Use of the Original, Modified, or New Intracerebral Hemorrhage Score to Predict Mortality and Morbidity After Intracerebral Hemorrhage

Raymond Tak Fai Cheung, MBBS, PhD; Liang-Yu Zou, MBBS, MPhil

Background and Purpose—A simple clinical scale of intracerebral hemorrhage (ICH), comprising the Glasgow Coma Scale score, age, infratentorial origin, ICH volume, and intraventricular hemorrhage, was recently shown to predict 30-day mortality. We studied how well the original ICH Score would predict morbidity and mortality and determined whether modification would improve the predictions.

Methods—Patients admitted to a regional hospital with acute ICH in 1999 were reviewed. Independent predictors of mortality or good outcome (modified Rankin score $\leq 2$) at 30 days were identified by logistic regression to devise a new ICH Score for comparison with the original Score. A modified Score was created by substituting National Institutes of Health Stroke Scale (NIHSS) for the Glasgow Coma Scale.

Results—The mortality rate was 22%, and 35% had good outcome. Independent factors for mortality were high NIHSS score, intraventricular hemorrhage, subarachnoid extension, and narrow pulse pressure. Independent factors for good outcome were low NIHSS score and low admission temperature. For all ICH Scores, no patient had a maximum score of 6. Cutoff values of $\geq 3$ and $< 3$ provided the best Youden’s index of diagnostic test in all ICH Scores for mortality and good outcome, respectively. The original and modified ICH Scores predict mortality equally well. The new and modified ICH Scores are slightly better for prediction of good outcome.

Conclusions—All 3 ICH Scores are simple clinical grading scales. As reliable predictors of good outcome and/or mortality, they are useful in clinical research studies and standardization of clinical protocols. (Stroke. 2003;34:1717-1722.)

Key Words: cerebral hemorrhage • intracerebral hemorrhage • outcome • prognosis • stroke assessment

Intracerebral hemorrhage (ICH) accounts for 10% to 20% of all strokes and is more fatal and disabling than ischemic stroke or subarachnoid hemorrhage (SAH).\textsuperscript{1-3} Although there have been some advances in the treatment of ischemic stroke and SAH,\textsuperscript{3-5} there is no effective medical or surgical therapy for ICH.\textsuperscript{6} Prognostic models for mortality and functional outcome after ICH have been proposed and validated.\textsuperscript{7-15} These models include neurological features, other clinical parameters, laboratory results, and neuroimaging findings. Of various characteristics, level of consciousness on admission (as the Glasgow Coma Scale [GCS] score) and hematoma volume are the most consistent outcome predictors. Less consistent factors include age, presence and degree of intraventricular hemorrhage (IVH), presence and degree of hydrocephalus, brainstem hemorrhage, and medical complications. Several models require complex algebraic calculations. This lack of a simple, standard, widely accepted clinical grading scale or early prognostic model for ICH similar to those available for ischemic stroke and SAH\textsuperscript{4,5} may have contributed to heterogeneity in recruitment criteria for previous ICH studies and variability in clinical management of ICH.

Based on analyses of 152 ICH patients, a simple clinical grading scale of ICH, called the ICH Score, has been proposed recently.\textsuperscript{16} It is composed of a basic neurological examination (2 points for GCS score of 3 to 4, 1 point for GCS score of 5 to 12, and 0 points for GCS score of 13 to 15), age (1 point for $\geq 80$ years and 0 point for $<$ 80 years), ICH volume (1 point for $\geq 30$ mL and 0 points for $<30$ mL), presence of IVH (1 point), and infratentorial origin (1 point).\textsuperscript{16} Thirty-day mortality increased steadily with the ICH Score, but there was no corresponding information for morbidity at 30 days. The ICH Score has the potential of becoming a standard assessment tool that can be easily and quickly determined on presentation of ICH by physicians without special training in stroke neurology and that will permit uniformity in communication and treatment selection in clinical management and clinical trial. It was proposed that the ICH Score could be used in risk stratification for ICH treatment studies and that the Score should be validated on independent data sets.\textsuperscript{16} Nevertheless, mortality may not be the most clinically and socially important outcome for new treatment trials of stroke\textsuperscript{17,18}; reduction in morbidity with...
increased proportion of patients with good outcome is more meaningful. The present study was conducted to determine how well the original ICH Score can predict morbidity and mortality at 30 days in an independent cohort of ICH patients and whether modification can improve the predictions.

Subjects and Methods

Our regional hospital provides general hospital services to 0.5 million of the population in Hong Kong. Beginning in October 1996, the following information was entered into our stroke database: age, sex, National Institutes of Health Stroke Scale (NIHSS) and GCS scores on admission, type of stroke, risk factors for stroke, results of laboratory investigations, and major findings on CT of the brain. Patients admitted via the emergency department with nontraumatic ICH in 1999 were identified from our stroke database for a detailed review of medical records and CT findings. Similar to the article on the original ICH Score, other variables were abstracted from data available at the time of initial evaluation of the ICH: body temperature at the emergency department, first systolic and diastolic blood pressures (BPs), pulse pressure (the difference between systolic and diastolic BPs), first pulse rate, location of ICH, presence of IVH, ICH volume (according to the ABC/2 method in which A is the greatest diameter on the largest hemorrhage slice, B is the diameter perpendicular to A, and C is the approximate number of axial slices with hemorrhage multiplied by the slice thickness), subarachnoid extension of ICH, presence of mass effect (midline shift >5 mm), presence of hydrocephalus, and first serum glucose level. We also recorded the use of external ventricular drainage or surgical hemotoma evacuation, presumed cause of ICH, and modified Rankin score 30 days after ICH. Patients who died before 30 days had a modified Rankin score of 6. Good outcome was defined by a modified Rankin score of ≤2 at 30 days.

Age, GCS, NIHSS, ICH volume, body temperature, systolic and diastolic BPs, mean BP, pulse pressure, pulse rate, hemoglobin, white cell count, platelet count, prothrombin time, activated partial thromboplastin time, serum glucose, urea, and creatinine were considered continuous variables; sex, smoking, drinking, hypertension, diabetes mellitus, ischemic heart disease, atrial fibrillation, presumed cause of ICH, surgical evacuation, ventricular drainage, side of ICH, location of ICH (supratentorial or infratentorial), site of ICH (basal ganglia, thalamic, lobar, pontine, or cerebellar), IVH, subarachnoid extension, mass effect, and hydrocephalus were categorical variables. For univariate analyses, overall frequencies or mean±SD values of specific parameters were compared by Pearson’s χ² test or 1-way analysis of variance (ANOVA), respectively. Pearson’s test was used to reveal the correlation between GCS and NIHSS. Outcome models were developed for all ICH patients with mortality or good outcome at 30 days as the dependent variable. Multivariate logistic regression analyses were performed by use of the forward stepwise method with removal based on likelihood ratio and including all parameters available on initial presentation (ie, except presumed cause of ICH, surgical evacuation, and ventricular drainage).

The original ICH Score was applied to our data set using identical cutoff values and points for age, GCS, ICH volume, IVH, and infratentorial origin as by Hemphill and colleagues. A new ICH Score was created by adopting the independent factors generated from the multivariate logistic regression analyses for the mortality and good outcome at 30 days. Three continuous variables were categorized and assigned certain points to permit calculation of the new ICH Score: NIHSS score of 0 to 10 (0 points), 11 to 20 (1 point), or 21 to 40 (2 points); temperature ≤36°C (0 point) or >36°C (1 point); and pulse pressure <60 mm Hg (1 point) or ≥60 mm Hg (0 point). For the same purpose, points were assigned to 2 categorical variables: IVH (1 point) and subarachnoid extension (1 point). In addition, a modified ICH Score was developed from a simple substitution of GCS with NIHSS as 1 of the factors using the same cutoff values as the new ICH Score.

Numerical data were expressed as mean±SD. All statistical analyses were performed with SPSS (version 11.0), and P<0.05 (2 tailed) was taken to infer statistical significance. Different cutoff values of the original, modified, and new ICH Scores were used to identify the best Youden’s index of diagnostic test for a comparison among the 3 ICH Scores. The sensitivity, specificity, positive predictive value, and negative predictive value of different ICH Scores were computed using the same cutoff values that generated the best Youden’s index.

Results

One hundred forty-two patients were admitted to our hospital with acute nontraumatic ICH in 1999. At 30 days after ICH, the outcome was unknown in 1 patient; 31 (22%) were dead; 49 (35%) had good outcome; and 61 (43%) were alive with significant impairment. Main characteristics of the cohort are summarized in Table 1. Data were missing in 8 patients for GCS score, 19 patients for NIHSS score and admission temperature, 15 patients for initial hemodynamic measurements, 3 patients for complete blood counts and serum biochemistry, 11 patients for clotting time, 12 patients for serum glucose on admission, and 1 patient for neurosurgical interventions. CT brain films were not retrievable for 12 patients, but CT brain reports were available for 2 patients, indicating supratentorial ICH with IVH and SAH in 1 patient and mass effect with hydrocephalus in both patients. One patient had a midline pontine ICH. Pearson’s χ² test or 1-way ANOVA showed a significant association between some of these factors with outcome at 30 days (Table 1). There was a significant linear correlation between GCS score and NIHSS score through the use of Pearson’s test (P<0.001; correlation coefficient=−0.730).

Multivariate logistic regression analyses identified some independent predictors of mortality or good outcome at 30 days (Table 2). The distribution of patients with good outcome, bad outcome, or death against increasing points on the original ICH Score is shown in the Figure, panel a; no patient had the maximum score of 6. Mortality rates were very low and rates of good outcome were high when the original ICH Score was ≤2; mortality rates became high with a zero rate of good outcome when the original ICH Score was ≥3. The Figure, panel b, shows the similar distribution of different outcomes against increasing points on the modified ICH Score generated from substituting NIHSS for GCS. A new ICH Score was generated from adopting the 5 independent predictors (Table 2) from our multivariate logistic regression analyses (Figure, panel c). No patient had the maximum score of 6 on the modified or new ICH Score. The mortality rates were very low for a modified or new ICH Score of <3 but high when the modified or new ICH Score was ≥4. Different cutoff values of the 3 ICH Scores were tested to generate the highest Youden’s index of diagnostic test; best results were obtained with any of the ICH Scores of ≥3 for mortality and <3 for good outcome (Table 3). The original ICH Score was rather specific with a high negative predictive value for mortality and was sensitive with a high negative predictive value for good outcome. The modified ICH Score was sensitive with a high negative predictive value and reasonably specific for both mortality and good outcome. The new ICH Score was sensitive with a high negative predictive value for mortality and specific with high positive and
TABLE 1. Univariate Analyses of Characteristics of 141 Patients With Nontraumatic ICH

| Parameter                              | Fatal Outcome (n=31) | Bad Outcome (n=61) | Good Outcome (n=49) | P  
|----------------------------------------|----------------------|--------------------|---------------------|-----
| Age, y                                 | 75.2±11.2            | 68.1±11.7          | 67.0±12.9           | 0.009
| Female sex                             | 19 (61.3)            | 27 (44.3)          | 16 (32.7)           | 0.042
| Hypertension                           | 26 (83.9)            | 52 (85.2)          | 39 (79.6)           | 0.727
| Diabetes mellitus                      | 6 (19.4)             | 19 (31.1)          | 6 (12.2)            | 0.054
| Ischemic heart disease                 | 5 (16.1)             | 12 (19.7)          | 3 (6.1)             | 0.121
| Atrial fibrillation                    | 4 (12.9)             | 5 (8.2)            | 0 (0.0)             | 0.053
| History of smoking                     | 4 (12.9)             | 12 (19.7)          | 12 (24.5)           | 0.448
| History of drinking                    | 4 (12.9)             | 11 (18.0)          | 5 (10.2)            | 0.491
| GCS score                              | 7.6±4.0              | 12.4±3.2           | 14.3±1.8            | 0.000
| NIHSS score                            | 31.7±8.8             | 18.5±7.5           | 6.7±5.1             | 0.000
| Admission temperature, °C              | 36.3±1.1             | 36.3±0.5           | 36.4±0.6            | 0.798
| Systolic BP, mm Hg                     | 192.1±39.3           | 185.0±26.6         | 179.5±34.0          | 0.272
| Diastolic BP, mm Hg                    | 109.1±28.2           | 95.8±17.7          | 93.3±21.3           | 0.008
| Mean BP, mm Hg                         | 136.8±28.3           | 125.5±18.0         | 122.0±23.2          | 0.024
| Pulse pressure, mm Hg                  | 82.9±33.0            | 89.2±23.2          | 86.2±26.1           | 0.604
| Pulse rate, bpm                        | 83.5±16.4            | 80.2±16.8          | 77.9±11.8           | 0.303
| Supratentorial ICH                     | 25 (83.3)            | 51 (96.2)          | 45 (93.8)           | 0.094
| Site of ICH                            |                      |                    | 0.613               |     
| Basal ganglia                          | 15 (50.0)            | 30 (57.7)          | 23 (48.9)           |     
| Thalamic                               | 7 (23.3)             | 13 (25.0)          | 13 (27.7)           |     
| Lobar                                  | 4 (13.3)             | 7 (13.5)           | 8 (17.0)            |     
| Pontine                                | 4 (13.3)             | 1 (1.9)            | 3 (6.4)             |     
| Cerebellar                             | 0 (0.0)              | 1 (1.9)            | 0 (0.0)             |     
| Left-sided ICH                         | 11 (39.3)            | 29 (54.7)          | 23 (48.9)           | 0.417
| Presumed cause                         |                      | 0.056              |                     |     
| Hypertension                           | 23 (74.2)            | 53 (86.9)          | 36 (73.5)           |     
| Amyloid                                | 4 (12.9)             | 5 (8.2)            | 1 (2.0)             |     
| Vascular malformation                  | 1 (3.2)              | 0 (0.0)            | 2 (4.1)             |     
| Other                                  | 3 (9.7)              | 3 (4.9)            | 10 (20.4)           |     
| ICH volume, mL                         | 71.2±50.6            | 26.0±24.6          | 8.2±9.0             | 0.000
| IVH                                    | 26 (86.7)            | 21 (39.6)          | 10 (21.3)           | 0.000
| Subarachnoid extension                 | 14 (45.2)            | 8 (15.4)           | 3 (6.4)             | 0.000
| Mass effect                            | 26 (83.9)            | 24 (45.3)          | 4 (8.5)             | 0.000
| Hydrocephalus                          | 15 (48.4)            | 9 (17.0)           | 3 (6.4)             | 0.000
| Hemoglobin, g/dL                       | 12.9±1.7             | 13.7±2.0           | 13.8±1.7            | 0.051
| White cell count, 10^9/L               | 10.8±4.1             | 10.0±4.0           | 9.4±3.1             | 0.304
| Platelet, 10^9/L                       | 205.0±74.9           | 200.6±60.0         | 222.0±49.2          | 0.175
| Prothrombin time, s                    | 14.2±8.9             | 12.5±1.0           | 12.5±0.8            | 0.162
| Activated partial thromboplastin time, s| 33.4±22.0            | 28.2±2.9           | 29.6±4.1            | 0.115
| Serum glucose, mmol/L                  | 8.5±2.6              | 8.1±3.3            | 5.9±0.9             | 0.000
| Serum urea, mmol/L                     | 7.1±1.6              | 6.6±3.5            | 6.9±3.3             | 0.716
| Serum creatinine, μmol/L               | 95.1±31.3            | 91.6±32.8          | 106.4±63.7          | 0.236
| Surgical evacuation                    | 1 (3.2)              | 6 (10.0)           | 1 (2.0)             | 0.163
| Ventricular drainage                   | 2 (6.5)              | 6 (10.0)           | 2 (4.1)             | 0.484

*Number with percentages of subtotal in parentheses is used for categorical variables, and mean±SD is used for numerical variables.
negative predictive values for both mortality and good outcome. According to Youden’s index, the original ICH Score was a reliable “diagnostic test” for mortality but less reliable for predicting good outcome. The new ICH Score was slightly worse in predicting mortality but better for predicting good outcome than the original ICH Score. Nevertheless, the modified ICH Score was the most reliable of all (Table 3).

**Discussion**

The present study involves retrospective analyses of the prospectively collected information in our stroke database plus extraction of additional data from our records. Missing data in a good number of patients is a weakness of our study.

Clinical grading scales are useful in the evaluation and management of patients with acute neurological disorders such as head injury and stroke. These scales include the GCS for head injury, the Hunt and Hess scale and World Federation of Neurological Surgeons scale for SAH, the NIHSS for ischemic stroke, and the Spetzler-Martin scale for arteriovenous malformation.23–27 Useful clinical grading scales serve the following purposes: they permit standardization of assessment and prognostication, improve communication among healthcare providers, and allow risk stratification for treatment selection in clinical care and enrollment in clinical trials.16

Although prognostic models for mortality and functional outcome after ICH are available,7–15 there was no simple, clinical grading scale for ICH until the original ICH Score was proposed.16 The full range of the original ICH Score is 0 to 6, but only exceptional patients will have the maximal score of 6 from an infratentorial ICH plus an ICH volume ≥30 mL.28 In the article by Hemphill et al,16 30-day mortality rates were 0%, 13%, 26%, 72%, 97%, and 100% for an original ICH Score of 0, 1, 2, 3, 4, and 5, respectively; these figures are similar to those of the present study. On the other hand, there was no information on the usefulness of the original ICH Score in predicting morbidity at 30 days.16 When the original ICH Score was applied to the present cohort, it had a fair prediction of good outcome.

Although both the GCS and NIHSS were significant factors in the univariate analyses, the NIHSS but not the GCS was an independent predictor for both mortality and good outcome at 30 days. There are 2 possible explanations: NIHSS has a wider range than GCS, and NIHSS measures not only level of consciousness but also neurological deficits.27

With the availability of intravenous thrombolysis for acute ischemic stroke and the emphasis on treating strokes as brain attack, NIHSS is becoming the standard assessment in all acute stroke patients.21,29,30 Differentiation between ischemic stroke and ICH can be made only on neuroimaging study. It may be preferable to substitute NIHSS for the GCS and then use the modified or new ICH Score.

Although the present study confirmed the importance of IVH in predicting mortality, age, ICH volume, and infratentorial location were not independent predictors of mortality or good outcome. Age and infratentorial location were not independent predictors of outcome in some studies.7–10 ICH volume is not an independent predictor of mortality in infratentorial ICH.16 It is plausible that age, ICH volume, and other factors are associated with some other factors; therefore, they may not stand out in the multivariate analyses.

![Image](http://stroke.ahajournals.org/)

**Table 2. Multivariate Analyses of Independent Predictors of Mortality or Good Outcome at 30 Days**

<table>
<thead>
<tr>
<th>Independent Predictor</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subarachnoid extension</td>
<td>73.6 (2.9–1987.8)</td>
<td>0.010</td>
</tr>
<tr>
<td>IVH</td>
<td>34.6 (1.7–698.0)</td>
<td>0.021</td>
</tr>
<tr>
<td>High NIHSS</td>
<td>1.3 (1.1–1.6)</td>
<td>0.008</td>
</tr>
<tr>
<td>Narrow pulse pressure</td>
<td>1.1 (1.0–1.1)</td>
<td>0.050</td>
</tr>
<tr>
<td><strong>Good outcome</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low admission temperature</td>
<td>8.3 (1.0–68.4)</td>
<td>0.049</td>
</tr>
<tr>
<td>Low NIHSS</td>
<td>1.5 (1.3–1.8)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Discussion**

The present study involves retrospective analyses of the prospectively collected information in our stroke database plus extraction of additional data from our records. Missing data in a good number of patients is a weakness of our study.

Clinical grading scales are useful in the evaluation and management of patients with acute neurological disorders such as head injury and stroke. These scales include the GCS for head injury, the Hunt and Hess scale and World Federation of Neurological Surgeons scale for SAH, the NIHSS for ischemic stroke, and the Spetzler-Martin scale for arteriovenous malformation.23–27 Useful clinical grading scales serve the following purposes: they permit standardization of assessment and prognostication, improve communication among healthcare providers, and allow risk stratification for treatment selection in clinical care and enrollment in clinical trials.16

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With the availability of intravenous thrombolysis for acute ischemic stroke and the emphasis on treating strokes as brain attack, NIHSS is becoming the standard assessment in all acute stroke patients.21,29,30 Differentiation between ischemic stroke and ICH can be made only on neuroimaging study. It may be preferable to substitute NIHSS for the GCS and then use the modified or new ICH Score.

Although the present study confirmed the importance of IVH in predicting mortality, age, ICH volume, and infratentorial location were not independent predictors of mortality or good outcome. Age and infratentorial location were not independent predictors of outcome in some studies.7–10 ICH volume is not an independent predictor of mortality in infratentorial ICH.16 It is plausible that age, ICH volume, and other factors are associated with some other factors; therefore, they may not stand out in the multivariate analyses.
Low NIHSS as a predictor of good outcome is not surprising. NIHSS is a potent predictor of outcome in ischemic stroke. Interestingly, low temperature on admission was an independent predictor of good outcome, although there was no difference in the mean temperature among patients of different outcomes. This observation suggests that low temperature on admission was largely observed in some ICH patients with good outcome. There is strong experimental evidence that hypothermia protects against ischemic brain injury. Clinical trials testing hypothermia as an acute stroke therapy are now ongoing or being planned. Although some factors such as NIHSS predict both mortality and good outcome, the present results indicate that other factors may predict either mortality or good outcome.

Adopting our independent predictors to generate the new ICH Score is convenient because calculation of the hematoma volume is not required. In addition, the new ICH Score is slightly better than the original ICH Score in predicting good outcome at 30 days. Nevertheless, a simple substitution of the GCS with NIHSS in the original ICH Score to generate a modified ICH Score seems to have the best prediction of both mortality and good outcome at 30 days. Youden’s index is a good measure of the ability of any test or method to correctly identify the target; the best test has an index of 1, and an index of 0 indicates a rather useless test.

In conclusion, usefulness of the original ICH Score in predicting 30-day mortality is confirmed in an independent cohort of ICH patients. Nevertheless, the original ICH Score may be less reliable in predicting good outcome at 30 days. In addition, our results indicate that NIHSS may be a better factor than GCS and that other factors may turn out to be independent predictors of good or fatal outcome in different cohorts of ICH patients on multivariate analyses. All 3 ICH Scores are simple clinical grading scales. The original or modified ICH Score may be used in future clinical trials of ICH interventions or for prognostication of ICH patients, as well as standardization of clinical assessment and management of ICH if mortality is the key issue. Nevertheless, the new or modified ICH Score may be preferred when good outcome is the primary target. Overfitting of data remains a possibility, and all 3 ICH Scores should be tested for generalizability in independent cohorts of ICH patients.

Acknowledgment

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**TABLE 3. Sensitivity, Specificity, Positive Predictive Value, and Negative Predictive Value of the Original, Modified, and New ICH Scores ≥3 and <3 for Mortality and Good Outcome at 30 Days, Respectively, to Achieve the Best Youden’s Index of Diagnostic Test**

<table>
<thead>
<tr>
<th></th>
<th>Original ICH Score</th>
<th>Modified ICH Score</th>
<th>New ICH Score</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Mortality</td>
<td>Good Outcome</td>
<td>Mortality</td>
</tr>
<tr>
<td>Sensitivity, %</td>
<td>78.6</td>
<td>93.5</td>
<td>92.0</td>
</tr>
<tr>
<td>Specificity, %</td>
<td>90.4</td>
<td>60.5</td>
<td>70.1</td>
</tr>
<tr>
<td>Positive predictive value, %</td>
<td>71.0</td>
<td>58.9</td>
<td>56.1</td>
</tr>
<tr>
<td>Negative predictive value, %</td>
<td>93.4</td>
<td>93.9</td>
<td>97.1</td>
</tr>
<tr>
<td>Youden’s index</td>
<td>0.690</td>
<td>0.540</td>
<td>0.711</td>
</tr>
</tbody>
</table>


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http://stroke.ahajournals.org/content/34/7/1717

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