Machine learning models for predicting long-term cardiovascular outcomes in kidney transplantation recipients.

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Background:

Cardiovascular disease is the leading cause of death in kidney transplant recipients (KTR). Though necessary for optimal KTR selection and organ allocation, clinical decision support tools that can predict cardiovascular transplant outcomes are lacking. This study aims to develop machine learning (ML) models to predict the incidence of major adverse cardiovascular events in KTR.

Methods:

We included KTR Saint University hospital between 2015 and 2023. 454 features were investigated including demographic, clinical, laboratory, and imaging variables. We studied the following outcomes: all-cause mortality, cardiovascular death, hospitalization for heart failure, and non-fatal myocardial infarction. We compared twelve different ML models for each cardiovascular outcome, where one of the twelve models is an ensemble of the other eleven models stacked in multiple layers. Interpretability and robustness are enhanced with feature selection and five-fold cross validation. Model performance was primarily measured with Area Under Curve (AUC).

Results:

518 patients were included in the study. The mean age of patients was 57.0 +/- 13.8, XX% males, 46.9% white and 47.6% African American. The best models had AUCs of 79.2%, 65.4%, 86.5%, and 83.3% for all-cause mortality, cardiovascular death, hospitalization for heart failure, and non-fatal myocardial infarction, respectively. The two most important features for each of the outcomes were as follows: For all-cause mortality, diastolic blood pressure (p-value<0.001) and BNP (p-value=0.011). For cardiovascular death, BNP (p-value=0.001) and days from pretransplant left heart catheterization to transplant (p-value=0.157. For hospitalization for heart failure, BNP (p-value<0.001) and diastolic blood pressure (p-value<0.001). For non-fatal myocardial infarction, BNP (p-value=0.010) and systolic blood pressure (p-value=0.021). Interestingly, a positive stress test or whether a patient had left heart catheterization did not significantly contribute to the models’ performance.

Conclusion:

ML models can be developed to predict cardiovascular outcomes in KTR with reasonable accuracy.

Clinical Implications:

Machine learning models can be a useful tool for clinical decision-making in predicting post kidney transplant outcomes aiming for better risk modification, organ allocation, and patient outcomes.