New Prediction Score for Hematoma Expansion and Neurological Deterioration after Spontaneous Intracerebral Hemorrhage: A Hospital-Based Retrospective Cohort Study

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Objective: To ensure hematoma expansion and neurological deterioration in the management of acute spontaneous intracerebral hemorrhage, accurate prediction is crucial for initial assessment on admission. We conducted this study to develop a new clinical prediction score using only noncontrast computed tomography image and simply measurable variables. *Methods:* This study was a retrospective cohort analysis. The study took place in a single academic medical center in Japan. Development of the prediction score was conducted based on patients who presented between October 2010 and June 2015, using univariate and multivariate logistic regression. We then validated the results in a second cohort between July 2015 and April 2017. The primary outcome was hematoma expansion and the secondary outcome was neurological deterioration up to 14 days after onset. *Results:* In total, 622 patients were included in the analysis after excluding unsuitable cases. Of these, 457 patients were included in the development cohort and 165 were included in the validation cohort, with 10.8% meeting the criteria for hematoma expansion and 8.8% showing neurological deterioration. In the multivariate analysis, predictors of expansion or deterioration were as hematoma heterogeneity on computed tomography, niveau formation, peripheral edema, hematoma volume of more than 30 mL, and anticoagulant use. We then created the HEAVN score based on the univariate regression coefficients. The C-statistics for the hematoma expansion scores were .81 and .80 in the development and validation cohorts, respectively. Similar results were obtained for neurological deterioration. *Conclusions:* The HEAVN score is simple and useful for predicting hematoma expansion and neurological deterioration based on imaging and background data. **Key Words:** Prediction score—hematoma expansion—neurological deterioration—spontaneous intracerebral hemorrhage.

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Introduction

Several clinical trials have attempted to develop predictors or prediction scores for hematoma expansion after acute spontaneous intracerebral hemorrhage (sICH). Predictors often include computed tomography angiography spot sign, time to baseline computed tomography (CT) from symptom onset, hematoma size, use of anticoagulants, extension of hematoma to the ventricles, and recurrent cerebral hemorrhage.[1-5]

However, these scores are slightly complicated, and not applicable to all patients, as emergency computed tomography angiography is not readily available in many centers and the timing from onset to CT is not always known. Several researchers have lately addressed a part of the problem by showing that noncontrast CT findings such as hypodensities were useful as predictors of prognosis or hematoma expansion.[6,7]

Some previous reports have focused on the ability of these scores to select patients at risk of hematoma expansion[1,2] to conduct further research concerning its prevention. However, the most important thing is to identify patients at high risk of exacerbation of neurological symptoms, thereby elucidating who would need the most intensive treatment. Identifying those patients at high risk of hematoma expansion and neurological deterioration is challenging. Therefore, we aimed to develop a prediction score for both outcomes after acute sICH.

Methods

Study Design

Patients with primary sICH seen at a single academic hospital, Center Hospital of National Center for Global Health and Medicine, were retrospectively enrolled in this cohort study. The study protocol was approved by the research ethics board of National Center for Global Health and Medicine, Tokyo, Japan (NCGM-G-002193-00). Because this study was a retrospective observational study, patient information was anonymized and deidentified before analysis. Therefore, the need for patient consent was waived.

Participants

We included patients with acute sICH who were admitted to our hospital, and then formed a development cohort of patients admitted between December 2010 and June 2015 and a validation cohort of patients admitted between July 2015 and February 2017. Patients were excluded if they had an emergency operation that was decided at the time of admission before follow-up CT, if there were no follow-up CTs within 24 hours after admission, or if they had a primary intraventricular hemorrhage. All patients in the development and validation cohort were treated according to the American Heart Association/American Stroke Association Stroke organization guidelines for the management of sICH[8] and none received recombinant factor VIIa.

Procedures

Demographic and clinical characteristics were collected, including age, sex, medication use, and medical history. Concerning admission, we collected the systolic and median blood pressures (including whether hypotensive treatment was successful within 2 hours), modified Rankin Scale scores before onset and on admission, prothrombin time (international normalized ratio), activated partial thromboplastin time, and platelet count. In the imaging analysis, experienced neurosurgeons (blinded to clinical and outcome data) confirmed the hemorrhage location (deep, lobar, or suboccipital) and characteristics (heterogeneity, niveau formation, multiple hematomas, peripheral edema, extension into ventricles, and baseline intracerebral hemorrhage volume was entered into the model as a categorical variable [<30, 31-60, or >60 mL]). Heterogeneity was considered to be present if the main hematoma contained several densities (low irregular density). Hemorrhages with well-defined boundaries between areas of different density, either horizontal or curved, were classified as having a "niveau." Each scan was independently evaluated by 2 stroke neurosurgeons. Ambiguous cases were those that could not be included in these definitions (Fig 1).

Main Outcomes

Hematoma expansion was defined as volume expansion of more than 33% and/or absolute growth larger than 5 mm of the maximum diameter from baseline CT. For follow-up, we checked all CTs from 24 hours to 14 days after admission. Clinical outcomes included neurological deterioration until 14 days from admission, as assessed by a Glasgow Coma Scale score higher than 4 points, National Institutes of Health Stroke Scale (NIHSS) motor paralysis score of 2 points or higher, NIHSS aphasia score of 1 point or higher, or death from sICH. These were obtained from the medical records.

Statistical Analysis

Statistical analysis was performed using JMP 11.0 (SAS Institute Inc., Cary, NC). Statistical significance for intergroup differences was assessed by Pearson χ^2 test or Fisher exact test for categorical variables and the Wilcoxon test for continuous variables. Data were summarized as mean ± standard deviation or median (interquartile range), as appropriate. Covariates were tested for association with hematoma expansion and neurological deterioration by univariate. Significant predictors from the univariate analysis and nonsignificant variables chosen for their potential clinical relevance were tested for their association with hematoma expansion or neurological deterioration in a