Prognostic models in the ICU: From development to clinical practice

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Introduction

In the Intensive Care Unit (ICU) clinicians are faced with difficult decisions regarding provision of life support. End-of-life decision-making is perceived as a heavy burden and prognostication is the part of medical practice they feel most insecure about [1,2]. Survival predictions made by mathematical models may add to what clinicians already know and thereby have the potential to improve clinical decision-making. Clinicians do not always trust the models, however, due to lack of evidence about: their clinical credibility (e.g. the use of clinically relevant variables and refraining from adding unnecessary complexity); external validity (i.e. accuracy and generality) especially for their use in individual patients; and clinical effectiveness (i.e. their impact on patient outcomes) [3].

The aim of our work is to study optimal prognostication in the ICU and the role prognostic models can play in the care for (elderly) ICU patients. Specifically, we address: development and validation of prognostic models; acceptance and perceived needs of models by clinicians; comparison of predictive performance with clinicians; investigation of the models' fitness for clinical use; and their ability to alter individual patient decisions.

Methods

To get an overview of the field, we systematically reviewed literature on prognostic models of mortality and/or survival in the ICU and assessed their clinical credibility, validity and impact in clinical practice. To understand behaviour of predictive performance over time we used Statistical Process Control to monitor the discrimination, calibration and accuracy of two existing prognostic models: a recalibrated Simplified Acute Physiology Score-II (SAPS-II) model and a classification tree built for ICU patients aged >80 years.

To assist clinicians with making decisions about individual patients we built prognostic models that provide a prediction of mortality on each day of ICU stay. We first discover frequent temporal patterns in Sequential Organ Failure Assessment (SOFA) scores. SOFA scores were categorized as low (*L*) if SOFA $\in \{0, \ldots, 6\}$, medium (*M*) if SOFA $\in \{7, 8\}$ or high (*H*) if SOFA $\in \{9, \ldots, 24\}$. The pattern *M,H* means a medium score on day x followed by a high score on day $x+1$. Second these patterns were used as candidate predictors of hospital mortality along with the following candidates: day of prediction, SAPS-II, SOFA, type of admission, number of readmissions, and interactions of admission type and number of readmissions with the other variables. Predictive performance (discrimination, calibration and accuracy) was compared to that of physicians and a recalibrated SAPS-II model.

To understand how clinicians make end-of-life decisions and understand the possible role of objective models we observed daily clinical conferences in two hospitals; sent questionnaires to intensivists of three centres regarding their view on this process and their attitude towards objective prognostic models of mortality; and designed a study in which attending physicians of patients who died after deciding to stop treatment receive objective predictions of mortality of that patient. We will measure the effect of this additional information on how sure they feel about their decision and their perception of the survival chance by asking the same set of questions before and after they received this information.

Results

We found 7 studies describing 17 ICU models published between January 1966 and June 2010. We found that the use of these models in clinical practice is still very premature as their clinical credibility is moderate, the models are rarely cited or (externally) validated by others and their impact in clinical practice was not studied. The predictive performance of the classification tree and SAPS-II gradually decreased in a prospective validation set of 12,143 patients taken from the same centres for which the models were developed. The tree was less sensitive to changes in case-mix than SAPS-II, but both of them regained their original performance after repeated recalibration.

Temporal models achieved the same level of performance as physicians. For the last part of our work we built a prognostic model aimed at the individual patient level on a dataset of 5,935 patients with a total of 27,853 admission days. Model performance in terms of discrimination and calibration was comparable to that of physicians and better than SAPS-II.

We observed that end-of-life decision-making during clinical conferences is poorly structured and decision-making elements are mainly considered outside the conference. Physicians wish to receive additional objective information regarding their patients' chances of survival, but a minority does not trust this information.

Discussion

There is room for improvement of the end-of-life decision-making process and inter-collegial communication. Objective prognostic models may have the potential to improve the end-of-life decision-making process, but their use in clinical practice is still very premature. Future work should assess their possible role and their impact on clinical decisions and patient outcomes.

References

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