External Validation of Hematoma Expansion Prognostic Models in Spontaneous Intracerebral Hemorrhage

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Disclosure

I acknowledge my continuing obligation to disclose to AANS/NREF/NPA, promptly and in writing, any change in my circumstances.

I further acknowledge that if there is any case where my private interest conflict with the interests of AANS/NREF/NPA, I will indicate that I may have a conflict and abstain from any vote, speaking engagement, planning related to that issue.
Introduction

Previous spontaneous intracerebral hemorrhage (ICH) scores were used to predict mortality and functional outcomes.

Hematoma expansion has been found to be an independent predictor of outcome in ICH.

Three prediction scores for hematoma expansion (PREDICT A Score, 9-Point Score, BRAIN Score) have recently been developed.

We aim to independently externally validate these three prediction models in our population, which has not been previously done.
Methods

External Validation
Discrimination (area under receiving operating characteristic curve)
Calibration (Hosmer-Lemeshow goodness of fit test)
Methods - Imaging Analysis

Volumetric Analysis (Segmentation):
- ICH volume
  [On admission]
- Hematoma expansion
  [Increase of >6mL or >33% in hematoma volume on 24hr CT]

CT Angiographic Spot Sign:
- Spot-like or serpiginous foci of enhancement without connection to outside vessels
- Greater than 1.5mm
- Hounsfield unit density of at least double that of background hematoma density

*CT Angiography performed with 90 second delayed phase imaging
## Prognostic Models

<table>
<thead>
<tr>
<th></th>
<th>PREDICT Score</th>
<th>9-Point Score</th>
<th>BRAIN Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours from ictus to CT (hours)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Warfarin use</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CTA spot sign</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>GCS</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline ICH volume (ml)</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>IVH extension</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Recurrent ICH</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Score range</td>
<td>0 – 23</td>
<td>0 – 9</td>
<td>0 – 24</td>
</tr>
</tbody>
</table>
Results

- Area Under Receiver Operator Curve

Hosmer-Lemeshow test all were $p>0.05$, indicating good calibration.
Comparing Scores

Hematoma Expansion Prediction Scores

Akaike Information Criterion vs. Area Under the Curve
Discussion

This is the first study to validate the PREDICT A, 9-Point and BRAIN scores in an independent patient cohort with spontaneous ICH in a non-western population.

Based on a unique AUC/AIC matrix used to compare the scores, the PREDICT A score performed the best with highest AUC (0.79) and lowest AIC (101).

The PREDICT A score, however, has greater granularity when dichotomising the individual variables. Hours from onset-to-CT time and CTA spot sign have been found to be independent predictors of hematoma expansion, both of which have greater granularity in the PREDICT A score and could therefore theoretically confer a more accurate prediction of hematoma expansion.

The BRAIN score was specifically created for centres where CTA is not readily available or routinely performed for ICH. Understandably, it did not perform as well when used to predict hematoma expansion likely due to the absence of the CTA spot sign.
Summary

Prediction models must be validated internally and externally before they are considered widely applicable.

This external validation study satisfactorily demonstrates the validity of the PREDICT A, 9-Point and BRAIN scores in predicting hematoma expansion in a non-western population.

When compared head to head, the PREDICT A score performed best with highest AUC (0.79) and lowest AIC (101).