

Personalized risk prediction using “predictive pursuit” machine learning: a pilot study in cardiac transplantation.

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Introduction

Across healthcare, risk prediction tools are suboptimal whether used in diagnosis, prognosis or treatment planning. Use of retrospective datasets for derivation and validation, lack of personalisation of tools and inadequate use of machine learning are some of the problems with the current paradigm.

Objective

To improve accuracy of risk prediction using a novel personalized machine learning model ("predictive pursuit") by conducting a pilot study of wait-list and post-transplant mortality in cardiac transplantation.

Methods

Using the United Network for Organ Sharing(UNOS) database of US patients registered for cardiac transplantation 1985-2015, our novel algorithm used different predictive models for different "predictive clusters" of patient characteristics. In a training phase, relevance scores were assigned to each potentially relevant characteristic. In the validation phase, the best-fitting prediction cluster and predictive models were iteratively selected. For wait-list survival and post-transplant survival, predictive accuracy of predictive pursuit was compared with currently used algorithms was assessed by Area Under Receiver Operating Characteristic curve(AUROC).

Results

We included 96,729 individuals: 60,400 (62.4%) received transplants("transplanted") and 36,329 patients (37.6%) did not("wait-listed"). We identified 53 potentially usable characteristics with 33 recipient features,14 donor features and 6 donor-recipient compatibility features. For wait-list mortality at 3 months, 1 year, 3 years and 10 years, AUROC was 0.79(95% Confidence Interval,0.78-0.80), 0.81(0.80-0.82), 0.82(0.81-0.83) and 0.82(0.81-0.83) for our algorithms; 0.63(0.62-0.65), 0.65(0.64-0.66), 0.65(0.64-66) and 0.65(0.64-0.66) for the best currently used clinical predictive model; 0.68(0.67-0.69), 0.65(0.64-0.66), 0.68(0.67-0.69) and 0.66(0.65-0.67) for Cox Regression; and 0.75(0.74-0.77), 0.77(0.76-0.78), 0.78(0.77-0.79) and 0.79(0.78-0.80) for the best machine learning models, respectively. For post-transplant mortality at 3 months,1 year,3 years and 10 years, AUROC was 0.67(0.66-0.68), 0.65(0.65-0.65), 0.66(0.66-0.66) and 0.62(0.61-0.63) for our algorithms; 0.60(0.59-0.61), 0.59(0.58-0.59), 0.57(0.56-0.57) and 0.57(0.58-0.67) for the best currently used clinical predictive model; 0.57(0.56-0.58), 0.60(0.59 -0.61), 0.57(0.56-0.58) and 0.57(0.56-0.58) for Cox Regression; and 0.63(0.63-0.64), 0.62(0.61-0.63), 0.62(0.62 -0.62) and 0.58(0.57-0.59) for the best machine learning models, respectively.

Conclusions

Our novel "predictive pursuit" algorithm out-performs currently available clinical risk prediction scores as well as the best machine learning tools for prediction of wait-list and post-cardiac transplant mortality. The predictive pursuit algorithm has potential to personalise and greatly improve accuracy of risk prediction.