Use of Big Data and Machine Learning for Prediction of Hypotensive Events in High Risk ICU Patients from the MIMIC II MIT Database

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Background: Patients in high risk settings are often at risk of developing hemodynamic instability. Current methods of identifying such instability rely on the monitoring of invasive and noninvasive hemodynamic parameters that exhibit pronounced changes only when a critical event is already occurring. However, a number of published studies have recently demonstrated that hemodynamic instability can be detected earlier by analyzing the subtle complex changes in multiple hemodynamic variables and their relationships. The main objective of this preliminary study was to evaluate the feasibility of the early detection of hypotensive events in patients admitted to the ICU.

Methods: Data used in this study came from the MIMIC II MIT Research Database. Arterial pressure waveforms of 181 patients were analyzed and over 700 waveform features were extracted (Edwards Lifesciences, Irvine, CA). Mild hypotensive events were defined as a 10% drop of MAP from a moving average window of 60 minutes, MAP < 65 mmHg, and a minimum event duration of 15 minutes. Severe hypotensive events were defined as a 40% drop of MAP from a moving average window of 15 minutes, MAP < 50 mmHg, and a minimum event duration of 5 minutes. Only patients with severe events (n=122) or no events (n=59) were used for training the models. Sequential feature selection with logistic regression with a 10 fold cross validation was performed to narrow the number of features to be used in each model. Four models built with incrementally increasing training data sets were assessed in this study: Model 1) Severe events vs all non event patient data, 2) 5 minutes prior to severe event + event vs all non event data, 3) 10 minutes prior, and 4) 15 minutes prior. Leave-one-out cross validation was performed on all the data of each patient to validate the model. ROC analysis was performed to assess sensitivity and specificity of each model and AUC was calculated for 0, 5, 10, and 15 minutes prior to event to determine predictive value.

Results and Conclusion: 7 features were selected in Model 1, 14 in Model 2, 13 in Model 3, and 14 in Model 4. While all 4 models appear to have similar sensitivity and specificity (AUC > 0.85), with each increasing amount of event data added to the training set, the predictive value of the model also slightly increases with not much difference between Models 3 and 4 (Figure 1).

In conclusion, these preliminary results indicate that detection and prediction of severe hypotensive events is feasible. Further analysis will need to be done on more patients, with a completely independent validation set. In addition, other machine learning methods such as support vector machine, discriminant analysis, random forest, etc will also need to be assessed. Also, utilizing the clinical records of the MIMIC II patients to confirm events will also need to be assessed. Finally, due to the inherent nature of ICU patients receiving arterial lines, the training data was skewed towards the severe event category, and thus methods of balancing the data set, such as undersampling, will need to be performed and assessed as well.

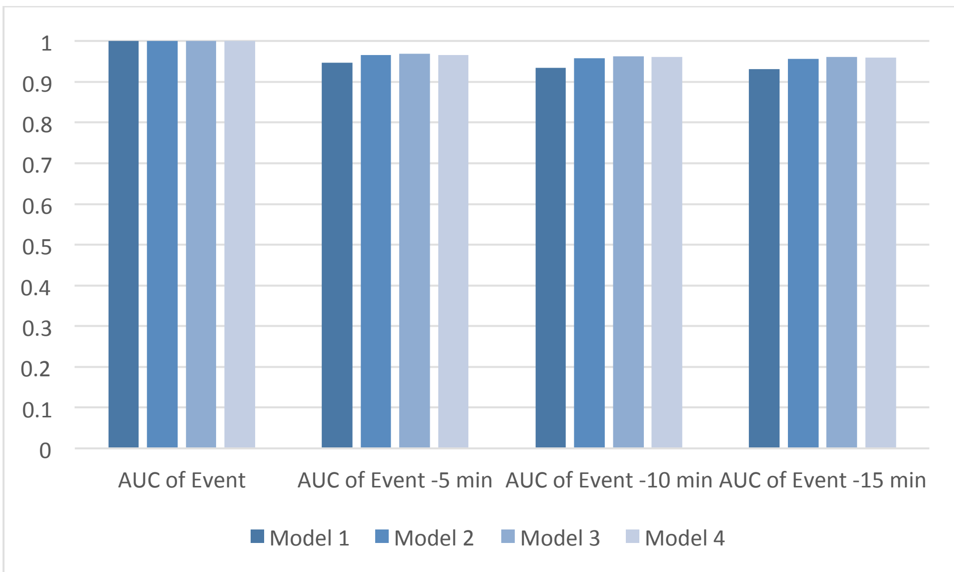

Figure 1. AUC results for Models 1 – 4, to assess sensitivity and specificity of model's ability to identify and predict severe events 0, 5, 10 and 15 minutes prior.