Predicting the Risk of Symptomatic Intracerebral Hemorrhage in Ischemic Stroke Treated With Intravenous Alteplase

Safe Implementation of Treatments in Stroke (SITS) Symptomatic Intracerebral Hemorrhage Risk Score

Michael Mazya, MD; José A. Egidio, MD, PhD; Gary A. Ford, MD, FRCP; Kennedy R. Lees, MD, FRCP; Robert Mikulik, MD, PhD; Danilo Toni, MD, PhD; Nils Wahlgren, MD, PhD; Niaz Ahmed, MD, PhD; for the SITS Investigators

Background and Purpose—Symptomatic intracerebral hemorrhage (SICH) is a serious complication in patients with acute ischemic stroke treated with intravenous thrombolysis. We aimed to develop a clinical score that can easily be applied to predict the risk of SICH.

Methods—We analyzed data from 31,627 patients treated with intravenous alteplase enrolled in the Safe Implementation of Treatments in Stroke (SITS) International Stroke Thrombolysis Register. The outcome measure was SICH per the Safe Implementation of Thrombolysis in Stroke-Monitoring Study (SITS-MOST) definition: a Type 2 parenchymal hemorrhage with deterioration in National Institutes of Health Stroke Scale score of ≥4 points or death. Univariate risk factors associated with the outcome were entered into a logistic regression model after stratification of continuous variables. Adjusted ORs for the independent risk factors were converted into points, which were summed to produce a risk score.

Results—We identified 9 independent risk factors for SICH: baseline National Institutes of Health Stroke Scale, serum glucose, systolic blood pressure, age, body weight, stroke onset to treatment time, aspirin or combined aspirin and clopidogrel, and history of hypertension. The overall rate of SICH was 1.8%. The risk score ranged from 0 to 12 points and showed a >70-fold graded increase in the rate of SICH for patients with a score ≥10 points (14.3%) compared with a score of 0 point (0.2%). The prognostic discriminating capability by C statistic was 0.70.

Conclusions—The SITS SICH risk score predicts large cerebral parenchymal hemorrhages associated with severe clinical deterioration. The score could aid clinicians to identify patients at high as well as low risk of SICH after intravenous alteplase. (Stroke. 2012;43:1524-1531.)

Key Words: cerebral infarct ■ database ■ intracerebral hemorrhage ■ prognosis ■ stroke management ■ thrombolysis

Intravenous thrombolysis with alteplase improves functional neurological outcome and reduces mortality in acute ischemic stroke.1 After numerous randomized controlled trials2–8 and safety monitoring studies,9–12 alteplase is now approved within 3 hours and recommended by major professional organizations within 4.5 hours of symptom onset.13,14 The proportion of patients who benefit from thrombolysis by at least 1 point on the modified Rankin Scale has been calculated to 32%,15 whereas 3% sustain worsened outcome by any degree of the modified Rankin Scale compared with placebo.16 However, alteplase has the potential to cause life-threatening intracerebral hemorrhage. Several clinical, radiological, and pharmacological factors have
been implicated in raising the risk for different varieties of thrombolysis-related cerebral hemorrhage.\textsuperscript{17,18} Not all types and amounts of cerebral blood extravasation have been found to cause symptoms superimposed on those caused by the acute ischemia itself or by edema or to worsen long-term functional outcome.\textsuperscript{19–22} Truly symptomatic intracerebral hemorrhage (SICH) caused by thrombolysis can be conceptualized as a homogenous blood clot large enough to exert a mass effect on brain tissue outside the infarct. Furthermore, it must be associated with distinct deterioration in neurological status occurring within a timeframe when an effect of alteplase is pharmacologically plausible. Previously published models of risk stratification in thrombolysis were designed for a less specific outcome definition, that is, any type and size of hemorrhage plus any level of neurological decline within a variable timeframe.\textsuperscript{23,24} There is currently a lack of risk scores that predict true SICH.

To be clinically practical, a risk score should be easy to apply at the bedside using information available in the emergency situation. To perform accurately, it should use variables that confer independent prognostic information and must take into account the complex profile of patients with multiple risk factors. Such a score could be useful in adjusting for baseline risk and patient selection in future trials of reperfusion therapy and could be combined with future radiological methods and biomarkers predicting thrombolytic complications.

In the present study, we aimed to develop a risk score for SICH derived from a comprehensive multivariate analysis in a large prospectively collected cohort of patients treated with intravenous alteplase for acute ischemic stroke enrolled into the Safe Implementation of Treatments in Stroke–International Stroke Thrombolysis Register (SITS-ISTR).

### Methods

**Study Population**

All patients recorded in the SITS-ISTR between December 25, 2002, and March 1, 2010, were included in this study. Patients were included if they presented with stroke symptoms and were treated with intravenous alteplase (Actilyse; Boehringer-Ingelheim, Ingelheim, Germany) within as well as outside license criteria. The need for ethical approval or patient consent for participation in the SITS-ISTR varied among participating countries, but ethics approval and patient consent were obtained in countries that required this; other countries approved the register for conduct as an anonymized audit. The SITS-Monitoring STudy (MOST) data (n=6483)\textsuperscript{10} are embedded within the SITS-ISTR. The SITS-MOST was approved by the Ethics Committee of the Karolinska Institutet in Stockholm, Sweden, as well as by the Swedish Medical Products Agency. The SITS International Coordination Office did regular online monitoring of the SITS-ISTR data and checked individual patient data monthly to identify errors or inconsistencies. For a sample of patients included in SITS-MOST, source data were verified on-site by monitors under the supervision of the national coordinator.

**Procedures**

The SITS-ISTR is an ongoing, prospective, Internet-based, academic-driven, multinational, observational monitoring register for clinical centers using thrombolysis for the treatment of acute ischemic stroke. The methodology of the SITS-ISTR, including the procedure for data collection and management, patient identification, and verification of source data, has been described previously.\textsuperscript{10}

We collected baseline and demographic characteristics, stroke severity per the National Institutes of Health Stroke Scale (NIHSS), risk factors, onset-to-treatment time, medication history, and imaging data on admission and follow-up.

The main outcome measure of this study was SICH per the SITS-MOST definition: a local or remote Type 2 parenchymal hemorrhage on imaging 22 to 36 hours after treatment or earlier if the imaging scan was performed due to clinical deterioration combined with a neurological deterioration of $\geq 4$ NIHSS points from baseline or from the lowest NIHSS score before baseline and 24 hours or leading to death within 24 hours. A grading of Type 2 parenchymal hemorrhage for intracranial hemorrhage indicates a coagulum exceeding 30% of the infarct with substantial space occupation.

In addition to the SITS-MOST definition, we used 2 other definitions of SICH to enable comparison with previously published data: (1) SICH per the European Cooperative Acute Stroke Study (ECASS) II definition: any type of intracerebral hemorrhage on any posttreatment imaging after the start of thrombolysis and increase of $\geq 4$ NIHSS points from baseline, or from the lowest value within 7 days, or leading to death; and (2) SICH per the National Institute of Neurological Disorders and Stroke (NINDS) definition: any deterioration in NIHSS score or death within 7 days combined with intracerebral hemorrhage of any type (including petechial) on any posttreatment imaging after the start of thrombolysis.

All assessments of imaging studies and neurological status were done according to clinical routine at centers participating in the SITS-ISTR. A follow-up CT or MR scan at 22 to 36 hours after intravenous tissue-type plasminogen activator treatment was required for all patients. All SICH events (per SITS-MOST, ECASS II, and NINDS definitions) were adjudicated centrally by the SITS International Coordination Office based on submitted imaging and clinical data.

### Statistical Analysis

We performed descriptive statistics for baseline, imaging, and demographic data, comparing patients with and without SICH per SITS-MOST definition. All baseline variables available in the SITS-ISTR were analyzed. For continuous variables, median and interquartile range values were calculated. For categorical variables, we calculated percentage proportions by dividing the number of events by the total number of patients, excluding missing or unknown cases, as done in previous SITS publications.\textsuperscript{10–12} For calculation of significance of difference between medians and proportions, we used the Mann-Whitney $U$ test and the Pearson $\chi^2$ method, respectively. To avoid variable selection caused by spurious correlations, only variables showing an association with SICH at the $P\leq 0.10$ level in the univariate analysis were included as potential predictors into the multivariate logistic regression model. In this analysis, variables significant at $P<0.05$ were regarded as independent risk factors for SICH. Stratification of continuous variables was necessary for bedside practicality. In an exploratory manner, we obtained the cutoff value for each variable, which resulted in the highest univariate odds ratio for SICH per SITS-MOST in a dichotomization. If several adjacent values showed the same OR at dichotomization, the lowest value was chosen to include all levels of the variable with the highest odds for SICH. Stroke severity by NIHSS was stratified in an explorative manner into 3 levels optimizing the difference between the univariate ORs for SICH of the respective strata. Stratification of the NIHSS into more groups did not result in an improved predictive ability of the score. A new multivariate logistic regression analysis was performed, including the stratified continuous risk factors and the categorical risk factors, obtaining the final adjusted ORs for SICH per SITS-MOST. Point values were assigned to the risk factors based on their adjusted ORs: $1$ point for OR $>1.0$ and $\leq 1.7$, $2$ points for OR $>1.7$ and $<2.7$, and $3$ points for OR $\geq 2.7$.

For each patient, the SITS SICH risk score was calculated as the sum of point values assigned to their risk factors with possible total individual scores ranging between 0 and 12. Rates of SICH by all 3 definitions were calculated among patients in each score category. Score categories were collapsed when the prevalence of a given score was $<1\%$, that is, for $\geq 9$ points. For clinical practicality, we also performed a stratification of the total risk scores for SICH per SITS-MOST into 4 tiers: low, average, moderate, and high risk. The discriminating capacity of the risk score in the derivation cohort was assessed using the area under the receiver operating characteristic curve ($C$ statistic) as an index of model performance. All analyses were performed using STATISTICA 10.0.
Internal Validation
The model was developed on a population of 15,814 patients with odd database entry numbers, a random pick, avoiding potential chronological and geographical confounding factors. All statistical methods described were performed at this stage. Having obtained the score model, it was internally validated on the remaining 15,813 patients with even database entry numbers. In both populations, only patients with complete data for all score variables and outcomes were included in the analysis. Validation was performed by evaluating the discriminating capability of the model by receiver operating characteristic analysis as well as calibration using the Hosmer-Lemeshow goodness-of-fit method. Both methods were subsequently also applied to the entire database population with complete data for score variables and outcomes.

Results
In total, 31,627 patients with ischemic stroke treated with intravenous thrombolysis were recorded in SITS-ISTR at 669 centers from 34 countries, of whom 93.3% (29,508 of 31,627) were from Europe. Data were complete for all score variables and the main outcome in 13,908 (87.9%) patients in the model derivation cohort, in 13,896 (87.9%) patients in the internal validation cohort, and in 27,804 patients (87.9%), in the entire database. Follow-up imaging results at 22 to 36 hours were available in 96.4% of cases.

The time from symptom onset to tissue-type plasminogen activator treatment ranged between 3 and 4.5 hours in 10.3% (3,257 of 31,627 patients), whereas 1.5% (459 of 31,627 patients) were recorded as treated 270 minutes after stroke onset.

In the entire population, the rate of SICH per SITS-MOST was 1.8%, the rate of SICH per ECASS II was 5.1%, and the rate of SICH per NINDS was 7.4%.

Table 1 shows the baseline characteristics of patients with SICH per the SITS-MOST definition compared with those without SICH. Multivariate logistic regression analysis resulted in 9 risk factors independently associated with SICH per SITS-MOST. These are reported in Table 2 together with the attributed score points for each risk factor.

The SITS SICH Risk Score
The SITS SICH risk score showed a strong association with SICH per the SITS-MOST definition with a >70-fold increase
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Table 2. Final Multivariate Scoring Model Using Risk Factors for SICH per SITS-MOST After Stratification of Continuous Variables

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR (95% CI)</th>
<th>P Value</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin + clopidogrel</td>
<td>3.2 (1.9–5.2)</td>
<td>&lt;0.001</td>
<td>3</td>
</tr>
<tr>
<td>Aspirin monotherapy</td>
<td>1.8 (1.5–2.1)</td>
<td>&lt;0.001</td>
<td>2</td>
</tr>
<tr>
<td>NIHSS ≥13</td>
<td>2.2 (1.7–3.0)</td>
<td>&lt;0.001</td>
<td>2</td>
</tr>
<tr>
<td>NIHSS 7–12</td>
<td>1.6 (1.1–2.1)</td>
<td>0.006</td>
<td>1</td>
</tr>
<tr>
<td>B–Glucose ≥180 mg/dL</td>
<td>2.1 (1.7–2.6)</td>
<td>&lt;0.001</td>
<td>2</td>
</tr>
<tr>
<td>Age ≥72 y</td>
<td>1.7 (1.4–2.0)</td>
<td>&lt;0.001</td>
<td>1</td>
</tr>
<tr>
<td>Systolic BP ≥146 mm Hg</td>
<td>1.6 (1.3–2.0)</td>
<td>&lt;0.001</td>
<td>1</td>
</tr>
<tr>
<td>Weight ≥95 kg</td>
<td>1.6 (1.2–2.0)</td>
<td>&lt;0.001</td>
<td>1</td>
</tr>
<tr>
<td>Onset-to-treatment time ≥180 min</td>
<td>1.5 (1.2–2.0)</td>
<td>0.002</td>
<td>1</td>
</tr>
<tr>
<td>History of hypertension</td>
<td>1.4 (1.1–1.7)</td>
<td>0.004</td>
<td>1</td>
</tr>
</tbody>
</table>

Overall Risk Level | Total Score | SICH Rate (95% CI) |
Low                | 0–2 points  | 0.4% (0.2%–0.6%)  |
Average            | 3–5 points  | 1.5% (1.3%–1.7%)  |
Moderate           | 6–8 points  | 3.6% (3.1%–4.1%)  |
High               | ≥9 points   | 9.2% (5.9%–12.5%) |

Multivariate ORs with CIs. For clinical practicality, the total score is tiered into 4 levels according to risk severity. Points are attributed strictly either for “aspirin combined with clopidogrel” or “aspirin as antiplatelet monotherapy.” Absence of aspirin treatment and history of hypertension, NIHSS 0–6, and values of continuous parameters below the stated cut points are scored as zero points.

SICH indicates symptomatic intracerebral hemorrhage; SITS-MOST, Safe Implementation of Thrombolysis in Stroke-Monitoring Study; NIHSS, National Institutes of Health Stroke Scale; BP, blood pressure.

Table 2 shows the final multivariate scoring model using risk factors for SICH per SITS-MOST after stratification of continuous variables. The model includes several risk factors, such as aspirin and clopidogrel use, NIHSS score, age, blood glucose level, history of hypertension, weight, and onset-to-treatment time. The model is designed to predict SICH rates and has been validated using various methods, including internal validation, external validation, and validation in the entire population.

Discussion

In the entire material, the C statistic for the predictive capability of the score for SICH per ECASS II was 0.67 and 0.66 for SICH per NINDS. The Hosmer-Lemeshow test statistic was 8.0 (P=0.09) in the validation cohort and 7.5 (P=0.19) in the entire population.

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Identifying patients at low risk of SICH may facilitate treatment by nonprofessionals. In a survey of American emergency physicians, 26% of 1105 respondents were reluctant to use thrombolysis in acute ischemic stroke for fear of SICH. Among this physician population, the highest acceptable rate of SICH was 3.4%, which is approximately double the average rate of SICH per SITS-MOST (1.8%) in the SITS-ISTR registry. Our risk score shows that 11% of thrombolysed patients have a risk for SICH of this magnitude or higher (≥3.7% with ≥7 points). Still, any decision whether to withhold thrombolysis because of an increased risk of SICH needs to weigh this against the potential benefit to the patient.

The SITS SICH risk score may be relevant and useful in three different contexts: (1) the score may aid clinicians as well as patients and families in the process of decision-making when faced with acute ischemic stroke eligible for thrombolytic treatment; (2) as neuroimaging modalities and biomarkers evolve in their ability to predict SICH, they could be used in conjunction with the SITS SICH risk score; and (3) the risk score may be useful in clinical trials for patient selection and balancing the risk of SICH between randomized groups.

Risk Factors for SICH per SITS-MOST

We have identified nine clinical and anamnestic parameters that have been included in the risk score. They are presented in this section by order of decreasing multivariate ORs for SICH, as shown in Table 2. The strongest predictor of SICH in our material is current dual antiplatelet therapy with aspirin and clopidogrel. This has been previously suggested by Diedler et al. as well as in a pooled analysis of the Stroke-Acute Ischemic NXY treatment (SAINT) I and II trials. Single antiplatelet treatment with aspirin is also an independent risk factor, which, however, is not the case for monotherapy with clopidogrel. Stroke severity has been shown in several studies to be associ-
ated with various definitions of SICH after thrombolysis. Multivariate analysis of outcomes in the SITS-MOST study has previously shown NIHSS score ≥8 to be associated with increased risk for SICH per SITS-MOST. In our study, explorative stratification of the NIHSS, aiming to maximize the difference in OR for SICH between groups, resulted in 3 levels: NIHSS 0 to 6, 7 to 12, and ≥13. Further stratification did not improve model performance. An elevated baseline serum glucose level ≥10 mmol/L is also independently associated with SICH, a finding consistent with previously published results. It is noteworthy that this association was not seen in patients with known diabetes mellitus and baseline glucose levels <10 mmol/L. Current guidelines recommend treatment with insulin titration in patients with stroke and serum glucose >10 mmol/L, although it is unclear whether reducing blood glucose reduces the risk of hemorrhage. Age is another well-known predictor of SICH. In our population, the sharpest increase in risk for SICH occurs in the beginning of the eighth decade of life with 72 years being the optimal cutoff level between lower and higher risk groups. A detailed analysis of age-related SICH risk in the SITS material was recently published by Ford et al. Elevated baseline blood pressure is another independent risk factor for SICH in our register, previously reported by Ahmed et al. Meanwhile, it remains an open question whether acute antihypertensive therapy attenuates SICH risk. Dichotomizing baseline systolic blood pressure, we aimed for a maximum risk difference between groups above and below the cut point. Here, a level of 146 mm Hg was found optimal. Adding more strata did not improve overall score performance. Stratifying the next risk factor, body weight, we found the level of ≥95 kg to have the strongest association with an increased risk for SICH. It is intriguing that neither the net dose of alteplase nor the dose in mg/kg of body weight elevated the risk for SICH. A recent analysis by Diedler et al has demonstrated a higher incidence of symptomatic intracerebral hemorrhage in patients >100 kg despite the lower per-kilogram dose of alteplase. Furthermore, in agreement with findings in the ECASS III trial as well as previous results from the SITS-ISTR, we found a small but significant increase in the risk for SICH in patients treated between 3 and 4.5 hours after symptom onset. Lastly, the independent risk factor with the lowest but statistically significant impact is a known history of hypertension. This is, to our knowledge, previously unreported; however, results from the SITS-ISTR have shown that patients with a history of untreated hypertension have increased rates of SICH per SITS-MOST.

Comparison With Previous SICH Scores

Major differences exist between the present study and the 2 previously published risk scores for intracerebral hemorrhage.
after stroke thrombolysis. The SITS SICH score predicts large parenchymal hemorrhages associated with severe clinical deterioration. It is designed using data from >30,000 patients using weighted risk factors. The Hemorrhage After Thrombolysis (HAT) score was designed through a literature review and tested on 400 patients. The Multicenter Recombinant Tissue-Type Plasminogen Activator Stroke Survey Group score was constructed with unweighted parameters using data from 1205 patients; however, of these, only 481 had complete data for relevant variables. Importantly, both scores were designed to assess the risk for any amount of blood extravasation on CT related to any clinical deterioration, that is, the NINDS definition of SICH. This definition is confounded by clinical deterioration due to infarct edema, new infarction, and intra- and interrater variability in assessment of NIHSS deterioration of 1 point, required for labeling as “symptomatic” in the NINDS studies. These confounders may be present concomitantly with small amounts of blood in the infarct core on follow-up imaging. Thus, it can be argued that the 2 previous scores predict any clinical deterioration, which only in part may depend on cerebral hemorrhage.

In the HAT score study, the C statistic was 0.74, whereas the score by Cucchiara et al.23 had a C statistic of 0.68 in the original population. Both scores have recently been subjected to external validation using the pooled SAINT I and II cohorts. This resulted in lower predictive capability with C statistic values of 0.59 for both algorithms.

The SITS SICH risk score does not require waiting for a measurement of a blood platelet count (required by the Stroke Survey Group score) nor a volumetric measurement of the manifest infarct size on initial imaging (used in the HAT score). It can thus readily be calculated immediately on presentation or even in the prehospital setting en route to the hospital. Under these circumstances, the stroke center’s average door-to-needle time could be used to calculate a probable onset-to-treatment time required by our score.

Study Limitations
Despite our belief that the patient data in the SITS-ISTR are representative for clinical practice across a variety of demographics and stroke center types, for the risk score to be suitable for routine clinical practice, an external validation is warranted.33 Like with other register-based studies, the presented results are based on retrospective, explorative analysis of observational material. Data for the relevant variables and outcomes were missing in 12.1% of our patients, which may have had an influence on the outcome. Furthermore, stratification of continuous variables as well as conversion of risk factor ORs to score point values, although necessary for clinical practicality, can be assumed to have resulted in a loss of information and decreased
model accuracy. We cannot exclude that some patients in the intravenous thrombolysis register were given additional intra-arterial therapy, although this is likely to be marginal. The present study is based on patients treated between the end of 2002 and beginning of 2010. During this period, intra-arterial therapy was not widely available across Europe, where 93.3% of our patients were treated.

Conclusions
The SITS SICH risk score shows good predictive ability for the risk of SICH in patients with ischemic stroke treated with intravenous thrombolysis. Our score may aid clinicians to identify patients with the highest as well as the lowest risk of SICH. However, we cannot propose withholding treatment with alteplase in patients otherwise eligible according to current guidelines. An external validation of our score is warranted. Furthermore, a study of the clinical effect of recombinant tissue-type plasminogen activator across risk score categories is needed to assess whether some patients at high risk of SICH may still have a favorable risk-to-benefit ratio with treatment.

Appendix
Scientific Committee of SITS International

Scientific Committee of Fighting Stroke (Uppdrag Besegra Stroke)

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Disclosures
J.A.E. has received fees from Boehringer Ingelheim as a member of an Advisors’ Committee and for educational activities. He has also received fees for the ECASS II and ECASS III trials. He has also received fees from Novo Nordisk as an investigator for the Factor
Seven for Acute Hemorrhagic Stroke (FAST) trials. G.A.F. has received fees and expenses from Boehringer Ingelheim for educational activities. He has also received fees and expenses from Lundbeck for educational activities. His institution has received grant assistance from Boehringer Ingelheim toward administrative expenses for coordination of SITS in the United Kingdom, fees for consultancy work, and study payments. K.R.L. has received fees and expenses from Boehringer Ingelheim for his role as chairman of the independent data safety monitoring board of the ECASS III trial with alteplase and related lectures. He has also received fees from Paion, Forest and Lundbeck for the Desmoteplase in Acute Ischemic Stroke Trial (DIAS) trials with desmoteplase. His institution has received grant assistance toward administrative expenses for coordination of SITS in the United Kingdom. R.M. has received research support from European Regional Development Fund Project FNUSA-ICRC (No. CZ.1.05/1.1.00/02.0123). D.T. has served as a consultant for Boehringer Ingelheim and has been paid lecture fees for attending and speaking at workshops held by Boehringer Ingelheim, Sanofi-Aventis and Novo Nordisk. N.W. has received expenses from Boehringer Ingelheim for his role as member of the Steering Committee in relation to the ECASS III trial with alteplase and serves as a consultant to Thrombogenics as chairman of the Data Safety Monitoring Board. SITS International (chaired by N. Wahlgren) received a grant from Boehringer Ingelheim and Ferrer for the SITS-MOST/ISTR. His institution has also received grant support toward administrative expenses for coordination of the SITS-MOST/ISTR. N.W. has also received lecture fees from Boehringer Ingelheim and Ferrer. N.A. is a senior researcher in SITS International, which receives a grant from Boehringer Ingelheim and Ferrer for the SITS-MOST/ISTR.

References
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Background and Objectives: Symptomatic intracerebral hemorrhage (SICH) is a serious complication of acute ischemic stroke treated with intravenous alteplase. The objective of this study was to develop a clinical score that could easily predict the risk of SICH.

Methods: Data from the Safe Implementation of Treatments in Stroke (SITS) International Stroke Thrombolysis Register were analyzed for 31,627 patients who received alteplase treatment. The outcome measure was SICH defined as a 2-point NIHSS increase with a 2-type intracerebral hemorrhage or death. The continuous variables were dichotomized and the variables associated with SICH were entered into a multivariable model. The ORs were transformed into points according to the distribution within the score range and the score was calculated by adding these points. The model was internally validated with bootstrapping.

Results: Nine independent predictors of SICH were identified: alteplase NIHSS score, serum glucose level, systolic blood pressure, age, weight, time from stroke to treatment, aspirin or aspirin plus clopidogrel, and history of hypertension. The overall SICH rate was 1.8%. When the score was expressed in 4 levels, a 70-fold increase in the rate of SICH was observed. The C-statistic for the prediction was 0.70.

Conclusion: The SITS SICH score is useful for identifying patients who are at risk of severe hemorrhagic complications after alteplase therapy. The score is also useful in determining which patients would benefit from alteplase treatment.

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Key Words: cerebral infarct □ database □ intracerebral hemorrhage □ prognosis □ stroke management □ thrombolysis

Abstract 14

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Safe Implementation of Treatments in Stroke (SITS) Symptomatic Intracerebral Hemorrhage Risk Score

Michael Mazya, MD; José A. Egido, MD, PhD; Gary A. Ford, MD, FRCP; Kennedy R. Lees, MD, FRCP; Robert Mikulik, MD, PhD; Danilo Toni, MD, PhD; Nils Wahlgren, MD, PhD; Niaz Ahmed, MD, PhD; for the SITS Investigators

(Stroke. 2012;43:1524-1531.)

Key Words: cerebral infarct □ database □ intracerebral hemorrhage □ prognosis □ stroke management □ thrombolysis

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Table 2. Final Multivariate Scoring Model Using Risk Factors for SICH per SITS-MOST After Stratification of Continuous Variables

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR (95% CI)</th>
<th>P Value</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin + clopidogrel</td>
<td>3.2 (1.9–5.2)</td>
<td>&lt;0.001</td>
<td>3</td>
</tr>
<tr>
<td>Aspirin monotherapy</td>
<td>1.8 (1.5–2.1)</td>
<td>&lt;0.001</td>
<td>2</td>
</tr>
<tr>
<td>NIHSS ≥13</td>
<td>2.2 (1.7–3.0)</td>
<td>&lt;0.001</td>
<td>2</td>
</tr>
<tr>
<td>NIHSS 7–12</td>
<td>1.6 (1.1–2.1)</td>
<td>0.006</td>
<td>1</td>
</tr>
<tr>
<td>Age ≥72 y</td>
<td>2.2 (1.7–2.9)</td>
<td>&lt;0.001</td>
<td>2</td>
</tr>
<tr>
<td>Systolic BP ≥146 mm Hg</td>
<td>1.6 (1.3–2.0)</td>
<td>&lt;0.001</td>
<td>1</td>
</tr>
<tr>
<td>Weight ≥95 kg</td>
<td>1.6 (1.2–2.0)</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Onset-to-treatment time ≥180 min</td>
<td>1.5 (1.2–2.0)</td>
<td>0.002</td>
<td>1</td>
</tr>
<tr>
<td>History of hypertension</td>
<td>1.4 (1.1–1.7)</td>
<td>0.004</td>
<td>1</td>
</tr>
</tbody>
</table>

Overall Risk Level: Total Score; SICH Rate (95% CI)

- Low: 0–2 points, 0.4% (0.2%–0.6%)
- Average: 3–5 points, 1.5% (1.3%–1.7%)
- Moderate: 6–8 points, 3.8% (3.1%–4.1%)
- High: ≥9 points, 9.2% (5.9%–12.5%)

Multivariate ORs with CIs. For clinical practicality, the total score is tiered into 4 levels according to risk severity. Points are attributed strictly for “aspirin combined with clopidogrel” or “aspirin as antiplatelet monotherapy.” Absence of aspirin treatment and history of hypertension, NIHSS 0–6, and, values of continuous parameters below the stated cut points are scored as zero points.

SICH indicates symptomatic intracerebral hemorrhage; SITS-MOST, Safe Implementation of Thrombolysis in Stroke-Monitoring Study; NIHSS, National Institutes of Health Stroke Scale; BP, blood pressure.