Prediction of Neurologic Injury in Pediatric ECMO

Henry Noren¹, Disha Mishra¹, Priyamvada Prathima³, Louise Lu¹, Valentina D’Souza¹, Yang Miao¹, Yongzhi Sun¹, Joseph Greenstein¹, Casey Overby Taylor¹, Dennis Leung², Melania Bembea²

¹Department of Biomedical Engineering, Johns Hopkins University, Baltimore, MD
²Department of Anesthesiology and Critical Care Medicine, Johns Hopkins School of Medicine, Baltimore, MD

Background

• Extracorporeal Membrane Oxygenation (ECMO) partially replaces function of heart and lungs: life support.
• 25% of pediatric ECMO patients develop neurologic injury such as stroke or hemorrhage, increasing mortality by 85%. Injuries occur due to the delicate balance between bleeding and clotting during ECMO.
• Clinicians need a method to predict the onset of neurologic injuries to better inform the administration of blood products and anticoagulation factors.

Objective and Hypothesis

• Objective: Using the PEDECOR database, develop models to predict neurologic injury: 1) using pre-ECMO data and 2) adding time series lab and blood product data.
• Hypothesis: Models trained on lab measurements and blood product time-series data will better predict the risk of neurologic injury in pediatric ECMO patients than pre-ECMO demographic and patient history features alone.

Methods and Results

Pre-ECMO Model: Low AUC, Non-iterative predictions on static data

Input Features: Demographics and Medical History (static)
Models: Random Forest, Naïve Bayes, K-nearest Neighbor, Logistic Regression
Output: Predict if patient will ever have neurologic injury during ECMO

Time-Series Model: Higher AUC, Daily predictions on dynamic data

Input Features: Pre-ECMO inputs, lab values, blood product infusions (dynamic daily)
Model: Random Forest trained every 24 hours with new time series data
Output: Predict if ECMO patient will ever have neurologic injury every 24 hours

Neurologic Injuries of interest:
- Stroke
- Hemorrhage

Discussion and Conclusion

Model Performance
• Results support the hypothesis: Time series model has a higher AUC (> 0.77) than pre-ECMO model AUC (< 0.55).
• Models including data on daily lab measurements and blood products given perform better predictions of neurologic injury.

Feature Importance:
• The Pre-ECMO highest risk factors for onset of neurologic injury were age, illness, and ventricular dysfunction.
• The time series features identified as the highest risk factors were antithrombin III and bilirubin, which are lab measurements relevant to coagulation in the blood.

Future Work
• The time series prediction model has low precision indicating a high false positive rate. Improving this metric could improve the clinical application of this prediction model.

Dataset

• Inclusion Criteria: Patients less than 18 years of age.
• Exclusion Criteria: Patients cannulated at non-PEDECOR institution for >24 hours, death within 6 hours of ECMO cannulation.

Fig 1: Breakdown of Pediatric ECMO Outcomes Registry (PEDECOR) dataset based on neurological outcomes, and training / testing split used in the model.