Grading Scale for Prediction of Outcome in Primary Intracerebral Hemorrhages

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Background and Purpose—This study aimed to independently derive an intracerebral hemorrhage grading scale (ICH-GS) for prediction of 3 outcome measures.

Methods—We evaluated 378 patients with primary ICH at hospital arrival and during the next 30 days. Independent predictors were identified by multivariate models of in-hospital and 30-day mortality. Points were allotted to each predictor based on its prognostic performance. ICH-GS was also evaluated to predict good 30-day functional status and ICH-GS was compared with the ICH score as the reference scoring system.

Results—Independent predictors were age, Glasgow Coma Scale, ICH location, ICH volume, and intraventricular extension, all components of the ICH score. Nevertheless, different cutoffs and scoring improved substantially the prognostic power of the predictors. Compared with the ICH score, ICH-GS explained more variance in the 3 outcome measures, had higher sensitivity in predicting in-hospital and 30-day mortality, and performed equally well in predicting good functional outcome at 30 days follow up.

Conclusions—The derived ICH-GS is a simple yet robust scale in predicting in-hospital and 30-day mortality, as well as good 30-day functional status, with equivalent performance. **(*Stroke*. 2007;38:1641-1644.)**

Key Words: intracerebral hemorrhage ■ mortality ■ outcome ■ prognosis ■ risk factors

Accurate prediction of outcome after primary intracerebral hemorrhage (ICH) is necessary to distinguish those patients who need special care or who would benefit from particular therapeutic strategies. Several scales for prediction of ICH mortality have been designed to date[1–6] with different characteristics regarding applicability, scale components, scoring and performance. Of them, the ICH score has proven to be reliable in predicting 30-day mortality[2] in different populations and clinical circumstances.[3,5] Nevertheless, other measures of outcome such as in-hospital mortality and 30-day good physical performance also need a prognostic score, because different scenarios may require different predictions. Therefore, we sought to develop an ICH grading scale (ICH-GS) for prediction of outcome after primary ICH based on evaluations performed at hospital arrival.

Methods

Study Population

We studied 1025 consecutive adults with acute symptomatic cerebrovascular disease attending a tertiary referral center between March 1999 and September 2003.[7] Of these, 378 patients with primary ICH were analyzed for prediction of in-hospital mortality. After excluding 68 patients who were lost to follow up, 310 were analyzed for prediction of 30-day mortality and good functional outcome (supplemental Figure I, available online at http://stroke.ahajournals.org). The internal Committee of Ethics of our hospital approved the present study. Informed consent was obtained from the patients or their closest relative.

ICH was defined as a sudden focal neurological deficit with confirmation of the brain hemorrhage by CT. ICH volume was calculated by analysis of CT scans according to the *ABC/2* method. The patient's functional status was assessed by the Glasgow outcome scale at 30 days follow up, considering Glasgow outcome scale IV and V as good functional status.

Scale Derivation

Bivariate analyses were performed to identify risk factors associated with in-hospital and 30-day mortality by χ^2 statistics. Age, Glasgow Coma Scale (GCS) at hospital presentation, and ICH volume were dichotomized to transform them into nominal variables using the median value or its nearest multiple-of-5 integer. Multivariate analyses were constructed to find independent predictors of in-hospital and 30-day mortality. Input variables were those significantly associated with mortality in bivariate analyses; but demographic characteristics, risk factors, blood pressure measures, and in-hospital neurological and nonneurological complications were included in multivariate analyses as potential confounders. Adjusted ORs and 95% CIs are provided. The fitness of the models was evaluated by using the Hosmer-Lemeshow goodness-of-fit test, which was considered as reliable if $P>0.2$. After identifying independent predictors of in-hospital and 30-day mortality, cutoffs or value intervals were selected for continuous variables to determine

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references for score assignments. These cutoffs and intervals were identified by risk modeling, which consisted of analyses of absolute differences and ORs for mortality for every point of GCS and every 5 points of age and ICH volume. Those cutoffs or intervals with the greatest ORs and that yielded the scale with the widest area under the receiver operating characteristic curve were selected to be included in the final model. To be certain about the reliability of these selections, a proof-and-error phase was also performed in which under the area receiver operating characteristic curves of the different scales were compared. Both procedures, the analytic and the empirical, were consistent. Then, ICH-GS was generated by allotting points to each category based on their participation in the prediction of death. After deriving an ICH-GS with the best prognostic properties, we proved it also in prognosis of good outcome at 30 days. Statistical significance was set at $P<0.05$. SPSS version 12.0 was used for all calculations.

Analyses of prognostic performance were done for both ICH-GS and the ICH score. Spearman rank correlation (r) and determination (r^2) coefficients were calculated to estimate the amount of variance in outcome explained by the scales. Sensitivity, specificity, predictive values, and likelihood ratios were calculated considering the discrete value of each scale with the greatest Youden index. Prediction accuracy was estimated by calculating the areas under the receiver characteristic curves. ICH-GS was validated internally by using the bootstrap method in the original derivation data set by sampling with replacement for 200 iterations.

Results

We analyzed 187 (49.5%) men and 191 (50.5%) women with a mean age of 64.2 years (range, 15 to 99 years) (supplemental Table I, available online at http://stroke.ahajournals.org). Mean duration of the hospital stay was 10 days (range, 0 to 82 days). The main risk factor for ICH was hypertension (n=258 [68%]).

In bivariate analysis, factors associated with mortality were age 65 or more years, GCS at hospital admission less than 8, ICH volume more than 70 mL, irruption into the ventricular system, and infratentorial location of the hematoma. These variables were also independent predictors in multivariate logistic regressions (Table 1). After risk modeling, ICH-GS was generated by assigning points to the independent predictors with a minimum scoring of 5 points and a maximum of 13 coinciding with the categories of ICH-GS with those of the ICH score but with different cutoffs and points assignment (Table 2). ICH-GS explained more variance than did the ICH score for in-hospital mortality ($r^2=0.442$ versus 0.343; respectively), 30-day mortality ($r^2=0.438$ versus 0.342; respectively), and good functional outcome at 30 days follow up ($r^2=0.332$ versus 0.267; respectively). ICH-GS had significantly higher sensitivity than the ICH score in predicting both in-hospital (78.2% versus 63.8%, respectively; $P<0.05$) and 30-day mortality (78.5% versus 64.4%, respectively; $P<0.05$) (supplemental Table II, available online at http://

TABLE 1. Multivariate Analysis of Factors Associated With In-Hospital and 30-Day Mortality: Two Binary Logistic Regression Models

	In-Hospital Mortality, No. (%)*		30-Day Mortality, No. (%)†	
Variable	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age, years				
≥65 years	2.33 (1.37–3.97)	0.002	3.44 (1.94–6.09)	<0.001
<65 years				
GCS at hospitalization				
<8	16.11 (6.82–38.03)	<0.001	11.51 (4.54–29.17)	<0.001
≥8				
ICH volume				
>70 mL	10.50 (2.80–39.37)	<0.001	10.36 (2.17–49.54)	0.003
≤70 mL				
Extension into ventricles				
Present	1.84 (1.08–3.15)	0.02	2.20 (1.23–3.94)	0.008
Absent				
ICH location				
Infratentorial	3.95 (1.65–9.47)	0.002	2.53 (1.04–6.16)	0.04
Supratentorial				

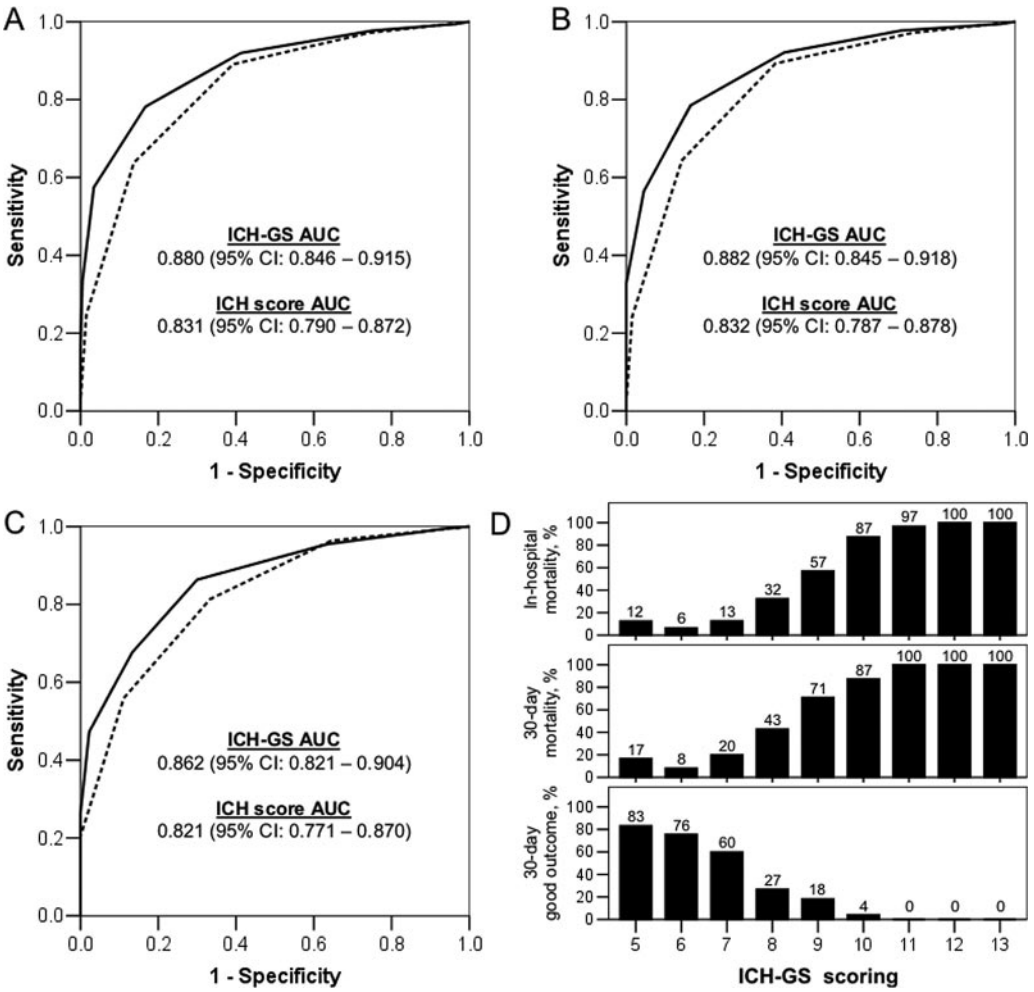
*Analysis on 378 patients included in initial analysis, case fatality rate=46% (n=174). Hosmer-Lemeshow test for goodness of fit in final step of the regression model: χ^2 0.995, 6 df, $P=0.986$. Adjusted for ICH risk factors, demographic variables, and in-hospital neurological and nonneurological complications.

†Analysis on 310 patients who were followed up to 30 days, case fatality rate=57% (n=177). Hosmer-Lemeshow test for goodness of fit in final step of the regression model: χ^2 1.84, 7 df, $P=0.968$. Adjusted for ICH risk factors, demographic variables, and in-hospital neurological and nonneurological complications.

TABLE 2. Score Assignments in Both ICH-GS and the ICH Score

ICH-GS		ICH Score	
Characteristic	Points	Characteristic	Points
Age, years		Age, years	
<45 years	1	<80 years	0
45–64 years	2	≥80 years	1
≥65 years	3		
GCS score at hospital admission		GCS score at hospital admission	
13–15	1	13–15	0
9–12	2	5–12	1
3–8	3	3–4	2
ICH location		ICH location	
Supratentorial	1	Supratentorial	0
Infratentorial	2	Infratentorial	1
ICH volume		ICH volume	
For supratentorial location		<30 mL	0
<40 mL	1	≥30 mL	1
40–70 mL	2		
>70 mL	3		
For infratentorial location			
<10 mL	1		
10–20 mL	2		
>20 mL	3		
Extension into ventricles		Extension into ventricles	
No	1	No	0
Yes	2	Yes	1

Note. The original distribution of items of the ICH score is rearranged in the order of ICH-GS to facilitate comparison; otherwise, the ICH score is that as proposed by Hemphill and colleagues.[2]



Areas under the receiver operating characteristic curves of both ICH-GS (continuous line) and the ICH score (dotted line) in predicting (A) in-hospital and (B) 30-day mortality as well as (C) 30-day good outcome. Rates of in-hospital and 30-day mortality, as well as of 30-day good outcome, by ICH-GS scoring (D) (homogeneity in the 3 distributions, $P<0.001$).

stroke.ahajournals.org). Moreover, ICH-GS had higher accuracy than the ICH score in predicting mortality and good functional outcome (Figure).

Discussion

In a prospective design and with the largest sample size to date,[1–6] we derived a system for prediction of 3 outcome measures in patients presenting with ICH. Independent predictors were those consistently reported in previous studies, which includes the original report of the ICH score.[1–9] However, in this report, every component of the scale was obtained by multivariate analysis and not at a discretional level. Our study confirms previous results on the importance of the clinical and radiological components of ICH-GS in predicting mortality[2,3,5] and adds new information in that different selection of cutoff values and point assignments based on the prognosticator's properties can further refine previous models. In ICH-GS, points assigned to clot volume are in function of the hemorrhage location, because the infra- and supratentorial spaces differ in compliance. Also, age is divided into 3 intervals coinciding with the most important stages of the adulthood. In ICH-GS, it is possible to find patients with every scoring from 5 to 13 points. It seems convenient to assign a minimum of 5 points to the lowest probability of dying, because having zero points in ICH score does not necessarily mean the absence of death[3,5]; hence, we assigned one point to the lowest category of every scale item and 2 or 3 points, respectively, to the highest. With future effective treatments, the prognosis for every point of ICH-GS will certainly change.

Indeed, the use of a prognostic scale goes beyond numbers and estimations. It could sensitize to the staff entrusted with the care of patients regarding a particular prognosis, facilitating a bedside humanitarian approach. With future studies applying this scale, futile actions could be clarified, avoiding useless actions in cases in which the overwhelming evidence points to a fatal outcome, but in those in which there is evidence of a favorable prognosis, unnecessary stress and the consequences motivated by this factor could be diminished. However, because all current ICH scales are not perfect prediction models, other variables such as biochemical markers, genomics, or advanced brain imaging technology should be included in future refinement of the existing scales.

In summary, ICH-GS is a robust method able to predict different outcome measures with equivalent performance. It retains simplicity and reliability and represents a refinement

of previous prognostic models. We are confident about the performance of ICH-GS in clinical practice; however, it should receive systematic evaluation and, of course, the test of time.

Disclosures

None.

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