The American Journal of Surgery 220 (2020) 1368–1369

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

My Thoughts / My Surgical Practice

Developing a mortality risk score for long-term surgical ICU patients: A pilot study

Severe critical illness requiring intensive care unit (ICU) care is common at the end of life in the US, with as many as 1 in 5 American deaths occurring in an ICU.[1] A significant number of these deaths occur after a prolonged ICU stay, creating a potentially preventable added burden for the patient, the family and loved ones of the patient, and the hospital and healthcare system. Accurate prognostic instruments for prolonged-stay ICU patients may inform quality improvement efforts[2] and help providers and families make decisions regarding end of life care. Several such instruments exist for mortality prediction upon ICU admission (e.g. Acute Physiology and Chronic Health Evaluation [APACHE]),[3] however, we lack a strong instrument for mortality prediction beyond the first week of the ICU stay. This is of particular interest given recent research demonstrating a mortality inflection point at 14 days of ICU stay.[4] Thus, we undertook a pilot study in which we aimed to create a risk score for use on the 14th day of surgical ICU (SICU) admission, using physiologic data and chronic comorbidities abstracted from the electronic health record (EHR), to predict in-hospital mortality.

We queried the prospectively maintained SICU registry at our quaternary care system for all patients, over a 1-year time period (July 1, 2018 to June 30, 2019), whose ICU length of stay (LOS) was at least 14 days. This registry contains all surgical ICU patients at our institution, excluding cardiac and neurosurgery. Charts were reviewed for a total of 42 parameters encompassing demographics, physiology, pharmacological and mechanical support, and lab values on day 14 of ICU admission. Given existing literature suggesting that duration of physiologic abnormality contributes to mortality risk,[5] we incorporated a time component to several of the variables by recording them as multi-level categorical values describing the duration for which the patient demonstrated a particular derangement.

Our cohort was randomly split into derivation and validation cohorts. In the derivation cohort, we tested each parameter for association with mortality, first using univariate logistic regression, then entering all parameters with a p-value <0.2 into a multivariable model and narrowing our list by backward elimination. Multiple imputation was used to handle missing values. Significant coefficients ($p < 0.05$) from this model were divided by the lowest coefficient and rounded to the nearest whole number to create an integer-weighted scoring system.[6] This scoring system was evaluated in both the derivation and validation cohorts using the area under the receiver operating characteristic curve (AUROC). We determined an optimal cut point in the derivation cohort using the Youden index.[7] This study was considered exempt by the Institutional Review Board at our institution.

We found 165 patients with a LOS ≥14 days. The derivation cohort consisted of 82 patients, and the validation cohort consisted of 83. We found Glasgow Coma Scale (GCS) ($p = 0.002$), total bilirubin ($p = 0.032$), requirement of renal replacement therapy (RRT) for 3 or more days ($p = 0.006$), and a palliative care consult in the first 14 days ($p = 0.030$) to be associated with mortality. Our formula is:

45 - 3(GCS) + (Total bilirubin) + 18(RRT 3 or more days) + 12(palliative care consult)

AUROC in the derivation cohort was 0.906. The empirical optimal cut point using the Youden method was 34. With patients dichotomized at this point (≥34 predicted to die in the hospital), the sensitivity was 77% and specificity was 97%. The validation cohort continued to demonstrate reasonable discrimination (AUROC = 0.707), with significantly decreased sensitivity at 47% but excellent specificity at 94%, using the cut point of 34.

We recognize that there are an abundance of critical illness scoring systems. However, existing mortality prediction scores are validated for use on admission to the ICU.[3] Because patients who stay in the SICU for a prolonged period are more likely to die in the hospital, it is important to re-evaluate these patients, beyond the admission time point, for mortality risk, so that timely goals of care plans can be initiated.[4] Here we have demonstrated that a relatively simple process can be used to generate a score for this purpose.

The score is not ready for clinical use in its presented form, given its lack of validation beyond our single center and the loss of sensitivity in the validation cohort. However, the reasonable discrimination in the validation cohort and the excellent specificity – which is arguably more important than sensitivity for end-of-life decisions – provide proof of concept that such a score is achievable using readily available parameters from the EHR.

Future efforts to refine a long-term SICU patient scoring system might aim to reduce some of the variability inherent in our proposed parameters, such as the possibility that some of those on RRT for ≥3 days may have chronic kidney disease (CKD) or that those with a depressed GCS may be sedated on a ventilator. It should be noted, though, that CKD and mechanical ventilation were both considered and failed to demonstrate association. Additionally, the inclusion of palliative care consultation in the scoring system introduces a subjective measure. However, inclusion of a subjective prediction is not inherently bad – previous scoring systems include such criteria,[8] and clinician estimates of mortality risk have previously been shown to be predictive in ICU patients.[9]

https://doi.org/10.1016/j.amjsurg.2020.05.030

In our practice, we have found that long-term SICU patients require immensely complex decision-making. An inability to predict mortality risk beyond SICU admission has led us to re-examine a weak spot in caring for some of our sickest patients. We have demonstrated here that an accurate scoring system based on easily accessible information is feasible and hope to motivate further development of a refined score.

Author contributions

JSH, NDM: conceptualization. JSH, KD, BLD, EAM, MAP, JAS: data collection. JSH, AJY: data analysis and interpretation. JSH, NDM: drafting of the manuscript. AJY, KD, BLD, EAM, MAP, JS, NDM: critical review and revision of the manuscript.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Meetings at which this material has been presented

Society of Critical Care Medicine 2020, Orlando, FL.

Declaration of competing interest

No authors have conflicts to declare. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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15 May 2020