Machine Learning Improves Prediction of Important Events in Mechanical Thrombectomy

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Hypothesis

Logistic regression is not the optimal analysis for predicting patient outcomes for those patients with acute ischemic stroke treated with mechanical thrombectomy and machine learning techniques can be used to improve predictive analysis.

Introduction

Acute ischemic stroke is a major cause of morbidity and mortality but the outcomes for patients are widely variable, and there is little consensus on what factors should be taken into consideration when choosing between conservative therapy, TPA, and mechanical thrombectomy. Logistic regression was used to assess mechanical thrombectomy patient outcomes in major trials, but machine learning has not been appropriately assessed for patient outcomes or symptomatic intracranial hemorrhage (sICH). This abstract will compare machine learning models to logistic regression and provide a framework for predictive modeling to aid the interventionalist with patient selection.

Methods

At a single comprehensive stroke center with a multi-state referral network, 600 consecutive patients evaluated with CT perfusion for stroke were retrospectively analyzed. Patients were included if thrombectomy was attempted and excluded if the pre-intervention dataset was incompletely documented. Eighty-five patients were included in the study. We compiled a data set using previous RCT and retrospective analysis to guide items selected for inclusion within the data collection. These items include patient specific factors, such as hypertension, smoking, sex category, diabetes, as well as factors relating to patient care received, such as transfer from outside institution, and whether the patient had received IV TPA.

First the unified data set was divided into training and testing sets via sampling with repletion (Bootstrap sampling). Using data available prior to intervention, machine learning models including artificial neural network (ANN), support vector machine (SVM), decision tree, naive bayes, and multivariate logistic regression were created from training data sets to predict hemorrhage, and symptomatic intracranial hemorrhage. Predictive performance of the generated models was evaluated on unseen testing data. T-test with Sidak multiple testing correction was used to compare models based on overall accuracy and receiver operating characteristic curves area under the curve (AUC) generated from model application to unseen testing data.

Results

SVM (accuracy 67.01% +/- 7.73 AUC.739 +/- .089) and naive bayes (accuracy 72.75 +/- 7.49% AUC .726 +/- .088) models significantly outperformed logistic regression, (accuracy 62.34 +/-8.01%, AUC .536 +/- .085) with p<.001 for accuracy and AUC, at hemorrhage classification. Analysis for symptomatic intracranial hemorrhage showed that SVM (accuracy:89.37 +/- 3.39% AUC .566 +/- .141) analysis significantly outperformed all other models including traditional logistic regression (p<.001).
For the classification of good outcomes, defined as mRS 0 or 1, ANN (accuracy 57.6% +/- 6.2) SVM (58.7% +/- 5.3) and naive bayes (63.5 +/- 5.3%) and decision tree (59.2% +/- 5.4) models significantly outperformed logistic regression, (54.1 +/- 8.5%) with p<.001 for all comparisons to logistic regression.

For the classification of good outcomes defined as mRS 0, 1, or 2, all machine learning models significantly outperformed logistic regression with p<.005 for accuracy at outcome classification.

Analysis for ROC AUC showed that significant improvement in comparison to traditional logistic regression for comparable models (p<.001) for either definition of good outcome.

Conclusions

Machine learning methods outperform multivariate logistic regression at the prediction of sICH and hemorrhage. The prediction of patient outcome with machine learning methods also outperforms multivariate logistic regression. These methods could help the interventionalist predict and avoid sICH prior to thrombectomy, though prediction of sICH remains difficult.

References


Keywords

machine learning, mechanical thrombectomy, patient outcomes