Predicting long-term cardiac outcomes following kidney transplantation using interpretable machine learning models

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 identify pre-transplant factors that can predict major adverse cardiovascular events.

Methods:

The investigators collected 454 demographic, clinical, laboratory, and imaging features to build a database of transplanted patients at Saint University hospital between 2015 and 2023. We then compared twelve different machine learning models for four cardiovascular outcomes, 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 +/- 13.8., XX% males. For the outcome of all-cause mortality, cardiovascular death, hospitalization for heart failure, and non-fatal myocardial infarction, the best model had AUCs of 79.2%, 65.4%, 86.5%, and 83.3%, respectively. The three most important features for each of the outcomes were as follows: For all-cause mortality, diastolic blood pressure (p-value<0.001), BNP (p-value=0.011), and HBA1c (p-value=0.007). For cardiovascular death, BNP (p-value=0.001), days from pretransplant left heart catheterization to transplant (p-value=0.157), and diastolic blood pressure(p-value=0.001). For hospitalization for heart failure, BNP (p-value<0.001), diastolic blood pressure (p-value<0.001), and pretransplant HDL-C (p-value=0.027). For non-fatal myocardial infarction, BNP (p-value=0.010), systolic blood pressure (p-value=0.021), and pre-transplant triglyceride levels (p-value=0.068). Interestingly, positive stress tests indicating obstructive coronary artery disease did not significantly contribute to the models’ performance.

Conclusion:

Pretransplant factors such as BNP, systolic and diastolic blood pressures,and HDL-C and triglyceride levels are important features for cardiovascular outcome prediction following kidney transplantation.

Clinical Implications:

Understanding what pretransplant factors could predict future cardiovascular outcomes in kidney transplant patients enable early intervention, ultimately improving kidney transplant outcomes.