Predictive Risk Score for Cerebral Malperfusion in Type A Aortic Dissection Utilizing Machine Learning Models

Alexander Mills, Akiko Tanaka, Yuki Ikeno, Lucas Bernal, Harleen Sandhu, Charles Miller, Charles Green, Danny Ramzy, Anthony Estrera

Department of Cardiothoracic and Vascular Surgery
McGovern Medical School at UTHealth
Memorial Hermann Heart & Vascular Institute

Department of
Cardiothoracic & Vascular Surgery

UTHealth Houston
McGovern Medical School

Introduction

- Cerebral malperfusion due to acute type A aortic dissection (ATAAD) can lead to severe neurologic deficits and operative death
- Early detection of risk for this sequela can aid clinical decision-making
- Machine learning models have been used to develop clinical risk scores and can efficiently analyze large datasets

Hypothesis

A machine learning model would be able to produce a novel predictive risk score for cerebral malperfusion to aid in early risk assessment

Methods: Data

- Single institution study
- Patients undergoing ATAAD repair from 2001 to 2020
- Admission data (i.e., history, laboratory values, imaging) was identified

Methods: Analysis

- Missing data: handled with missRanger imputation (RStudio)
- A random forest regression machine learning model identified key predictor variables for cerebral malperfusion (primary outcome)
- Risk scores were calculated for these variables using a generalized regression model
- Predictive strength of the model: area under the curve, sensitivity/specificity, and negative/positive predictive values

Results

- 650 patients were identified
- Median age was 58.0 (interquartile range: 47.0-69.0)
- 183 (28.1%) were female
- 119 patients (18.3%) diagnosed with cerebral malperfusion

Predictor variables for Cerebral Malperfusion (Calculated Score)

- Hemiparesis on presentation (4)
- Presenting comatose (2)
- Presenting with altered mental status (2)
- Concomitant celiac malperfusion (1)
- Concomitant renal malperfusion (1)
- Prior history of stroke (1)
- Prior history of transient ischemic attack (1)
- Dissection extending into either common carotid artery (1)

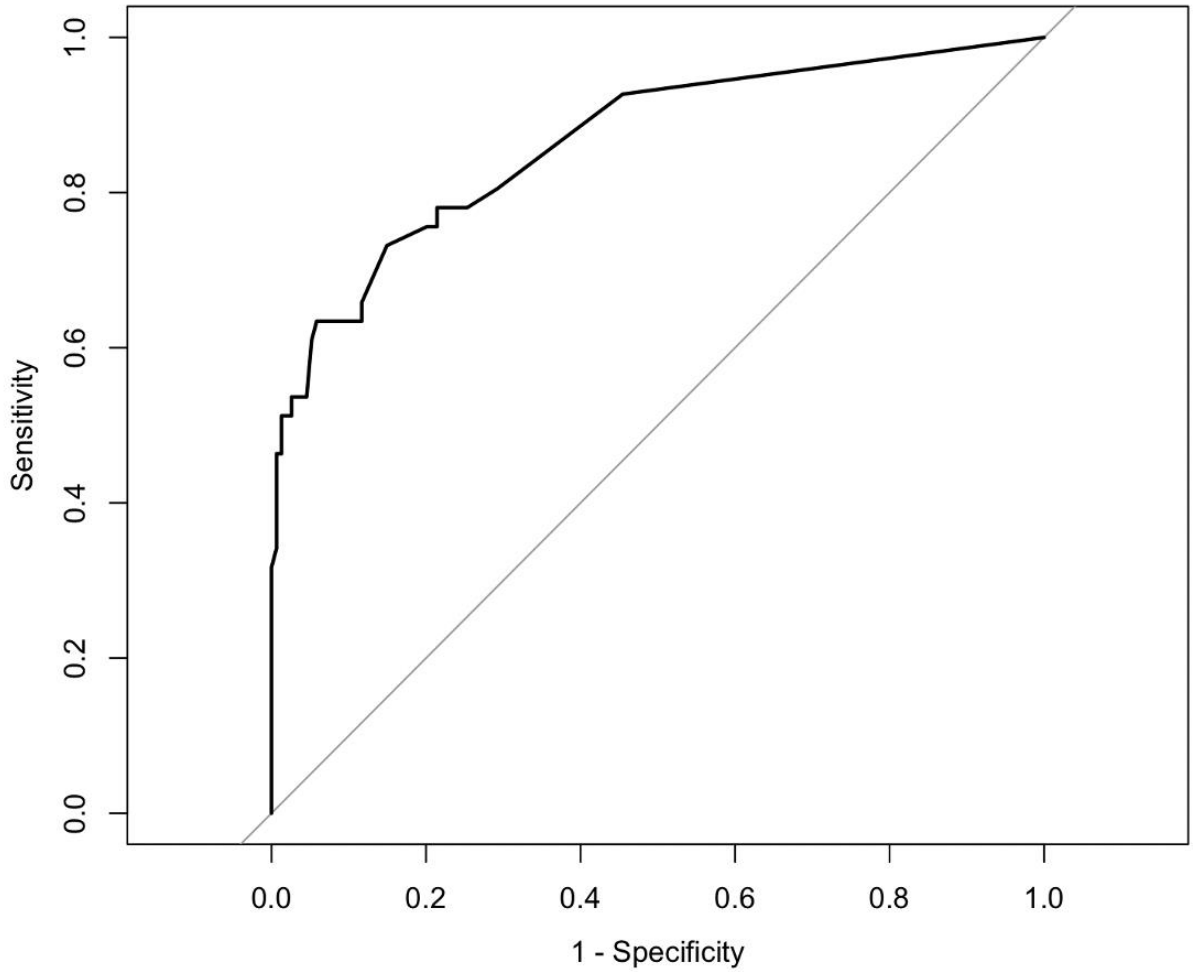
Model Discrimination and Accuracy

- Area under the curve: 0.866 (0.798-0.933, $p<0.001$)
- Score of ≤1 , the sensitivity was 95.0%
- Score of ≥4, the specificity was 97.0%.

Model Predictability across Different Risk Scores

p-value	AUC	95% CI	Risk Score	Sensitivity	Specificity	PPV	NPV
<0.001	0.8655	0.7976-0.9333	>0	94.9%%	51.1%%	30.40%	97.50%
			>1	95.00%	51.2%%	30.40%	97.80%
			>2	79.8%%	78.9%%	45.90%	94.60%
			>3	69.70%	92.10%	66.40%	93.10%
			>4	58.00%	97.00%	81.20%	91.20%
			>5	48.70%	98.90%	90.60%	89.60%
			>6	37.80%	99.20%	91.80%	87.70%
			>7	31.10%	99.80%	97.40%	86.60%
			>8	16.00%	100.00%	100.00%	84.20%

Receiver Operating Curve



Conclusion

- A novel predictive risk score was developed using machine learning models to aid in the early detection of cerebral malperfusion
- This model uses readily available information, is easy to calculate, and can aid the surgical team in clinical decision-making

Thank You!

Department of
Cardiothoracic & Vascular Surgery

UTHealth Houston
Heart & Vascular

UTHeartVascular
info.ctvs@UTHeartVascular
https://med.uth.edu/cvs/