Predicting Length of Stay For Acute Stroke Patients Using Hemodynamic Features

Zach Murphy,1,2 Michael Ainsworth,1 Alex Hepp,1 Varun Naga,1 Athena Obzueski,1 Kirby Gong,1 Elizabeth Zink,1 Joseph Greenstein,4 Raimond Winslow,4 Mona Bahouth,5
1Department of Biomedical Engineering, Johns Hopkins University, 2Johns Hopkins University School of Medicine, 3Neuroscience Critical Care Unit, Johns Hopkins Medicine 4Institute for Computational Medicine, Johns Hopkins University, 4Department of Neurology, Johns Hopkins University School of Medicine

● Stroke is a leading cause of death and disability.
● During the acute stroke period, there is a disruption of the blood-brain barrier and cerebral blood flow autoregulation.
● Hemodynamic variability has been associated with worse outcomes.
● Using hemodynamics to predict normal vs abnormal lengths of stay (LOS) may help in risk profiling, care coordination, and resource allocation.

Methods

● Combine static and time-series data to feed models.
● Predictive models include Generalized Linear Models, Random Forest, and XGBoost.
● Output label: patient length of stay (LOS).
● LOS converted into a binary label.

Results

● Included 2,025 patients from Johns Hopkins Stroke Center.
● Demographics matched general stroke population well.

Figure 1: Design image demonstrating the project pipeline. Data taken from the first 24 hours of admission. Feature space is used to train models to predict patient length of stay.

Figure 2: Top 20 features using RF feature ranking. High scoring features were derived from Glasgow, orientation, pulse, and IV features.

Figure 3: ROC and Precision-Recall curves for final models. XGBoost scored the highest with an AUC of 0.840.

Table 1: XGBoost statistics for the optimal operating point.

<table>
<thead>
<tr>
<th>Specificity</th>
<th>Sensitivity</th>
<th>PPV</th>
<th>NPV</th>
<th>F1-score</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80</td>
<td>0.76</td>
<td>0.70</td>
<td>0.85</td>
<td>0.73</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Figure 4: AUC scores for varying time windows. The observation window for time series data was increased to 48 hours and 72 hours. Model AUCs yielded comparable results.

Discussion / Conclusion

● Our results enable prediction of LOS ≥ 7 days for stroke patients with respectable performance after the first 24 hours of admission, and can be updated at each 24 hours interval.
● Limitations include data coming from a single site as well as inability to capture non-medical factors related to LOS such as insurance plan and social determinants.
● Further work is needed to refine these models, validate in other stroke centers, and implement into clinical practice in order to understand the full impact of such predictions.