibiotics. C-reactive protein levels have been found to be higher in worsening disease and may provide prognostic value.^{4,5}

Decision Point #1: Discharge Versus Admit

PSI/PORT may add value; consider the new MuLBSTA score; adjust for elderly patients.

Each of these scores was designed to predict mortality and is used to determine which patients can safely be sent home. A low-risk **CURB-65 score** (0 or 1) confers a 0.6% to 2.7% risk of mortality.⁶ A low-risk **PSI/PORT score** (< 90) confers a 0.1% to 2.8% risk of mortality.⁷ Comparing the utility of the 2 scores, CURB-65 may not identify patients requiring ICU admission as well as PSI/PORT. In addition, CURB-65 does not take into account patients' comorbidities (eg, COPD), which may have a major impact on outcomes in COVID-19 patients. While CURB-65 is considerably faster to compute, with fewer inputs, this advantage matters less in the age of electronic

records and resources. PSI/PORT places a larger emphasis on age than CURB-65, assigning points by absolute age (ie, a 70-year-old gets 70 points), which seems more consistent with what we know about the high mortality of COVID-19 in elderly patients.

In both of these cohorts, community acquired pneumonia (CAP) was generally defined as a combination of clinical (eg, fever, cough, dyspnea, rales) and radiographic (eg, infiltrate on chest x-ray) findings in the absence of risk factors for healthcare-associated pneumonia. Neither the CURB-65 or PSI/PORT studies differentiated between viral and bacterial pathogens as a cause for the pneumonia, although the incidence of viral-associated CAP may be up to 29%, with rhinoviruses and influenza being the most common.^{8,9}

Recently, the **MuLBSTA score** was developed as a clinical prediction tool to risk stratify patients specifically diagnosed with viral pneumonia.⁹ The aim of this tool was to predict clinical characteristics that affect mortality in patients with viral pneumonia. Interestingly, the score uses predictors of adverse outcomes that correlate with the clinical characteristics that are reported in COVID-19 patients. The presence of a multilobar infiltrate, low lymphocyte count, smoking history, and advanced age all were independent risk factors for mortality in this population, and are all relatively consistent with risk factors from the Chinese COVID-19 cohort. However, this score was derived from a single-center, retrospective, not-exter-

Table 1. Risk Factors Associated With Poor Prognosis in Subjects Infected with COVID-19

Factor	Odds Ratio (95% CI) for Mortality		
	CAP	COVID-19 Chinese Cohort ^{1,2}	COVID-19 South Korea CDC Cohort ¹⁰
Age ≥ 60 years*	5.2 (3.9-6.8)	9.9 (8.5-11.7)	30.7 (14.7-64)
Male sex	1.7 (1.3-2.2)	1.7 (1.5-1.9)	2.0 (1.2-3.1)
Cardiovascular disease	2.6 (1.9-3.5)	5.9 (4.6-7.5)	-
Diabetes	2.1 (1.4-3.1)	3.5 (2.8-4.6)	-
Chronic lung disease	1.5 (1.1-2.0)	2.8 (1.9-4.1)	-
Cancer	3.2 (2.3-4.4)	2.4 (1.1-5.6)	-
Lymphocyte count < 0.8 (x 10 ⁹ /L)	-	8.8 (4.3-18.4)	-
Bilateral consolidations on imaging	-	1.98†	-
Ground glass opacities on imaging	-	2.1†	-

*In the South Korea CDC Dataset,¹⁰ the odds ratio for death in the group aged ≥ 60 years is 30.7 (95% CI, 14.7-64) and the odds ratio for death in male gender is 1.95 (95% CI, 1.23-3.07). South Korea has very robust testing and case fatality rates were significantly lower across all age groups as compared to the Chinese data, but even more so in patients aged < 60 years, a group in which there seem to be many positive patients with mild symptoms.

†Not statistically significant.

Abbreviations: CAP, community acquired pneumonia; CDC, Centers for Disease Control and Prevention; CI, confidence interval.

nally-validated study design, which may lead to bias and has unknown applicability and generalizability.

Takeaways

- Due to stronger emphasis on age and comorbidities, the PSI/PORT score may be a more accurate tool than the CURB-65 score in disposition decision-making for COVID-19 patients, as age and underlying disease seem to be the major contributors to adverse patient-oriented outcomes.
- The MuLBSTA score examines a patient population with similar characteristics to those with COVID-19 pneumonia. However, it is based on a single-center, retrospective study, which limits its applicability and reliability. We recommend its use as adjunct to clinical suspicion, but not in isolation.
- All of these scores likely underestimate the importance of advanced age and of low lymphocytes.

Decision Point #2: ICU, Ventilator, Vasopressors

SMART-COP for decision to start respiratory or vasopressors; LIPS to predict acute respiratory distress syndrome (ARDS); CAP-PIRO for mortality after ICU admission. None are designed specifically for viral pneumonia.

For patients presenting to the emergency department with CAP, it has been established that delayed admission to the ICU is associated with higher mortality.¹¹ The **SMART-COP** score was designed to predict which patients with CAP require intensive respiratory or vasopressor support.¹² It uses readily available information, and is 92.3% sensitive in identifying which patients need ICU-level care. In contrast to other scores, SMART-COP does not explicitly consider age as a variable, although it does include age-adjusted cutoffs for respiratory rate and oxygen level.

The **SCAP score** uses 8 variables that identify patients at risk for “severe CAP,” defined by adverse outcomes such as need for ICU admission, development of sepsis, or requirement of mechanical ventilation.¹³ SMART-COP and SCAP share several common predictors of adverse patient-oriented outcomes potentially necessitating a higher level of care: age (SMART-COP, aged > 50 years; SCAP aged > 80 years), multilobar involvement on radiography, respiratory rate > 30 breaths/min, confusion (new onset), PaO₂/FiO₂ < 250 mm Hg, decreased pH (SMART-COP, < 7.35; SCAP, < 7.30), and systolic blood pressure < 90 mm Hg.

If the pandemic stretches resources beyond the ability to care for all patients, some states have developed plans to use a SOFA score > 11 as a cutoff to

help with decision-making in these dire situations.¹⁴ However, recent studies have shown that SOFA should be used cautiously as part of a decision-making framework and does not meet the ethical cutoffs for prediction across different patient populations.¹⁴⁻¹⁵

The LIPS score is differentiated in that it was designed to estimate risk of ARDS, and it has utility at the time of critical care contact.¹⁶ The CAP-PIRO score was designed to predict mortality of CAP patients who are already admitted to the ICU, therefore limiting its utility in the disposition decision-making process.¹⁷ Like most scores, these scores do not differentiate between causes of pneumonia, nor were they designed to specifically risk stratify patients with viral pneumonia.

Takeaways

- The SMART-COP and SCAP scores are useful tools in predicting a need for a higher level of care for patients with CAP, including patients with viral-associated pneumonia. However, the specific utility of these scores in viral pneumonia is unknown.
- Common predictors of adverse outcomes that may necessitate ICU admission/vasopressors/mechanical ventilation are advanced age, multilobar involvement on radiography, tachypnea, acute confusion, arterial blood gas findings consistent with ARDS, and hypotension.
- More specific to viral pneumonia, a decreased absolute lymphocyte count may predict adverse outcomes.
- The importance of advanced age is likely underestimated by these scores.

Decision Point #3: ECMO

Very little specific experience for COVID-19 patients, but tools exist to guide resource use.

Many of the COVID-19 fatalities are due to ARDS. The **Murray score** was developed to determine which patients are sick enough for veno-venous ECMO, a critical decision point during this crisis.¹⁸ The **RESP** and PRESET scores attempt to predict mortality of patients on ECMO, which may be helpful during the difficult potential situation when rationing of ECMO may become necessary.¹⁹⁻²⁰ At this point, there is very limited guidance specific to the use of ECMO in COVID-19 patients, though it has been utilized in China.

For patients with worsening respiratory failure, a Murray score ≥ 3 suggests a condition severe enough to consider initiating ECMO. The score was initially developed to assess the severity of ARDS but was then utilized in the **CESAR trial** (the first modern randomized controlled trial to compare traditional vent management to ECMO) to determine appropriateness for ECMO.²¹ The initial and validation

trials did not specifically address ARDS due to viral causes, but they also did not exclude these patients, so it is likely that the score is applicable to COVID-19 patients.

If the pandemic stretches beyond available healthcare resources, these tools may assist in a framework to develop new crisis standards of care for patients requiring ECMO. The RESP score had a lower predictive ability within its derivation cohort (internal area under receiver operating curve) than PRESET, but PRESET's patient population had a higher critical illness severity than has been noted in other ECMO cohorts and thus had a lower predictive ability when validated in subsequent cohorts. RESP requires 12 input variables, whereas PRESET requires 5. While this makes RESP more complicated to use, it has been validated in more subsequent cohorts than PRESET, so it may be preferable. RESP also specifically takes into account whether a viral pneumonia is underlying respiratory failure, which may increase its applicability to COVID-19 patients.

Takeaways

- There is little direct evidence or experience supporting the use of ECMO in COVID-19 patients.
- The Murray score can be used to help decide whether or not ARDS is severe enough to consider ECMO for the patient.
- If resources are stretched, the RESP score appears more useful than the PRESET score for helping the clinician assess a patient's mortality risk on ECMO.

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