

Prediction of Functional Outcome in Patients With Primary Intracerebral Hemorrhage

The FUNC Score

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Background and Purpose—Intracerebral hemorrhage (ICH) is the most fatal and disabling stroke subtype. Widely used tools for prediction of mortality are fundamentally limited in that they do not account for effects of withdrawal of care and are not designed to predict functional recovery. We developed an acute clinical score to predict likelihood of functional independence.

Methods—We prospectively characterized 629 consecutive patients with ICH at hospital presentation. Predictors of functional independence (Glasgow Outcome Score ≥ 4) at 90 days were used to develop a logistic regression-based risk stratification scale in a random subset of two thirds and validated in the remaining one third of the cohort.

Results—At 90 days, 162 (26%) patients achieved independence. Age, Glasgow Coma Scale, ICH location, volume (all $P < 0.0001$), and pre-ICH cognitive impairment ($P = 0.005$) were independently associated with Glasgow Outcome Score ≥ 4 . The FUNC score was developed as a sum of individual points (0–11) based on strength of association with outcome. In both the development and validation cohorts, the proportion of patients who achieved Glasgow Outcome Score ≥ 4 increased steadily with FUNC score. No patient assigned a FUNC score ≤ 4 achieved functional independence, whereas $>80\%$ with a score of 11 did. The predictive accuracy of the FUNC score remained unchanged when restricted to ICH survivors only, consistent with absence of confounding by early withdrawal of care.

Conclusions—FUNC score is a valid clinical assessment tool that identifies patients with ICH who will attain functional independence and thus, can provide guidance in clinical decision-making and patient selection for clinical trials. (*Stroke*. 2008;39:2304–2309.)

Key Words: intracerebral hemorrhage ■ outcome ■ models ■ statistical

Intracerebral hemorrhage (ICH) is the most devastating and least treatable form of stroke, causing, in addition, severe disability among survivors.^{1–4} Because ICH is widely considered to be fatal, withdrawal of care commonly occurs early in the hospital course, a situation that can deprive a “fighting chance” to those individuals whose prognosis may not be as grim as initially judged.^{5,6}

Accurate prediction of ICH outcome in the emergency department is crucial for families confronted with a patient’s need for invasive intensive care, which often requires hospital transfer, for physicians making decisions about the judicious allocation of scarce resources, and perhaps as a guide to the design of clinical trials. Fundamentally, it is identification of patients likely to recover functional independence, rather than simply survive, which can address the most pressing concern of families and medical teams with regard to direction of care.⁷

Existing tools to predict ICH mortality^{8–15} have been externally validated^{16–19} and are widely accepted for clinical use. However, there are important limitations to their application because they may be (1) significantly confounded by the self-fulfilling prophecy of withdrawal of care that is the most potent predictor of death in ICH,^{5,6,20} because all scores were tested and validated in cohorts in which withdrawal of care was common; and (2) uninformative to families who are most often preoccupied with their loved one’s chance of functional recovery, should the patient survive, rather than simply the likelihood of survival.^{21,22}

Currently available tools that are specifically designed to predict functional recovery in ICH^{14,23–26} have limited usefulness because they either were developed in highly selected groups of patients or excluded clinical predictors known to influence ICH outcomes.

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We sought to develop a clinical score, assessed on admission, to predict patients' likelihood of reaching functional independence should they survive ICH.

Subjects and Methods

We retrospectively analyzed data collected as part of an ongoing single-center prospective longitudinal cohort study of primary ICH.^{27,28} Patients with ICH with a baseline admission CT scan and data available on functional status at 90 days were considered eligible. At our center, all patients with ICH undergo CT scanning as well as additional imaging studies, including angiography, CT angiography, and MRI. Based on the results of these imaging studies as well as review of baseline clinical data, patients with secondary causes of ICH such as vascular malformation, central nervous system tumor, antecedent trauma or ischemic stroke, vasculitis, excessive anticoagulation (international normalized ratio >3.0), or blood dyscrasia were excluded.

Study subjects were identified by screening hospital admission logs. Patients with ICH, or next of kin, were approached by study personnel during the hospitalization and consent was sought for enrollment into the longitudinal study. For patients in whom consent could not be obtained, medical record information was stored in a database registry. All study procedures were approved by the local Institutional Review Board.

Information on demographics, medical history, and medication use and dosage was collected through interview of consenting subjects by study personnel or supplemented by the medical record review, as previously described.^{27,28} All CT scans were downloaded directly to a workstation and stored in DICOM format where they were reviewed by study investigators blinded to clinical data. Volume of ICH was calculated as previously described.²⁹ ICH was considered lobar in location if the origin of the hemorrhage appeared to be in the cerebral hemispheres superficial to the deep gray matter structures. Hemorrhages originating in the thalamus and basal ganglia were considered "deep" in location, as previously described.^{27,28}

Clinical variables, including hypertension, diabetes, and coronary artery disease, were defined as previously described.^{27,28} Glasgow Coma Scale (GCS) was the first one recorded on admission to the Massachusetts General Hospital emergency department. Pre-ICH cognitive impairment was defined as a history of cognitive impairment based on family interview and medical record review supplemented by the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) administered to a proxy/relative about changes in cognitive performance of the patient over the last 10 years.³⁰

Using a telephone interview, Glasgow Outcome Scale^{31,32} was determined at 90 days. "Functional independence" was defined as Glasgow Outcome Scale ≥ 4 .

All variables (age, GCS, gender, hypertension, diabetes, coronary artery disease, warfarin use, intraventricular hemorrhage (IVH), ICH volume, ICH location, pre-ICH cognitive impairment) were categorized and compared using χ^2 tests. The level of significance was set at 2-sided $P < 0.05$ for all statistical analyses. Those variables known to predict outcome in ICH (age, GCS, IVH, ICH volume, ICH location) and/or those that reached $P < 0.2$ in univariate analysis were considered for multivariable analysis.

A risk stratification scale was developed using logistic regression analysis within a randomly allocated two thirds of the cohort ("model development subset") and validated in the remaining one third ("model validation subset") of the patients. Goodness of fit of the predictor model was measured by c-statistic (area under the receiver operating characteristic curve) and reported for both subsets. The nearest integer from the parameter estimates obtained from the multiple logistic regression model was used in assigning the score points for FUNC score. Statistical analyses were performed using SAS version 9.1.3 (SAS Institute, Cary, NC).

Results

Patient Characteristics and Model Development

There were 795 consecutive ICH admissions with symptom onset between January 1, 1998, and August 31, 2005. Baseline

Table 1. Baseline Characteristics and Outcomes in the Entire ICH Cohort (N=629)

	Development Subset (n=418, N [%])	Validation Subset (n=211, N [%])
Sex, % male	221 (53)	116 (55)
Age, years		
<70	148 (35)	86 (41)
70–79	153 (37)	68 (32)
≥ 80	117 (28)	57 (27)
Hypertension	328 (78)	163 (77)
Diabetes	82 (20)	37 (18)
Coronary artery disease	93 (22)	48 (23)
Warfarin use	95 (23)	49 (23)
Pre-ICH cognitive impairment	65 (16)	30 (14)
GCS score		
≤ 8	149 (36)	74 (35)
≥ 9	269 (64)	137 (65)
ICH location		
Lobar	176 (42)	85 (40)
Deep	195 (47)	99 (47)
Infratentorial	47 (11)	27 (13)
ICH volume, cm ³		
<30	226 (54)	131 (62)
30–60	91 (22)	37 (18)
>60	101 (24)	43 (20)
IVH	230 (55)	108 (51)
Glasgow Outcome Score		
1	189 (45)	95 (45)
2	2 (0.5)	1 (0.5)
3	106 (25)	53 (25)
4	56 (13)	29 (14)
5	65 (16)	33 (16)

P value >0.05 for all test group comparisons.

CT scan was not performed or was missing in 46 of 795 (6%), and other data on demographics or medical history was missing in 19 of 795 subjects (3%), leaving 730 subjects with complete baseline information. Of these, 90-day outcome status was available for 629 of 730 (86%) patients. Those subjects without follow-up information had similar baseline characteristics as subjects with follow-up information, except for a lower likelihood of having lobar ICH location ($P=0.02$). There were 223 of 629 (53%) who were urgently transferred from community hospital emergency departments to the Massachusetts General Hospital emergency department, whereas the remaining 195 of 629 (47%) arrived directly to the emergency department ("nontransfer").

There were 345 of 629 (55%) patients who survived to 90 days and, of these, 162 of 345 (47%) achieved functional independence. For model development, two thirds of the total cohort (N=418 of 629) were randomly selected stratified by Glasgow Outcome Scale score, leaving one third (N=211 of 629) of subjects for validation (Table 1).

In the model development stage, age, admission GCS, ICH volume, presence of IVH, warfarin use, and history of

Table 2. OR for Independent (Glasgow Outcome Score ≥ 4) Functional Status at 90 Days Among the Patients From the Model Development Subset (N=418)

Predictor Variable	OR (95% CI)	P Value
ICH volume, cm ³		<0.0001
<30	54.1 (11.1–264.2)	
30–60	8.6 (1.7–42.3)	
>60	1.00	
Age, years		<0.0001
<70	9.2 (4.1–20.3)	
70–79	2.0 (0.95–4.4)	
≥ 80	1.00	
ICH location		<0.0001
Lobar	6.7 (2.3–19.3)	
Deep	1.5 (0.6–3.9)	
Infratentorial	1.00	
GCS score		<0.0001
≥ 9	8.0 (3.4–18.8)	
≤ 8	1.00	
Pre-ICH cognitive impairment		0.005
No	4.3 (1.5–12.0)	
Yes	1.00	

pre-ICH cognitive impairment were significantly associated with functional independence (all with $P < 0.01$) in the univariate analysis. ICH location, a known clinical predictor of outcomes in ICH, was also a candidate for multivariable analysis with a borderline probability value ($P = 0.19$).

After multivariable logistic regression analysis, clinical variables on admission independently associated with functional independence were age, GCS, ICH volume, ICH location, and pre-ICH cognitive impairment (Table 2), but not warfarin use (OR, 1.0; 95% CI, 0.5 to 2.0) or IVH (OR, 0.8; 95% CI, 0.4 to 1.4). The c-statistic for this model was 0.88. This model was subsequently tested in the validation subset (N=211) and showed a c-statistic of 0.82.

The FUNC Score

The FUNC score, a functional outcome risk stratification scale, was developed from logistic regression analysis of the model development subset (N=418). Based on strength of association with the log odds of the outcome, independent predictor variables were weighted to develop the FUNC score as a sum of individual points (Table 3). The score ranged from 0 to 11 with a score of 11 indicating strong likelihood of functional independence. GCS scores (≤ 8 and ≥ 9) and ICH volume (< 30 cm³, 30 to 60 cm³, and > 60 cm³) were divided into the most clinically meaningful categories³³ to facilitate the score's usefulness. ICH location categories received point values based on their graded strength of association with outcome. Based on the age distribution of the cohort, categories of age < 70 , 70 to 79, and ≥ 80 years were derived and graded point values assigned accordingly.

In the model development subset, more than 85% (12 of 14) of patients with a FUNC score of 11 reached functional independence at 90 days. On the contrary, only 2 of 48 (4%)

Table 3. Determinants of the FUNC Score

Component	FUNC Score Points
ICH volume, cm ³	
<30	4
30–60	2
>60	0
Age, years	
<70	2
70–79	1
≥ 80	0
ICH location	
Lobar	2
Deep	1
Infratentorial	0
GCS score	
≥ 9	2
≤ 8	0
Pre-ICH cognitive impairment	
No	1
Yes	0
Total FUNC score	0–11

patients with a score of 5 achieved independence. In fact, there were no patients with a FUNC score of ≤ 4 who reached functional independence (n=0 of 93). A similar trend was observed when the FUNC score was applied to the validation subset, in which patients demonstrated no chance of achieving functional independence at 90 days if their score was ≤ 4 and, conversely, at least a 75% chance of independence with a FUNC score of 11 (Table 4).

To eliminate the potential bias introduced by early withdrawal of care in patients with ICH,⁶ we applied the FUNC score to those 345 of 629 (55%) patients who survived to 90

Table 4. Proportion of Patients Who Achieve Functional Independence at 90 Days Stratified by FUNC Score*

FUNC Score	Functionally Independent at 90 Days, n/N (%)	
	Development Subset (N=418)	Validation Subset (N=211)
0	0/1 (0)	0/0 (0)
1	0/12 (0)	0/2 (0)
2	0/15 (0)	0/8 (0)
3	0/37 (0)	0/17 (0)
4	0/28 (0)	0/13 (0)
5	2/48 (4)	2/19 (10)
6	4/36 (11)	0/16 (0)
7	14/77 (18)	10/46 (22)
8	20/51 (39)	14/30 (47)
9	60/87 (69)	24/40 (60)
10	9/12 (75)	6/12 (50)
11	12/14 (86)	6/8 (75)

*n/N indicates proportion of subjects functionally independent at 90 days.

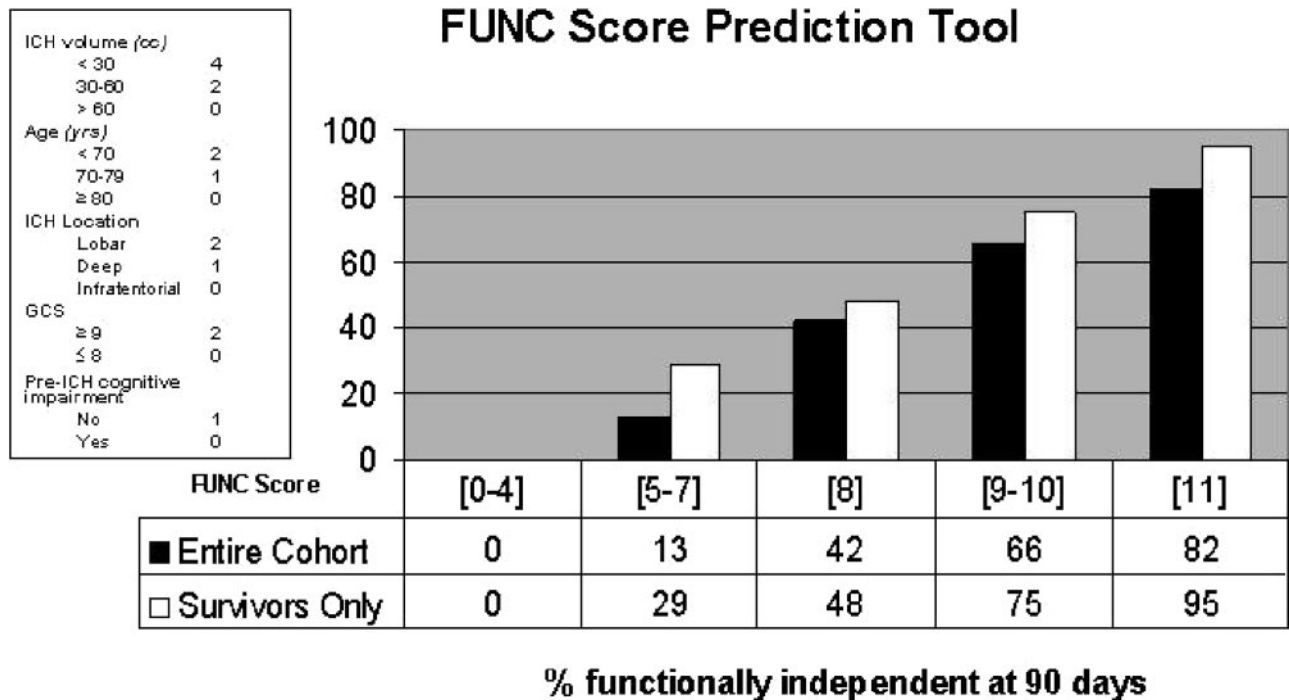


Figure. FUNC score prediction tool. Y-axis: percent of patients with ICH who reach functional independence at 90 days. X-axis: FUNC score categories. Data table: percent of functionally independent patients among the entire cohort and survivors only (per FUNC score category). Inset: FUNC score determinants provided to facilitate clinical use of this ICH outcome prediction tool.

days. In this “Survivors only” cohort, the FUNC score predicted functional independence at 90 days with similar reliability. Of 19 patients who survived ICH and had FUNC score of 11, 18 (95%) achieved Glasgow Outcome Scale ≥ 4 as compared with none of the patients who had FUNC scores ≤ 4 .

FUNC score predicted functional independence equally well regardless of whether patients had been transferred from a referring hospital emergency department (c-statistic 0.88). There were no patients in either the “transfer” or “nontransfer” subset who achieved functional independence at 90 days with FUNC score of ≤ 4 , whereas the proportion of patients who achieved functional independence in these respective subsets per FUNC score category did not differ. Furthermore, FUNC score’s ability to predict functional outcome at 90 days remained unchanged regardless of whether patients underwent a surgical intervention during their hospitalization (c-statistic 0.87).

To maximize clinical usefulness of the FUNC score, we grouped FUNC score values to define clinically meaningful outcome prediction categories by proportion of the patients who achieve functional independence at 90 days as follows: 0 to 4=0%; 5 to 7=1% to 20%; 8=21% to 60%; 9 to 10=61% to 80%; and 11=81% to 100%. These categories were incorporated into a clinical outcome prediction tool, “FUNC Score Prediction Tool” (<http://www.massgeneral.org/stopstroke/funcCalculator.aspx>), which was designed to facilitate ICH patient assessment by: (1) assigning a FUNC score on admission; and (2) early prognosis of functional outcome based on the data (“percent functionally independent at 90 days”) from both the entire cohort as well as ICH survivors only (Figure).

Discussion

We developed and validated an acute clinical scale, the FUNC score, to identify at hospital admission those patients

with primary ICH who are likely to recover functional independence. This simple tool is easy to use at the bedside, requiring information only from the initial patient evaluation and CT scan to complete. The FUNC score was similarly effective in identifying those patients who achieve functional independence at 90 days among the entire cohort as well as among the ICH survivors alone, suggesting that its predictive accuracy is substantially unaffected by withdrawal of care.

Developed and validated in an unselected consecutive cohort of patients with ICH, the FUNC score is widely generalizable compared, for example, with prior published prediction scores, which were developed in a cohort of patients with ICH that excluded both comatose and intubated patients.²⁴ The contributors to the FUNC score are easily and routinely measured in clinical practice, including on hospital admission. In addition to age, GCS, ICH volume, and ICH location, which have been used reliably by prior investigators,^{8,25,33} we identified pre-ICH cognitive impairment as an independent predictor of functional independence at 90 days. This variable can be simply and reliably determined using a basic set of questions³⁰ asking informants to compare the subject’s ability to perform a list of daily cognitive tasks involving memory, praxis, calculation, or reasoning with his or her baseline 10 years before the index event. In this format, cognitive impairment is defined as the presence of deficits in memory or other cognitive domains sufficient to interfere with activities of daily living. The role of pre-existing cognitive dysfunction in outcome from ICH is not unexpected because of the powerful role that premorbid functional status may play in rehabilitation after stroke.³⁴ Furthermore, because ICH is a disease of the elderly, cognitive dysfunction can be expected to be relatively common among affected patients. In fact, there is

reason to believe that patients with ICH may carry an even greater burden of cognitive impairment than equally aged individuals without ICH. The common vascular pathologies that underlie ICH such as cerebral amyloid angiopathy and hypertensive vasculopathy, both on their own, contribute to vascular cognitive decline,³⁵ whereas Alzheimer disease itself may accompany cerebral amyloid angiopathy.

We did not identify IVH as an independent predictor of functional independence at 90 days. Once adjusted for other variables, the effect of IVH on functional outcome lost its statistical significance in both the entire cohort as well as when restricted to the ICH survivors only. IVH was strongly correlated with GCS, ICH volume, and ICH location; thus, once controlled for these factors, IVH no longer remained significant. Given that IVH was a significant predictor in multiple prior assessment tools, we re-evaluated our model by entering IVH as a predictor variable. After this modification, IVH showed a modest effect on functional outcome but continued to lack significance (OR, 0.8; 95% CI, 0.4 to 1.4) in the model development subset. Furthermore, entering IVH into our model did not improve its goodness of fit (c-statistic=0.88).

Because patients with ICH are so often neurologically devastated on presentation, withdrawal of care by the physician-family team is common and, when it is tracked, becomes the most potent predictor of death in ICH.^{5,6,20} Although this practice clearly can alleviate patient and family suffering, it risks becoming a self-fulfilling prophecy.^{5,6} Furthermore, because withdrawal of care is so widely practiced and inconsistently accounted for in cohort studies of ICH outcome, it is often impossible to eliminate its effect on mortality.^{9,12,36–40} Thus, one of the limitations that might have hindered applicability of prior prediction tools is that they most likely were developed and validated in cohorts in whom withdrawal of care was not incorporated into the analyses.^{8–14,23–26}

We controlled for the effect of withdrawal of care on patient outcomes by applying the FUNC score exclusively to ICH survivors within our cohort. We assumed that because these patients survived to 90 days, they most likely avoided mortality as a result of early care limitations or withdrawal of care, which was shown to double the hazard of death²⁰ and lead to mortality in up to 77% of patients with primary ICH.⁶ Whether our cohort of ICH survivors is subject to other undetermined bias remains unclear. Nevertheless, the FUNC score reliably predicted functional independence in this group of patients, which allows us to conclude that, on admission, one can use the FUNC score rule to predict the likelihood of patient's functional independence provided that the patient survives to 90 days. Conversely, one could prognosticate that despite surviving to 90 days, those patients whose FUNC score is ≤ 4 will have no chance of reaching functional independence. When used in this context, the FUNC score could become a practical and reliable clinical instrument, applied a priori, for the multidisciplinary team of physicians to enable goal-of-care discussions with families as well as triage medical management based on calculated prognosis.

By offering prediction of functional outcome, rather than mortality, the FUNC score can be useful for patients, family members, and decision-makers whose primary concern is

not the likelihood of survival, but rather the likelihood of survival with recovery of function. Such a decision tool may also have applicability to the design and conduct of clinical trials in ICH.

Summary

The FUNC score is a valid clinical assessment tool (<http://www.massgeneral.org/stopstroke/funcCalculator.aspx>), which can be used to identify those patients with ICH who will attain long-term functional independence. FUNC score predictions of independence are essentially unchanged when restricted to 90-day ICH survivors, suggesting that the score is not substantially affected by early withdrawal of care. This acute outcome prediction scale provides essential guidance for physicians and families who are confronted with decision-making about direction of care for their patients and selection strategy for clinical trials.

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References

- Caplan L. Intracerebral haemorrhage. *Lancet*. 1992;14:656–658.
- Gebel JM, Broderick JP. Intracerebral hemorrhage. *Neurol Clin*. 2000; 18:419–438.
- Broderick JP, Adams HP Jr, Barsan W, Feinberg W, Feldmann E, Grotta J, Kase C, Krieger D, Mayberg M, Tilley B, Zabramski JM, Zuccarello M. Guidelines for the management of spontaneous intracerebral hemorrhage: a statement for healthcare professionals from a special writing group of the Stroke Council, American Heart Association. *Stroke*. 1999; 30:905–915.
- Flaherty ML, Kissela B, Woo D, Kleindorfer D, Alwell K, Sekar P, Moomaw CJ, Haverbusch M, Broderick JP. The increasing incidence of anticoagulant-associated intracerebral hemorrhage. *Neurology*. 2007;68: 116–121.
- Hemphill JC III, Newman J, Zhao S, Johnston SC. Hospital usage of early do-not-resuscitate orders and outcome after intracerebral hemorrhage. *Stroke*. 2004;35:1130–1134.
- Becker KJ, Baxter AB, Cohen WA, Bybee HM, Tirschwell DL, Newell DW, Winn HR, Longstreth WT Jr. Withdrawal of support in intracerebral hemorrhage may lead to self-fulfilling prophecies. *Neurology*. 2001;56: 766–772.
- Cordonnier C, Brainin M. Better scoring for better care? *J Neurol Neurosurg Psychiatry*. 2006;77:571.
- Hemphill JC III, Bonovich DC, Besmertis L, Manley GT, Johnston SC, Tuhim S. The ICH score: a simple, reliable grading scale for intracerebral hemorrhage editorial comment: a simple, reliable grading scale for intracerebral hemorrhage. *Stroke*. 2001;32:891–897.
- Ariesen MJ, Algra A, van der Worp HB, Rinkel GJE. Applicability and relevance of models that predict short term outcome after intracerebral haemorrhage. *J Neurol Neurosurg Psychiatry*. 2005;76:839–844.
- Lisk DR, Pasteur W, Rhoades H, Putnam RD, Grotta JC. Early presentation of hemispheric intracerebral hemorrhage: prediction of outcome and guidelines for treatment allocation. *Neurology*. 1994;44:133–139.
- Portenoy RK, Lipton RB, Berger AR, Lesser ML, Lantos G. Intracerebral haemorrhage: a model for the prediction of outcome. *J Neurol Neurosurg Psychiatry*. 1987;50:976–979.
- Flaherty ML, Haverbusch M, Sekar P, Kissela B, Kleindorfer D, Moomaw CJ, Sauerbeck L, Schneider A, Broderick JP, Woo D. Long-term mortality after intracerebral hemorrhage. *Neurology*. 2006;66:1182–1186.

13. Godoy DA, Pinero G, Di Napoli M. Predicting mortality in spontaneous intracerebral hemorrhage: can modification to original score improve the prediction? *Stroke*. 2006;37:1038–1044.
14. Ruiz-Sandoval JL, Chiquete E, Romero-Vargas S, Padilla-Martinez JJ, Gonzalez-Cornejo S. Grading scale for prediction of outcome in primary intracerebral hemorrhages. *Stroke*. 2007;38:1641–1644.
15. Takahashi O, Cook EF, Nakamura T, Saito J, Ikawa F, Fukui T. Risk stratification for in-hospital mortality in spontaneous intracerebral haemorrhage: a classification and regression tree analysis. *QJM*. 2006;99:743–750.
16. Cheung RTF, Zou L-Y. Use of the original, modified, or new intracerebral hemorrhage score to predict mortality and morbidity after intracerebral hemorrhage. *Stroke*. 2003;34:1717–1722.
17. Fernandes H, Gregson BA, Siddique MS, Mendelow AD, Hemphill JC III, Bonovich DC, Johnston SC, Manley GT. Testing the ICH score*response. *Stroke*. 2002;33:1455–1456.
18. Godoy DA, Boccio A, Hemphill JC III, Bonovich DC, Johnston SC, Manley GT, Gregson BA, Mendelow AD, Fernandes HM. ICH score in a rural village in the republic of argentina*response*response. *Stroke*. 2003;34:e150–151.
19. Jamora RDG, Kishi-Generao EM Jr, Bitanga ES, Gan RN, Apaga NEP, San Jose MCZ, Hemphill JC III, Bonovich DC, Johnston SC, Manley GT. The ICH score: predicting mortality and functional outcome in an Asian population. *Stroke*. 2003;34:6–7.
20. Zahuranec DB, Brown DL, Lisabeth LD, Gonzales NR, Longwell PJ, Smith MA, Garcia NM, Morgenstern LB. Early care limitations independently predict mortality after intracerebral hemorrhage. *Neurology*. 2007;68:1651–1657.
21. Gage BF, Cardinalli AB, Owens DK. The effect of stroke and stroke prophylaxis with aspirin or warfarin on quality of life. *Arch Intern Med*. 1996;156:1829–1836.
22. Ciccone ASR, Crespi V, Defanti C, Pasetti C. Thrombolysis for acute ischemic stroke: the patient's point of view. *Cerebrovasc Dis*. 2001;12:335–340.
23. Weimar C, Benemann J, Diener HC, for the German Stroke Study C. Development and validation of the Essen intracerebral haemorrhage score. *J Neurol Neurosurg Psychiatry*. 2006;77:601–605.
24. Weimar C, Roth M, Willig V, Kostopoulos P, Benemann J, Diener HC. Development and validation of a prognostic model to predict recovery following intracerebral hemorrhage. *J Neurol*. 2006;253:788–793.
25. Tuhim S, Dambrosia JM, Price TR, Mohr JP, Wolf PA, Hier DB, Kase CS. Intracerebral hemorrhage: external validation and extension of a model for prediction of 30-day survival. *Ann Neurol*. 1991;29:658–663.
26. Hallevy C, Ifergane G, Kordysh E, Herishanu Y. Spontaneous supratentorial intracerebral hemorrhage. Criteria for short-term functional outcome prediction. *J Neurol*. 2002;249:1704–1709.
27. O'Donnell HC, Rosand J, Knudsen KA, Furie KL, Segal AZ, Chiu RI, Ikeda D, Greenberg SM. Apolipoprotein e genotype and the risk of recurrent lobar intracerebral hemorrhage. *N Engl J Med*. 2000;342:240–245.
28. Rosand J, Eckman MH, Knudsen KA, Singer DE, Greenberg SM. The effect of warfarin and intensity of anticoagulation on outcome of intracerebral hemorrhage. *Arch Intern Med*. 2004;164:880–884.
29. Flibotte JJ, Hagan N, O'Donnell J, Greenberg SM, Rosand J. Warfarin, hematoma expansion, and outcome of intracerebral hemorrhage. *Neurology*. 2004;63:1059–1064.
30. Jorm AF, Korten AE. Assessment of cognitive decline in the elderly by informant interview. *Br J Psychiatry*. 1988;152:209–213.
31. Jennett B, Bond M. Assessment of outcome after severe brain damage. *Lancet*. 1975;1:480–484.
32. Anderson SI, Housley AM, Jones PA, Slattery J, Miller JD. Glasgow outcome scale: an inter-rater reliability study. *Brain Inj*. 1993;7:309–317.
33. Broderick JP, Brott TG, Duldner JE, Tomsick T, Huster G. Volume of intracerebral hemorrhage. A powerful and easy-to-use predictor of 30-day mortality. *Stroke*. 1993;24:987–993.
34. Hankey GJ, Jamrozik K, Broadhurst RJ, Forbes S, Anderson CS. Long-term disability after first-ever stroke and related prognostic factors in the Perth Community Stroke Study, 1989–1990. *Stroke*. 2002;33:1034–1040.
35. Bowler JV, Gorelick PB. Advances in vascular cognitive impairment 2006. *Stroke*. 2007;38:241–244.
36. Bronnum-Hansen H, Davidsen M, Thorvaldsen P. Long-term survival and causes of death after stroke. *Stroke*. 2001;32:2131–2136.
37. Dennis M. Outcome after brain haemorrhage. *Cerebrovasc Dis*. 2003;16:9–13.
38. Dennis MS, Burn JP, Sandercock PA, Bamford JM, Wade DT, Warlow CP. Long-term survival after first-ever stroke: the Oxfordshire Community Stroke Project. *Stroke*. 1993;24:796–800.
39. Fogelholm R, Murros K, Rissanen A, Avikainen S. Long term survival after primary intracerebral haemorrhage: a retrospective population based study. *J Neurol Neurosurg Psychiatry*. 2005;76:1534–1538.
40. Hardie K, Hankey GJ, Jamrozik K, Broadhurst RJ, Anderson C. Ten-year survival after first-ever stroke in the Perth Community Stroke Study. *Stroke*. 2003;34:1842–1846.

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