Prediction of Cardiac Arrest in the Pediatric ICU

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Background

- In-hospital cardiac arrest (IHCA) occurs in approximately 15,200 pediatric patients annually, with a survival rate of 25-30% at discharge.[1,2]
- Early prediction of IHCA could improve patient outcomes.

Our Data

Age Group	Total Patients	IHCA Patients	Male:Female
Newborn - 1 Month	65	3	40:25
1 Month - 1 Year	172	5	95:77
1 Year - 2 Years	95	1	57:38
2 Years - 5 Years	120	1	71:49
5 Years - 11 Years	267	1	149:118
11 Years - 18 Years	388	4	215:173
18 + Years	38	0	19:19
Total	1145	15	646:499

Feature Engineering

- **240 Hz ECG** – 23 heart rate variability (HRV) metrics were calculated from R wave peaks (NN intervals) after filtering outliers and removing ectopic beats.
- **0.5 Hz Vitals** – 96 total summary metrics were calculated for vital signs (e.g. respiratory rate).
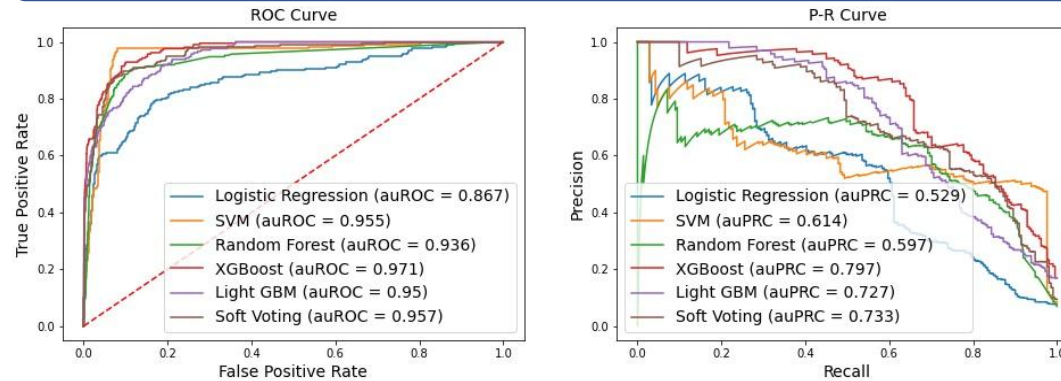- **Medications** – 43 therapeutic classes were one-hot encoded.

Results

Figure 1. Receiver operating curves and precision recall curves on held-out data. The best performing model was XGBoost (99.5% sensitivity, 69.6% specificity).
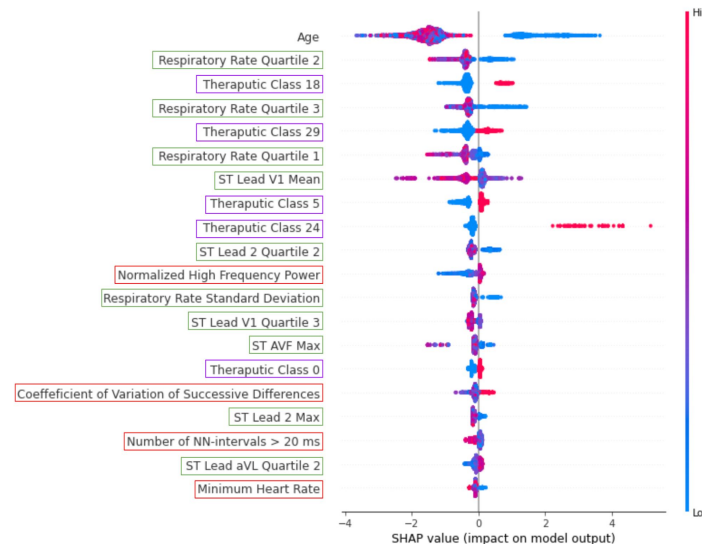

Figure 2. SHAP values for the top features from XGBoost. Positive SHAP values indicate a contribution to a positive prediction of IHCA. High feature values are in red. Low feature values are in blue. HRV metrics are in red boxes, vital signs features are in green boxes, and medications are in purple boxes.

Objective and Methods

Our Aim: To use machine learning to predict in-hospital pediatric cardiac arrest within 3 hours of onset by using multi-frequency waveform data.

1. Created 5 minute windows
2. Labelled windows within 3 hours of IHCA as positive, all others as negative
3. Performed feature engineering on each window
4. Normalized data by patient age group
5. Trained machine learning prediction models and evaluated on held-out data

Conclusions

- We have created high-performing models to predict pediatric IHCA by combining ECG waveforms, vital signs time series data, and medications data.
- Multiple heart rate variability metrics, a low respiratory rate, and several therapeutic classes of medications are key indicators of pediatric IHCA.
- Our results would enable earlier cardiac arrest intervention, improving patient outcomes.

References

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2. de Mos, N., van Litsenburg, R., McCrindle, B., Bohn, D., & Parshuram, C. (2006). Pediatric in-intensive-care-unit cardiac arrest: Incidence, survival, and predictive factors*. Critical Care Medicine, 34(4), 1209-1215. doi: 10.1097/01.ccm.0000208440.66756.c2