Novel Score Predicting Gastrostomy Tube Placement in Intracerebral Hemorrhage

Roland Faigle, MD, PhD; Elisabeth B. Marsh, MD; Rafael H. Llinas, MD; Victor C. Urrutia, MD; Rebecca F. Gottesman, MD, PhD

Background and Purpose—Dysphagia after intracerebral hemorrhage (ICH) contributes significantly to morbidity, often necessitating placement of a percutaneous endoscopic gastrostomy (PEG) tube. This study describes a novel risk prediction score for PEG placement after ICH.

Methods—We retrospectively analyzed data from 234 patients with ICH presenting during a 4-year period. One hundred eighty-nine patients met inclusion criteria. The sample was randomly divided into a development and a validation cohort. Logistic regression was used to develop a score based on weighted predictors of PEG placement.

Results—Age (odds ratio [OR], 1.64 per 10-year increase in age; 95% confidence interval [CI], 1.02–2.65), black race (OR, 3.26; 95% CI, 0.96–11.05), Glasgow Coma Scale (OR, 0.80; 95% CI, 0.62–1.03), and ICH volume (OR, 1.38 per 10-mL increase in ICH volume) were independent predictors of PEG placement. The final model for score development achieved an area under the curve of 0.7911 (95% CI, 0.6931–0.8892) in the validation group. The score was named the GRAVo score: Glasgow Coma Scale ≤12 (2 points), Race (1 point for black), Age >50 years (2 points), and ICH Volume >30 mL (1 point). A score >4 was associated with ≥12x higher odds of PEG placement when compared with a score ≤4 (OR, 11.81; 95% CI, 5.04–27.66), predicting PEG placement with 46.55% sensitivity and 93.13% specificity.

Conclusions—The GRAVo score, combining information about Glasgow Coma Scale, race, age, and ICH volume, may be a useful predictor of PEG placement in ICH patients.

Key Words: cerebral hemorrhage ■ enteral nutrition ■ stroke ■ tube feeding

Spontaneous intracerebral hemorrhage (ICH) is a devastating form of stroke, accounting for 15% to 20% of all strokes worldwide. ICH carries a high risk of poor long-term outcome, and treatment is largely supportive, aimed at promoting recovery. Oropharyngeal dysphagia is a common sequela after ICH, contributing significantly to overall morbidity.

Although most patients recover adequate swallowing function within a week, dysphagia may persist in some patients, often necessitating long-term parenteral feeding via a percutaneous endoscopic gastrostomy (PEG) to prevent malnutrition and to reduce aspiration.

Previously identified predictors of PEG placement in patients with stroke include variables largely associated with stroke severity, such as lesion volume and mental status impairment. Among the different stroke subtypes, patients with ICH have generally been identified as having higher risk for PEG tube placement than patients with ischemic stroke. Patients with ICH undergoing PEG placement are more likely to be black, have low Glasgow Coma Scale (GCS) scores, intraventricular blood, and hydrocephalus. However, to date, no established scoring system uses individual-level variables to predict risk of PEG placement in patients with ICH comprehensively and reliably. A scoring tool aiding in early identification of high-risk patients for PEG may aid physicians in clinical decision making and may help guide counseling of patients. Furthermore, reliably predicting risk for PEG placement may result in shorter hospital stays and allow for expedited transition to rehabilitation, thus potentially reducing costs and improving long-term outcomes.

In this study, we hypothesized that factors associated with ICH severity would be important predictors of subsequent need for a PEG tube. The present study aims to develop a clinically feasible risk prediction score to assist physicians in predicting PEG placement in patients with ICH.

Methods

Patients and Study Design

This study was approved by the Johns Hopkins University School of Medicine Institutional Review Board. We retrospectively analyzed

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medical records of patients in our prospective stroke database. Consecutive patients presenting with primary ICH to our academic centers (Johns Hopkins Hospital and Johns Hopkins Bayview Medical Center) between January 2010 and December 2013 were included. Patients with in-hospital ICH and interhospital transfers were excluded, as were patients with known intracerebral metastatic disease, known arteriovenous malformation, or cavernoma in the location of the hemorrhage. In addition, patients with pre-existing dysphagia and patients who died, were made comfort care, or transferred to hospice within the first 3 days of admission were excluded from analysis. Early deaths (≤3 days) were excluded because long-term feeding plans are typically not addressed by the neurological and neurocritical care team within the first 3 days of hospitalization. Patients alive on day 4 were included because a recovery trajectory can be established in some patients by this time, and most patients will have undergone ≥1 formal swallow evaluation. A few patients who were alive on day 4 and were possible candidates for PEG tube placement did not receive a PEG because they died before a PEG could be placed. In addition, a few patients for whom PEG placement was planned died before a PEG tube could be placed. These patients were included in the no PEG group because most practitioners have discussions about long-term feeding plans with other team members and family during this time period.

**Dysphagia Evaluation**
The primary outcome was placement of a PEG. At our institutions, all patients with ICH are administered a validated bedside swallow screen by a trained nurse before any oral intake to evaluate for risk of dysphagia and aspiration. This swallow screen incorporates a clinical symptom checklist along with the 3-ounce water swallow test, a standardized and validated test for dysphagia. Patients who fail bedside swallow screening are referred for a swallow evaluation by a speech and language pathologist (SLP) within 24 hours of admission, unless unable to participate, and are started on enteral feeding via a nasogastric tube according to national guidelines. Patients alive on day 4 were included because a recovery trajectory can be established in some patients by this time, and most patients will have undergone ≥1 formal swallow evaluation. A few patients who were alive on day 4 and were possible candidates for PEG tube placement did not receive a PEG because they died before a PEG could be placed. In addition, a few patients for whom PEG placement was planned died before a PEG tube could be placed. These patients were included in the no PEG group because most practitioners have discussions about long-term feeding plans with other team members and family during this time period.

**Clinical Data Collection**
Demographic data, including age, sex, and race, were collected for all patients. To study the potential relationship of PEG placement and stroke risk factors, the presence of the following variables was recorded: hypertension, hyperlipidemia, diabetes mellitus, smoking status, history of atrial fibrillation, chronic kidney disease, and history of ICH. To assess the potential association of PEG placement and medications commonly prescribed in patients with cerebrovascular disease, the prehospital use of antplatelet agents, anticoagulation and statins was also recorded. The following physiological parameters at presentation thought to be potentially related to ICH severity and outcome were recorded: GCS at presentation, blood pressure, interational normalized ratio, serum glucose, and estimated glomerular filtration rate by Modification of Diet in Renal Disease equation. In addition, data on length of intensive care unit stay, total length of hospitalization, and discharge location were collected.

**Neuroimaging Analysis**
ICH location on admission computed tomographic scan was categorized as deep, lobar, cerebellar, or brain stem, and ICH volume was calculated by the ABC/2 method (where A, B, and C reflect the dimensions of the hemorrhage by CT) as described previously. All images were reviewed by a vascular neurologist (R.F.). A second investigator (V.C.U.) reviewed randomly selected images for just >10% of the sample, and an intraclass correlation coefficient for a 2-way random effects model was used to assess inter-rater agreement of ICH volume (intraclass correlation coefficient, 0.87; 95% confidence interval [CI], 0.70-0.95). The presence of intraventricular hemorrhage, casting of the fourth ventricle, obstructive hydrocephalus, cortical involvement, and subarachnoid component were each recorded. All patients underwent follow-up neuroimaging within the first 24 hours of admission as per standard clinical practice, and repeat imaging was compared with the admission computed tomographic scan to assess for hematoma expansion. Hematoma expansion was defined as a proportional increase of >33% or an absolute increase ≥6 mL (if baseline ICH volume ≤5 mL) from the initial ICH volume. The ICH score as a score predicting mortality in ICH was determined for each patient as described previously.

**Statistical Analysis**
Statistical analysis was performed using STATA version 13 (Stata Statistical Software: Release 13, College Station, TX). A value of *P*<0.05 was considered statistically significant; 95% CIs are reported. For univariate analyses, continuous variables were analyzed using Student *t* tests for normally distributed variables, and Wilcoxon rank-sum tests (Mann–Whitney *U* test) for non-normally distributed variables. Categorical variables were analyzed using Pearson χ² analysis, and Fisher exact tests, when appropriate.

The prediction model was developed using a random sample of 50% of the data set (development group), and subsequently tested on the remaining 50% (validation group). In addition, the score was tested on the entire population after score development.

Simple logistic regression analysis was performed using basic demographic or physiological variables, as well as other variables, previously published to be associated with PEG placement or thought to be potentially clinically relevant for the placement of a PEG tube. A multivariable statistical model of predictors of PEG placement was developed using basic demographic variables, including age, sex, and race, as well as statistically significant variables from the simple logistic regression analyses. Independent predictors with *P*<0.1 were included as score variables in the final score. Continuous variables significantly associated with outcome were transformed into categorical variables based on clinically and statistically meaningful subdivisions to facilitate their application in a practical score. Akaike information criterion and area under the receiver operating characteristics curve were used for final model selection. Calibration was assessed with the Hosmer–Lemeshow test to determine goodness of fit. To generate a risk score, we assigned points to each variable proportional to its regression coefficients rounded to the nearest integer.

**Results**

**Patient Characteristics**
A total of 234 patients presented to the emergency departments at the Johns Hopkins Hospital or The Johns Hopkins Bayview Medical Center for primary ICH between January 2010 and December 2013. Patients who died, were made comfort care, or transferred to hospice within the first 3 days were excluded, leaving 189 patients for further analysis.

The average age was 62.7 years (range, 21–94 years), 60.3% were men, and 54.0% were black (Table 1). The median GCS at presentation was 14 (interquartile range [IQR],...
Table 1. Baseline Characteristics of Patients With ICH, With and Without PEG

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All Patients (n=189)</th>
<th>PEG (n=58)</th>
<th>No PEG (n=131)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean (SD)</td>
<td>62.7 (15.3)</td>
<td>65.1 (14.9)</td>
<td>61.6 (15.4)</td>
<td>0.157</td>
</tr>
<tr>
<td>Range</td>
<td>21–94</td>
<td>42–94</td>
<td>21–91</td>
<td></td>
</tr>
<tr>
<td>Race: black</td>
<td>102 (54.0)</td>
<td>33 (56.9)</td>
<td>69 (52.7)</td>
<td>0.591</td>
</tr>
<tr>
<td>Sex: male</td>
<td>114 (60.3)</td>
<td>36 (62.1)</td>
<td>78 (59.5)</td>
<td>0.743</td>
</tr>
<tr>
<td>GCS, median (IQR)</td>
<td>14 (11–15)</td>
<td>11 (7–14)</td>
<td>15 (13–15)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Seizure at onset</td>
<td>17 (9.0)</td>
<td>8 (13.8)</td>
<td>9 (6.9)</td>
<td>0.125</td>
</tr>
<tr>
<td>BP, mm Hg, median (IQR)</td>
<td>131 (105–157)</td>
<td>143 (120–174)</td>
<td>125 (102–155)</td>
<td>0.044</td>
</tr>
<tr>
<td>BP, mm Hg, median (IQR)</td>
<td>101 (87–120)</td>
<td>106 (96–120)</td>
<td>100 (80–122)</td>
<td>0.241</td>
</tr>
<tr>
<td>Glucose, mg/dL, median (IQR)</td>
<td>131 (105–157)</td>
<td>143 (120–174)</td>
<td>125 (102–155)</td>
<td>0.044</td>
</tr>
<tr>
<td>eGFR &lt;60 mL/min</td>
<td>53 (28.0)</td>
<td>15 (25.9)</td>
<td>38 (29.0)</td>
<td>0.657</td>
</tr>
<tr>
<td>INR, median (IQR)</td>
<td>1.1 (1.0–1.1)</td>
<td>1.1 (1.0–1.1)</td>
<td>1.1 (1.1–1.2)</td>
<td>0.545</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>155 (82.0)</td>
<td>49 (84.5)</td>
<td>106 (80.9)</td>
<td>0.566</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>69 (36.5)</td>
<td>19 (32.8)</td>
<td>50 (38.2)</td>
<td>0.476</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>39 (20.6)</td>
<td>10 (17.2)</td>
<td>29 (22.1)</td>
<td>0.443</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>18 (9.5)</td>
<td>4 (6.9)</td>
<td>14 (10.7)</td>
<td>0.413</td>
</tr>
<tr>
<td>Previous hemorrhagic stroke</td>
<td>12 (6.4)</td>
<td>2 (3.5)</td>
<td>10 (7.6)</td>
<td>0.350</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>23 (12.2)</td>
<td>6 (10.3)</td>
<td>17 (13.0)</td>
<td>0.610</td>
</tr>
<tr>
<td>Current smoking</td>
<td>53 (29.3)</td>
<td>12 (22.2)</td>
<td>41 (32.3)</td>
<td>0.174</td>
</tr>
<tr>
<td>Medications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antiplatelet agent</td>
<td>68 (36.0)</td>
<td>20 (34.5)</td>
<td>48 (36.6)</td>
<td>0.776</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>16 (8.5)</td>
<td>4 (6.9)</td>
<td>12 (9.2)</td>
<td>0.606</td>
</tr>
<tr>
<td>Statin</td>
<td>44 (23.3)</td>
<td>14 (24.1)</td>
<td>30 (22.9)</td>
<td>0.853</td>
</tr>
<tr>
<td>Imaging</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICH volume, mL, median (IQR)</td>
<td>11 (4–25)</td>
<td>20.5 (8–47)</td>
<td>8 (2–19)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hematoma expansion</td>
<td>18 (9.5)</td>
<td>5 (8.6)</td>
<td>13 (9.9)</td>
<td>0.778</td>
</tr>
<tr>
<td>Infratentorial origin</td>
<td>35 (19.0)</td>
<td>14 (24.1)</td>
<td>21 (16.7)</td>
<td>0.230</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td>0.216</td>
</tr>
<tr>
<td>Lobar</td>
<td>45 (24.5)</td>
<td>9 (15.5)</td>
<td>36 (28.6)</td>
<td></td>
</tr>
<tr>
<td>Deep</td>
<td>103 (56.0)</td>
<td>35 (60.3)</td>
<td>68 (54.0)</td>
<td></td>
</tr>
<tr>
<td>Brain stem</td>
<td>13 (7.0)</td>
<td>6 (10.3)</td>
<td>7 (5.6)</td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td>23 (12.5)</td>
<td>8 (13.8)</td>
<td>15 (11.9)</td>
<td></td>
</tr>
<tr>
<td>Isolated IVH</td>
<td>5 (2.7)</td>
<td>0 (0)</td>
<td>5 (3.8)</td>
<td>0.326</td>
</tr>
<tr>
<td>Intraventricular blood</td>
<td>75 (39.7)</td>
<td>33 (56.9)</td>
<td>42 (32.1)</td>
<td>0.001</td>
</tr>
<tr>
<td>Cortical involvement</td>
<td>61 (40.9)</td>
<td>13 (29.6)</td>
<td>48 (45.7)</td>
<td>0.067</td>
</tr>
</tbody>
</table>

Table 1. Continued

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All Patients (n=189)</th>
<th>PEG (n=58)</th>
<th>No PEG (n=131)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAH component</td>
<td>28 (15.1)</td>
<td>11 (19.0)</td>
<td>17 (13.3)</td>
<td>0.315</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>41 (21.7)</td>
<td>20 (34.5)</td>
<td>21 (16.0)</td>
<td>0.005</td>
</tr>
<tr>
<td>Fourth ventricle obliteration</td>
<td>48 (25.4)</td>
<td>24 (41.4)</td>
<td>24 (18.3)</td>
<td>0.001</td>
</tr>
<tr>
<td>ICH score, median (IQR)</td>
<td>1 (0–2)</td>
<td>2 (2–3)</td>
<td>1 (0–2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ICU stay, median (IQR)</td>
<td>4 (2–10)</td>
<td>13.5 (7–23)</td>
<td>3 (2–6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LOS, d, median (IQR)</td>
<td>10 (6–21)</td>
<td>24 (18–32)</td>
<td>8 (5–12)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Discharge</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Home</td>
<td>37 (19.6)</td>
<td>0 (0)</td>
<td>37 (28.3)</td>
<td></td>
</tr>
<tr>
<td>ACIR</td>
<td>69 (36.5)</td>
<td>21 (36.2)</td>
<td>48 (36.6)</td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>51 (27.0)</td>
<td>32 (55.2)</td>
<td>19 (14.5)</td>
<td></td>
</tr>
<tr>
<td>In-hospital death</td>
<td>32 (17.0)</td>
<td>5 (8.6)</td>
<td>27 (20.6)</td>
<td></td>
</tr>
</tbody>
</table>

P values compare persons with and without PEG placement. Numbers (%) are provided unless otherwise specified. ACIR indicates acute inpatient rehabilitation; BP, blood pressure; DBP, diastolic BP; eGFR, estimated glomerular filtration rate; GCS, Glasgow Coma Scale; ICU, intensive care unit; INR, international normalized ratio; IQR, interquartile range; IVH, intraventricular hemorrhage; LOS, length of stay; PEG, percutaneous endoscopic gastrostomy; SA, subacute rehabilitation; SAH, subarachnoid hemorrhage; and SBP, systolic BP.

11–15). One hundred fifty-five patients (82.0%) had a history of hypertension, 69 (36.5%) had hyperlipidemia, 39 (20.6%) had diabetes mellitus, and 12 (6.4%) had a previous hemorrhagic stroke. The median ICH volume was 11 mL (IQR, 4–25 mL), 56.0% were deep hemmorhages, and 24.5% were lobar hemorrhages. Thirty-five (19.0%) of all ICHs had infratentorial origin.

Fifty-eight patients (30.7%) underwent PEG placement during their hospitalization. The median time to PEG placement was 14.5 days (IQR, 12–18 days). In general, patients undergoing PEG placement were more likely to present with lower GCS (median, 11 versus 15), higher systolic blood pressure, and higher glucose levels than did patients without PEG placement (Table 1). Patients who received a PEG were more likely to present with higher ICH volume (median, 20.5 versus 8 mL), were more likely to have intraventricular hemorrhage (56.9% versus 32.1%), hydrocephalus (34.5% versus 16.0%), and obliteration of the fourth ventricle (41.4% versus 18.3%). The median ICH score was 2 (IQR, 2–3) in the PEG group, and 1 (IQR, 0–2) in the group without PEG. Patients undergoing PEG placement had a longer total length of stay (median, 24 versus 8 days), longer intensive care unit stay (median, 13.5 versus 3 days), and were more likely to be discharged to a subacute rehabilitation facility/nursing home (55.2% versus 14.5%).

Development of the PEG Prediction Model

Simple logistic regression in the development group identified the following clinical and imaging characteristics associated with PEG placement: GCS (OR, 0.79 per 1-point increase...
in GCS; $P<0.001$), systolic blood pressure (OR, 1.14 per 10 mm Hg increase in systolic blood pressure; $P=0.02$), ICH volume (OR, 1.37 per 10-mL increase in ICH volume; $P=0.002$), intraventricular hemorrhage (OR, 3.17; $P=0.011$), subarachnoid component (OR, 3.25; $P=0.047$), fourth ventricle obliteration (OR, 2.88; $P=0.025$), and ICH score (OR, 2.83 per 1-point increase in ICH score; $P<0.001$). In multivariable logistic regression only age (OR, 1.05; $P=0.042$), black race (OR, 3.26; $P=0.058$), GCS on presentation (OR, 0.80 per 1-point increase in GCS; $P=0.078$), and initial ICH volume (OR, 1.38 per 10-mL increase in ICH volume; $P=0.047$) were independent predictors of PEG placement with $P<0.1$ (Table 2). For score development, the best model included race in addition to age with a cut point at 50 years, GCS with a cut point at 12, ICH volume with a cut point at 30 mL. This model achieved an area under the curve of 0.8410 (95% CI, 0.7504–0.9316) and the Hosmer–Lemeshow test confirmed goodness of fit ($P=0.4602$).

**Model Validation and Risk Score**

In the validation group, the area under the curve for the complete model was 0.7911 (95% CI, 0.6931–0.8892), and the model fit the data well (Hosmer–Lemeshow, $P=0.3897$). A 4-item risk score was developed based on the following model: Log(odds) PEG=−5.47+1.94x+0.99x+2.41x+1.34x; where $x_1=$GCS≤12, $x_2=$black, $x_3=$age>50 years, $x_4=$ICH volume>30 mL. The score was termed GRAVo, representing the 4 components in the score, namely GCS, Race, Age, and Volume. Points for the GRAVo score were assigned as follows: 2 points for GCS ≤12, 1 point for black race, 2 points for age >50 years, and 1 point for ICH volume >30 mL, with a maximum of 6 points (Table 3). The model for the final score achieved an area under the curve of 0.7511 (95% CI, 0.6722–0.8300) in the entire sample (Figure). Each 1-point increase in the score was associated with a 2.27-fold increased odds of PEG placement (95% CI, 1.71–3.03; $P<0.001$). The PEG placement rates for patients with a score of 0 to 1, 2 to 3, and 4 to 6 were 8.7%, 19.6%, and 63.0%, respectively. No patient with a score of 0 underwent PEG placement, whereas all patients with a score of 6 had a PEG tube placed. The odds of PEG placement in patients with a score ≥4 was $8\times$ higher than in patients with a score ≤3 (OR, 7.86; 95% CI, 3.88–15.94). This cut point predicted PEG placement with 58.62% sensitivity, 84.73% specificity, 62.96% positive predictive value, and 82.22% negative predictive value. A score ≥2 predicted PEG placement with 46.55% sensitivity, 93.13% specificity, 75% positive predictive value, and 79.74% negative predictive value (OR, 11.81; 95% CI, 5.04–27.66).

**Discussion**

In the present study, we identified risk factors for PEG placement in patients with primary ICH and derived and validated a simple risk score. This GRAVo clinical risk score has 4 predictor variables: GCS on presentation (≤12; equivalent to 2 points), race (black; 1 point), age (>50 years; 2 points), and ICH volume (>30 mL; 1 point), for a maximum of 6 possible points. All components of the score are easy to obtain and are readily available at the time of presentation.

To be widely applicable in clinical practice, any clinical grading scale should be easy to use without need for complex mathematical calculations, while allowing for a reliable prediction using readily available predictor variables. A recent prognostic model included National Institutes of Health Stroke scale and presence of edema on follow-up imaging.\(^\text{10}\) However, the former is not routinely obtained in patients presenting with ICH, and the latter is difficult to quantify, thus limiting its use. Our risk score uses race and age, both of which are apparent at presentation. GCS is routinely obtained as part of the initial evaluation by emergency personnel and emergency department staff. In addition, ICH volume on computed tomography by the ABC/2 method is a fast and simple tool routinely used to estimate ICH size. Our score thus uses readily available variables to allow for calculation of a relatively simple score.

Several features of the individual components of our score are noteworthy. GCS as a quantitative measure of level of consciousness has been shown to be a robust predictor of outcome in previous ICH models.\(^\text{16,17}\) Because post-ICH dysphagia is

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**Table 2. Multivariable Analysis for Predictors of PEG Placement in Patients With ICH**

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, per 10 y</td>
<td>1.64</td>
<td>1.02–2.65</td>
<td>0.042</td>
</tr>
<tr>
<td>Race: black</td>
<td>3.26</td>
<td>0.96–11.05</td>
<td>0.058</td>
</tr>
<tr>
<td>Sex: male</td>
<td>1.53</td>
<td>0.46–5.13</td>
<td>0.491</td>
</tr>
<tr>
<td>GCS</td>
<td>0.80</td>
<td>0.62–1.03</td>
<td>0.078</td>
</tr>
<tr>
<td>SBP, per 10 mm Hg</td>
<td>1.14</td>
<td>0.97–1.32</td>
<td>0.105</td>
</tr>
<tr>
<td>ICH volume, per 10 mL</td>
<td>1.38</td>
<td>1.01–1.89</td>
<td>0.047</td>
</tr>
<tr>
<td>Intraventricular blood</td>
<td>1.59</td>
<td>0.41–6.14</td>
<td>0.500</td>
</tr>
<tr>
<td>SAH</td>
<td>0.58</td>
<td>0.11–3.14</td>
<td>0.528</td>
</tr>
<tr>
<td>Fourth ventricle obliteration</td>
<td>0.67</td>
<td>0.12–3.61</td>
<td>0.641</td>
</tr>
<tr>
<td>ICH score</td>
<td>1.18</td>
<td>0.44–3.22</td>
<td>0.740</td>
</tr>
</tbody>
</table>

$\text{CI}$ indicates confidence interval; GCS, Glasgow Coma Scale; ICH, intracerebral hemorrhage; OR, odds ratio; PEG, percutaneous endoscopic gastrostomy; SAH, subarachnoid hemorrhage; and SBP, systolic blood pressure.

---

**Table 3. Determination of the GRAVo Score**

<table>
<thead>
<tr>
<th>Score Component</th>
<th>Score Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td></td>
</tr>
<tr>
<td>≤50</td>
<td>0</td>
</tr>
<tr>
<td>&gt;50</td>
<td>2</td>
</tr>
<tr>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>GCS</td>
<td></td>
</tr>
<tr>
<td>&gt;12</td>
<td>0</td>
</tr>
<tr>
<td>≤12</td>
<td>2</td>
</tr>
<tr>
<td>ICH volume, mL</td>
<td></td>
</tr>
<tr>
<td>≤30</td>
<td>0</td>
</tr>
<tr>
<td>&gt;30</td>
<td>1</td>
</tr>
<tr>
<td>Total score</td>
<td>0–6</td>
</tr>
</tbody>
</table>

GCS indicates Glasgow Coma Scale; GRAVo, Glasgow Coma Scale ≤12 (2 points), race (1 point for black), age >50 years (2 points), and ICH volume >30 mL (1 point); and ICH, intracerebral hemorrhage.
not uncommonly related to decreased arousal and level of consciousness, it is not surprising that GCS was a reliable predictor in our model. Similarly, ICH volume and age have consistently been associated with outcome in various other prediction models. \(^{16-18}\) Interestingly, black race was a predictor of PEG placement in our model. The reasons for this finding are not entirely clear; however, it is consistent with a recent study suggesting that black race is associated with PEG placement. \(^{10}\) Blacks tend to present with more severe strokes when compared with whites, \(^{19}\) but because our prediction model adjusted for ICH volume and GCS, stroke severity is unlikely to explain the observed race difference in our model. The cause of ICH might possibly explain the observed difference; hypertension is more prevalent in blacks and is often poorly controlled. \(^{20-22}\) ICH in typical hypertensive locations, such as the basal ganglia, thalamus, and brain stem, may be more likely to be associated with dysphagia when compared with nonhypertensive locations, such as lobar hemorrhages of similar size. Thus, a higher rate of ICH in hypertensive locations in blacks may result in higher rates of dysphagia, thereby contributing to higher rates of PEG placement. Additional studies are needed to validate black race as a predictor of PEG placement and to determine whether the underlying cause is related to physiological differences, socioeconomic differences, or potential disparities in health resource allocation.

The rate of PEG placement of \(\approx 30\%\) in our sample is consistent with the rate of long-term dysphagia after stroke and comparable with other published reports on the frequency of PEG placement. \(^{4,23}\) This increases the generalizability of the positive and negative predictive values reported in this study. Every patient who did not receive a PEG tube was able to take adequate nutrition by mouth at the time of discharge. For patients receiving a PEG tube, the median time to PEG was 14.5 days (IQR, 12–18 days). Chart review revealed that in 12 of 58 patients (20.7\%), PEG placement was either the sole or a major contributing factor delaying discharge to rehabilitation. Early initiation of rehabilitation is important for optimal chance of recovery. \(^{24,25}\) A cut point of 5 predicted PEG placement with 46.55% sensitivity and 93.13% specificity. Choosing lower cut points will result in increased sensitivity at the expense of specificity. However, in the context of medical decision making for PEG placement, a score of 5 may be the most clinically useful cut point because high specificity with concomitant low false-positive rate is desired before committing patients to a PEG. Our score may allow for timely initiation and planning for PEG in certain patients (ie, with a score \(\geq 5\)), thus potentially reducing hospital length of stay and ensuring smooth and early transition to rehab. The GRAVo score may provide clinicians with a risk-prediction tool for PEG placement based on clinical and demographic variables; however, we acknowledge that our score is no substitution for SLP evaluation and should rather be used in conjunction with clinical and instrumental evaluation of dysphagia by SLP.

Our study has several limitations. By virtue of limiting the number of score variables any clinical risk score entails simplification at the expense of accuracy of outcome prediction. Decision making about the PEG placement is complex and multifactorial involving hospital course and changes on follow-up neuroimaging, as well as family and patient wishes and preferences. Many of such factors were not included in our score because they were not readily assessable on initial presentation or difficult to quantify. We do acknowledge, however, that an individual provider’s a priori expectations about the likelihood of a given patient needing a PEG may influence the decision about placing that PEG. This could lead to bias in this study, particularly if a provider assumes that a patient with a low GCS and large ICH volume is likely to require a PEG, potentially resulting in PEG placement at an earlier time compared with a patient not meeting those criteria. Although we validated our score in a separate cohort, the patients in the validation cohort were cared for by the same physicians and during the same time period as the patients in the development cohort. Thus, patients in both cohorts likely received similar counseling on prognosis and need for PEG, and it is possible that results may vary in an entirely different patient population cared for by different physicians with different viewpoints and a potentially different ethical framework. In addition, although care for ICH patients at our certified stroke centers is consistent with the current standard of care and American Heart Association guidelines, we acknowledge that our model is mainly reflective of the practice pattern at our institutions. In addition, this is a retrospective analysis of a small number of patients from 2 single stroke centers during the course of 4 years, limiting generalizability to larger populations. Additional validation of our score in an external data set is required.

In summary, the GRAVo score includes GCS on admission, black race, age, and ICH volume and is a reliable clinical score determining the risk of PEG placement after ICH in patients who survive the first 3 days. The score is easy to compute, and a score of \(\geq 4\) predicts need for PEG with 93% specificity. We hope that our score may provide a framework aiding clinicians together with patients and families in informed decision making with regards to PEG placement.
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We thank Kate Holden and Genevieve McKeon for providing valuable input on the dysphagia and SLP evaluations.

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References
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