ICU Admission and Mortality Prediction in Severe COVID-19: A Machine Learning Approach

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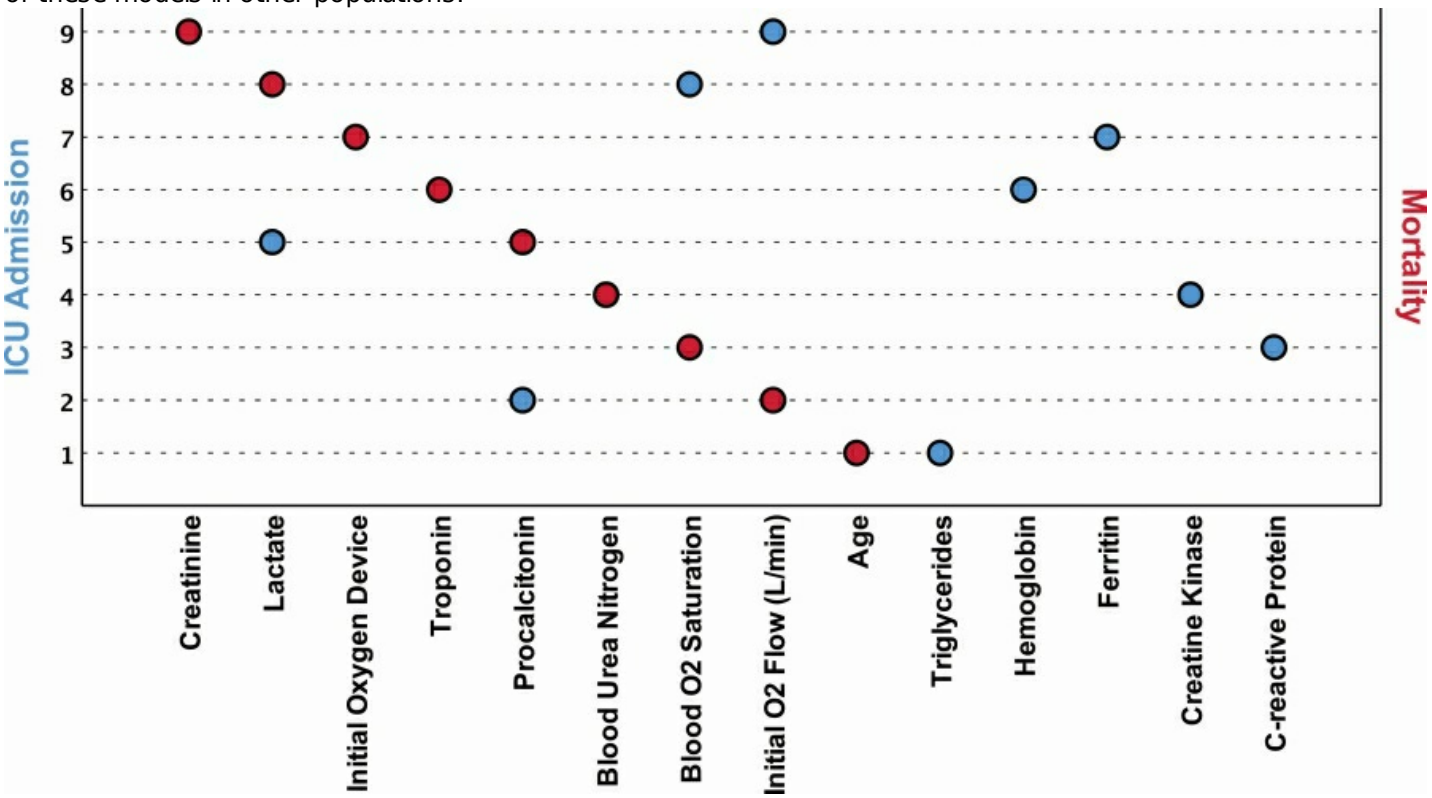
RATIONALE. Coronavirus Disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged in Wuhan, China in late 2019 and has expanded into a global pandemic. This mass casualty triage, while requiring tremendous resources, also required early decision-making and ultimately allocation of critical care resources. Primary Objective was to ascertain risk factors of COVID-19 patients requiring ICU admission. Identify biomarkers, clinical risk factors, and comorbid conditions that can predict clinical outcome. METHODS. Setting and Study Design. We performed a natural history/retrospective chart review of patient admissions (n=5,568) at our facility for patients admitted between March 1 - May 1, 2020, over 18 years of age, with a positive test less than 15 days before admission. We examined their inflammatory biomarker profile and clinical phenotype collected as part of their standard of care (n=90 variables). Analysis. Random forests used as a variable selector were assessed via a modified hamming distance between variable importance rankings of models with identical hyperparameters. The top 10% of variables (n=9) by mean decrease accuracy (MDA) were then included in a gradient-boosted tree model (xgboost package, R-Project) to build classifiers of ICU admissions and mortality. A random hyperparameter space search determined a final model that maximized 5-fold cross-validated AUC_{ROC}. All data was collected in compliance with the Code of Federal Regulations, Title 21, Part 11 and approved by the NYU IRB#20-00473. RESULTS. The classifiers of ICU admission and mortality had AUC_{ROC} = 0.93 and 0.90, and classification error = 15.6% and 20.2% based on the Youden's index-optimal probability threshold, respectively. Variables in the final predictive models of ICU admission and mortality are shown by rank (by MDA) in each model, with rank of 1 being the most important, Figure 1. In predicting ICU admission, the three most important variables were triglycerides, procalcitonin, and c-reactive protein; age, initial O2 flow (L/min), and blood O2 saturation were the three most important predictors of mortality. Procalcitonin, blood O2 saturation, lactate, and initial O2 flow (L/min) were predicted both ICU admission and mortality. CONCLUSION. Our models will be included in an online calculator that will be made available and can be used at point of care by providers to assist risk assessment and triage. Our analysis suggests that novel biomarker combinations may be important in assessment of COVID-19 severity. Future work will include validation of these models in other populations.



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