Early Risk Prediction of Atrial Fibrillation from Routine ECG and EHR Data Using Survival Models

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Introduction: Atrial fibrillation (AF) is the most common heart rhythm disorder. It poses a significant stroke risk. Therefore, making early and accurate predictions is essential for timely prevention such as anticoagulant therapy. *Objectives:* The study aims to develop high-precision predictive models for new-onset AF using routinely collected electronic health record (EHR) and 12-lead ECG variables from a large synthetic cohort of patients in Southern Alberta. *Methods:* Missing data is a severe problem in the dataset. To handle this problem and ensure robust and unbiased analysis, we applied multiple imputation (m = 5) for data with less than 50% missing. We saved 20% of the data for testing and performed 5-fold cross-validation on the remaining 80% to enhance generalizability. AF was the outcome of interest across all models. In the Cox Proportional Hazard (PH) and penalized Cox PH models, death was treated as a censoring event. For the Fine-Gray model, death was considered as a competing risk, reflecting that all-cause mortality could prevent AF onset. *Results:* Across the imputed datasets, the Cox PH model achieved mean C-index, AUC, and Brier scores of 0.9501, 0.9465, and 0.01439, while the penalized Cox PH model yielded 0.9504, 0.9461, and 0.01440, respectively. Twenty variables with the highest coefficients from the penalized Cox PH model were selected as covariates for the Fine-Gray model, which better accounted for competing risks but showed lower discriminative performance based on its mean C-index, AUC, and Brier Score of 0.78632, 0.78632 and 0.01486, respectively. *Conclusion:* L1 penalization reduced model complexity by selecting fewer variables without notably compromising predictive performance. While the Fine-Gray model appropriately accounted for competing risks, it showed worse discrimination compared to the Cox PH models. However, the Cox PH models may have overestimated performance due to potential overfitting. Overall, these predictive models hold promise for guiding targeted prevention strategies such as early anticoagulation. Future work will aim to enhance predictive accuracy by incorporating additional clinical variables and exploring deep learning methods to better identify high-risk individuals requiring timely intervention.