Focal Fluid-Attenuated Inversion Recovery Hyperintensity Within Acute Diffusion-Weighted Imaging Lesions Is Associated With Symptomatic Intracerebral Hemorrhage After Thrombolysis

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Background and Purpose—We investigated whether focal hyperintensity on fluid-attenuated inversion recovery image within acute infarcts is associated with symptomatic intracerebral hemorrhage (SICH) after thrombolysis.

Methods—Patients with acute ischemic stroke who underwent MRI screening before thrombolysis were enrolled. The presence of focal fluid-attenuated inversion recovery hyperintensity within acute infarcts did not preclude thrombolysis. SICH was defined as hemorrhagic transformation with any neurological decline (SICH-1) or with an increase in National Institutes of Health Stroke Scale of ≥4 (SICH-2) within 48 hours.

Results—Among 88 included patients, focal fluid-attenuated inversion recovery hyperintensity within acute infarct lesions was observed in 27 (30.7%) patients. Multivariate analysis showed that focal fluid-attenuated inversion recovery hyperintensity was independently associated with SICH-1 (OR, 13.64; 95% CI, 1.51 to 123.28) and SICH-2 (OR, 10.44; 95% CI, 1.11 to 98.35).

Conclusion—The presence of focal fluid-attenuated inversion recovery hyperintensity within acute infarcts may increase the risk of symptomatic intracerebral hemorrhage after thrombolysis. (Stroke. 2008;39:000-000.)

Key Words: acute stroke ■ intracerebral hemorrhage ■ MRI ■ thrombolysis

Because symptomatic intracerebral hemorrhage (SICH) is the most serious complication of thrombolytic therapy, there have been efforts to identify clinical and imaging variables associated with the risk of SICH.

Recently, the feasibility and safety of MRI screening before thrombolysis have been demonstrated. However, it is not known whether hyperintensity on fluid-attenuated inversion recovery (FLAIR) image within acute infarcts is associated with SICH after thrombolysis.

Methods

We conducted a retrospective analysis of prospectively registered patients in our center between March 2004 and October 2006. We included patients with acute ischemic stroke receiving MRI-based thrombolysis (intravenous tissue plasminogen activator [tPA], combined intravenous tPA and intra-arterial urokinase therapy within 3 hours of onset, or intra-arterial urokinase therapy between 3 and 6 hours after onset). We obtained demographics, risk factors, National Institutes of Health Stroke Scale score, blood pressure, body temperature and glucose level at baseline, stroke subtypes, onset-to-imaging time, onset-to-needle time, thrombolysis methods, diffusion-weighted imaging lesion volume, the presence of microbleeds, and the presence of focal FLAIR hyperintensity. This study was approved by the Institutional Review Board. Informed written consent was obtained from each patient or legal guardian.

The MRI and thrombolysis protocols have been previously described in detail: well-developed FLAIR hyperintensity corresponding to the whole acute diffusion-weighted imaging lesions belonged to exclusion criteria; however, the presence of focal FLAIR hyperintensity did not preclude thrombolysis.

SICH was defined as hemorrhagic transformation identified on CT causing any neurological decline (SICH-1) or causing an increase in National Institutes of Health Stroke Scale of ≥4 (SICH-2) within 48 hours after thrombolysis.

Fisher exact test or Mann-Whitney U test was used for univariate analysis to identify factors related to SICH. Because of infrequent occurrence of SICH, the predictive value of univariate findings was subsequently tested with a bootstrap resampling procedure in which a saturated logistic regression analysis with a forward selection process was repeated for each of 1000 bootstrap resamplings. The relative frequency of selection of the bootstrap resampling >50% was used as criterion for inclusion of predictors in the final multivariable model. SAS release 9.1 was used for statistical analysis.
Results

A total of 88 patients were included. Mean age (±SD) was 62.6 (±11.6) years, and 52 were male. The proportions of patients receiving intravenous tPA, intravenous tPA combined with intra-arterial urokinase, and intra-arterial urokinase were 39.8%, 18.2%, and 42.0%, respectively. Cardioembolism was identified in 42.0% and large-artery atherosclerosis in 38.6%. The involved arteries were middle cerebral (62.5%), distal internal carotid (15.9%), and verteobasilar (21.6%).

Focal FLAIR hyperintensity within acute diffusion-weighted imaging lesions was present in 27 (30.7%) patients. National Institutes of Health Stroke Scale was higher (median [range], 17 [4 to 32] versus 12 [1 to 32], P = 0.049), onset-to-needle time was longer (minute, median [interquartile range], 242 [166.0 to 434.7] versus 160.0 [126.5 to 256.0], P = 0.002), and intra-arterial thrombolysis was more commonly performed (17 of 27 [63.0%] versus 20 of 61 [32.8%), P = 0.01) in patients with focal FLAIR hyperintensity than in those without.

SICH-1 and SICH-2 were observed in 6 (6.8%) and 5 (5.7%) patients. In univariate analysis, factors associated with SICH (P < 0.05) were focal FLAIR hyperintensity (SICH-1-positive, 5 of 27 [18.5%] versus SICH-1-negative, one of 61 [1.6%]; SICH-2-positive, 4 of 27 [14.8%] versus SICH-2-negative, one of 61 [1.6%]), diffusion-weighted imaging lesion volume (SICH-1-positive, 37.1 ± 21.0 mL versus SICH-1-negative, 19.5 ± 24.4 mL; SICH-2-positive, 40.5 ± 21.6 mL versus SICH-2-negative, 19.5 ± 24.2 mL), and baseline systolic blood pressure (SICH-2-positive, 186.0 ± 21.5 mm Hg versus SICH-2-negative, 156.8 ± 32.9 mm Hg). Multivariate analyses showed that focal FLAIR hyperintensity was the only independent predictor of SICH-1 (OR, 13.64; 95% CI, 1.51 to 123.28) and SICH-2 (OR, 10.44; 95% CI, 1.11 to 98.35). Other multivariate models, including forward or backward stepwise, showed consistent results (data not shown).

In the 5 patients with focal FLAIR hyperintensity who developed SICH-1, the SICH occurred at the acute infarct area with focal FLAIR hyperintensity (Figure).

Discussion

This is the first study that suggests focal FLAIR hyperintensity within acute diffusion-weighted imaging lesions as a predictor of SICH after thrombolysis. We also showed that the location of SICH was mostly an area of acute ischemic lesion with focal FLAIR hyperintensity. The presence of FLAIR hyperintensity in hyperacute stroke may be explained by the following: the reported onset time by patients or their family may be imprecise; the vulnerability of individual brains to ischemia may be variable; or the collateral compensation may be insufficient. Thus, the presence of FLAIR hyperintensity in the hyperacute stroke period provides us with a “tissue clock” of ischemic damage.

Some may argue that the difference in baseline characteristics between patients with and without focal FLAIR hyperintensity might influence the development of SICH: however, stroke severity, onset-to-needle time, and thrombolytic methods were not related to SICH in this study. Moreover, multivariate analyses considering all potential clinical and imaging confounders of SICH were used and showed consistent results throughout different multivariate models. Thus,
we believe that the bias due to comparability between the 2 groups is not significant in this study.

It is questionable whether those with focal FLAIR hyperintensity should be excluded from thrombolysis based on our observation. Particularly, intravenous tPA therapy within 3 hours should not be withheld because of the presence of focal FLAIR hyperintensity. A recent study showed that an MRI-based group did not have significantly better outcomes than a CT-based group within 3 hours.8 Further studies with a larger sample will be needed to confirm and expand our observation.

Limitations should be noted. Other thrombolytic methods than intravenous tPA are not accepted as standard therapy. The interpretation of FLAIR hyperintensity by visual inspection is subjective. The number of patients in this retrospective study was small. Lastly, the CIs of OR were rather wide because of the low rate of intracerebral hemorrhage.

In conclusion, the presence of focal FLAIR hyperintensity within acute infarcts may increase the risk of hemorrhage after thrombolytic therapy.

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Disclosures
None.

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