Fluid-Attenuated Inversion Recovery Vascular Hyperintensity

An Early Predictor of Clinical Outcome in Proximal Middle Cerebral Artery Occlusion

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Background: Few data are available on the relationship between fluid-attenuated inversion recovery vascular hyperintensities and proximal middle cerebral artery occlusion prognosis.

Objectives: To assess a fluid-attenuated inversion recovery vascular hyperintensities score (FVHS) and explore its relationship with recanalization status and clinical outcomes after intravenous thrombolysis.

Design: Retrospective study.

Setting: Stroke unit in a university hospital.

Patients: Consecutive patients with proximal middle cerebral artery occlusion, thrombolysed within 6 hours, were selected from our prospective database. The FVHS (range, 0-10; divided into low, medium, and high thirds) was quantified on the magnetic resonance image obtained at admission. Recanalization rates, infarction size (Alberta Stroke Program Early CT Score applied to diffusion-weighted imaging [ASPECTS-DWI]), and 3-month functional outcomes (modified Rankin Scale score) were determined. Poor outcomes and large infarctions were defined as a modified Rankin Scale score higher than 2 and an ASPECTS-DWI score of 5 or lower, respectively.

Main Outcome Measures: Interaction among FVHS, recanalization status, and outcomes.

Results: Thirty-four patients had a low FVHS (≤4), 32 had a medium FVHS (5 or 6), and 39 had a high FVHS (≥7). The rate of poor functional outcome (modified Rankin Scale score ≥2) was higher for the group with low FVHSs than those with medium FVHSs and high FVHSs (82.3% vs 43.7% and 43.3%, respectively; P < .001). The rate of 24-hour large infarctions (ASPECTS-DWI score ≤5) was higher for those with low FVHSs than those with medium and high FVHSs (88.2% vs 56.2% and 51.3%, respectively; P = .002). The recanalization rate was not associated with FVHS. Multivariate analysis retained low FVHS as an independent early predictor of poor clinical outcome (odds ratio = 9.91; 95% CI, 2.01-48.93; P = .004) and large infarction (odds ratio = 6.99; 95% CI, 1.78-27.46; P = .005). Low FVHS remained associated with poor outcomes regardless of recanalization status. Early recanalization in patients with a low FVHS decreased the poor functional outcome rate from 100% to 64.7% (P = .02).

Conclusions: The FVHS is an early independent prognostic marker for patients with proximal middle cerebral artery occlusion. Synergy between FVHS and recanalization status appears to be a critical determinant of final outcomes, supporting intensive reperfusion treatment for patients with a low FVHS.

arachnoid spaces of the occluded artery territory. Slow antegrade or retrograde collateral circulation supposedly explains FVH in patients with acute ischemic stroke, which might be consistent with beneficial collateral arterial flow beyond the arterial occlusion site. The prognostic value of those FVHs in stroke patients remains controversial. Some authors noted that FVHs were associated with larger infarcts and poorer clinical outcomes regardless of the occlusion site. Conversely, others demonstrated that FVHs were correlated with better prognoses in accordance with recent computed tomographic angiography findings on collateral circulation. Lee et al proposed the only quantified FVH score (FVHS) to assess short-term clinical outcome on day 5 after M1-MCA occlusion in 22 patients. The relationship between collateral circulation and therapeutic intravenous thrombolysis effects, eg, recanalization and bleeding, also remains unresolved.

This study was undertaken to analyze FVHs in acute M1-MCA occlusion and their relationship with clinical factors. We aimed to determine whether the FVH level could independently influence final infarction size and ultimate 3-month clinical outcome.

METHODS

SUBJECTS

This study, conducted in the stroke unit of our institution between June 1, 2005, and May 31, 2011, included 105 patients (50 women; 55 men; mean [SD] age, 66.7 [13.6] years) identified from our prospective database. Consecutive patients were selected based on the following criteria: admitted for acute ischemic stroke, brain MRI and time-of-flight magnetic resonance angiography obtained within 4.5 hours of stroke onset, isolated M1-MCA occlusion, intravenous tissue plasminogen activator (tPA) administration within 6 hours, and follow-up MRI at 24 hours. Acute ischemic stroke was diagnosed based on clinical examination and brain MRI findings. Neurological deficit was assessed with the National Institutes of Health Stroke Scale (NIHSS) on admission. The modified Rankin Scale (mRS) was used to evaluate the final functional outcome at 3 months, with an mRS score higher than 2 defining poor functional outcome.

The patient’s vascular risk factors were considered to determine the cause of the stroke, which was classified according to the Trial of Org 1972 in Acute Stroke Treatment classification.

MRI PROTOCOL AND IMAGING ANALYSIS

All imaging was performed in the horizontal plane using a 1-T MRI scanner (Philips Intera) and recorded on the Centricity Picture Archiving and Communications System (Centricity Enterprise Web version 3.0; General Electric). Admission and follow-up MRIs were standardized and included diffusion-weighted imaging (DWI), FLAIR, gradient-echo, and time-of-flight magnetic resonance angiography on Willis circle sequences. We particularly focused on standard 3-mm-thick FLAIR sections with an intersection gap of 2 mm.

We defined FVHs as linear or serpentine hyperintensities relative to gray matter in the MCA-territory subarachnoid space. The FVH course often follows a sulcus or extends over several sulci. The FVH is supposed to represent arterial flow and then exhibits a tubular appearance often surrounded by dark cerebrospinal fluid spaces. Punctiform hypersignals were not retained as FVHs. The FVHs were differentiated from subarachnoid hemorrhage and inflammatory or carcinomatous leptomeningeal processes that usually show subarachnoid space hyperintensity on FLAIR imaging. In these cases, hyperintensity fills the sulcus and is often extensive or diffuse.

Two readers blinded to the other sequences quantified FVH (S.O. and N.C). Our score was based on a rostrocaudal extension of FVH. Thus, horizontal admission FLAIR MRIs were analyzed from the first M1-MCA appearance to the 10th image. Absence of FVH on 1 slice was rated 0 points. One or more FVHs recognized on 1 slice were rated 1 point. As 10 images were analyzed, the resulting FVHS ranged from 0 to 10. In cases of a discrepant score between the 2 readers, FLAIR images were reviewed and a consensus was established. Figure 1 gives 3 examples of the FVHS. Subsequently, DWI, gradient-echo, and time-of-flight magnetic resonance angiographic sequences were examined on admission and 24-hour MRIs. The Alberta Stroke Program Early CT Score applied to DWI (ASPECTS-DWI score) quantified infarction size; a score of 5 or lower defined a large infarct. The thrombolysis in myocardial infarction (TIMI) grade (0 indicates no recanalization; 1, poor recanalization; 2, partial recanalization; and 3, complete recanalization) was used to evaluate recanalization status on the 24-hour MRI. Symptomatic hemorrhage was defined by an NIHSS score increase of 4 or more points attributable to a bleed detected on the 24-hour MRI.

STATISTICAL ANALYSIS

The FVHSs of our 105 patients were divided a priori into thirds: low, medium, and high. Univariate analyses compared clinical and radiological characteristics among these 3 groups. Additional univariate analyses explored factors associated with poor 3-month functional outcome (mRS score >2) and large infarctions (ASPECTS-DWI score ≤5 on 24-hour MRI). Then, a logistic regression multivariate analysis included significantly associated variables (P < .10) to identify factors predictive of poor functional outcomes and large infarctions, forcing the low-FVHS pattern into the model.

Finally, to examine the low-FVHS effect on functional outcome and infarction size in patients with persistent occlusion or recanalization, we divided our cohort into 4 groups based on their low- vs medium- to high-FVHS status and TIMI grade of 0 or 1 vs 2 or 3.

Univariate analyses used χ2 test to compare nominal values, t test to compare 2 continuous values, or Kruskal-Wallis test to assess differences among more than 2 continuous values.

Interrater reliability of FVHS grading between the 2 observers was evaluated with κ statistic agreement: 0.00 to 0.20 indicates slight; 0.21 to 0.40, fair; 0.41 to 0.60, moderate; 0.61 to 0.80, good; and 0.81 to 1.00, excellent.

All computations were performed with the use of StatView version 5.0 software.

RESULTS

BASELINE CLINICAL AND IMAGING CHARACTERISTICS IN LOW-, MEDIUM-, AND HIGH-FVHS GROUPS

We found FVHs in 103 of 105 patients who met the inclusion criteria. The mean (SD) FVHS was 5.6 (2.2), the median was 6, and scores (0-10) were normally distributed (Figure 2). The FVHS was low (≤4) for 34 patients, medium (5 or 6) for 32 patients, and high (≥7)
Figure 1. A 40-year-old man with a National Institutes of Health Stroke Scale (NIHSS) score of 9, an onset-to–tissue plasminogen activator (tPA) interval of 245 minutes, and a 3-month modified Rankin Scale (mRS) score of 0 had a high fluid-attenuated inversion recovery (FLAIR) vascular hyperintensity score (FVHS) of 9 on FLAIR magnetic resonance imaging performed 220 minutes after stroke onset (A), an Alberta Stroke Program Early CT Score applied to diffusion-weighted imaging (ASPECTS-DWI) score of 8 on DWI and a left proximal middle cerebral artery (M1-MCA) occlusion on time-of-flight magnetic resonance angiography (TOF-MRA) on admission (B), and an ASPECTS-DWI score of 8 on DWI sequences and M1-MCA recanalization on TOF-MRA at 24 hours (C). A 65-year-old man with an NIHSS score of 10, an onset-to-tPA interval of 235 minutes, and a 3-month mRS score of 2 had a high FVHS of 7 on FLAIR imaging performed 210 minutes after stroke onset (D), an ASPECTS-DWI score of 9 on DWI and a left M1-MCA occlusion on TOF-MRA on admission (E), and an ASPECTS-DWI score of 8 on DWI sequences and no M1-MCA recanalization on TOF-MRA at 24 hours (F). A 67-year-old woman with an NIHSS score of 12, an onset-to-tPA interval of 110 minutes, and a 3-month mRS score of 4 had a low FVHS of 3 on FLAIR imaging performed 90 minutes after stroke onset (G), an ASPECTS-DWI score of 9 on admission DWI and a left M1-MCA occlusion on admission TOF-MRA (H), and an ASPECTS-DWI score of 7 on DWI sequences at 24 hours and M1-MCA recanalization on TOF-MRA (I). Arrows indicate FLAIR vascular hyperintensities.
for 39 patients. The κ analysis demonstrated a value of 0.80 in grading low, medium, or high FVHS by the 2 observers, indicating good agreement.

Comparisons of clinical and imaging data on admission among low-, medium-, and high-FVHS groups are reported in Table 1. Age, sex, vascular risk factors, blood pressure, temperature, glycemia, hematocrit, NIHSS score, stroke etiology, and onset-to-MRI and onset-to-thrombolysis interval were not associated with FVHS. The ASPECTS-DWI score on admission was significantly lower in the low-FVHS group than in the medium- and high-FVHS groups.

**CLINICAL AND IMAGING OUTCOMES ACCORDING TO FVHS**

Comparisons of clinical and imaging outcomes between low-, medium-, and high-FVHS groups are presented in Table 2. Whereas NIHSS scores on admission did not differ between the 3 groups, patients with low FVHSs had significantly higher mean 3-month mRS scores, with significantly more functional dependence (mRS score >2) than patients with medium and high FVHSs (82.3% vs 43.7% and 43.5%, respectively; *P* <.001). Rates of TIMI grades 2 and 3 and symptomatic bleeding were not associated with FVHS. Patients with low FVHSs had a lower mean 24-hour ASPECTS-DWI score and a significantly higher rate of final large infarction compared with patients with medium and high FVHSs (88.2% vs 56.2% and 51.3%, respectively; *P* = .002).

Univariate analysis associated poor outcomes (mRS score >2) with older age (*P* <.001), arterial hypertension (*P* = .01), high NIHSS score at admission (*P* <.001), ASPECTS-DWI score of 5 or lower at admission (*P* = .001), absence of recanalization (TIMI grade 0 or 1) at 24 hours (*P* <.001), and low FVHS (*P* <.001). Large final infarction (ASPECTS-DWI score ≤5) was associated with high NIHSS score on admission (*P* <.001), ASPECTS-DWI score of 5 or lower at admission (*P* <.001), absence of recanalization at 24 hours (*P* <.001), and low FVHS (*P* <.001).

Multivariate analysis retained age (odds ratio [OR] = 1.11; 95% CI, 1.05-1.18; *P* <.001), NIHSS score on admission (OR = 1.25; 95% CI, 1.08-1.44; *P* = .01), TIMI grade 0 or 1 (OR = 18.89; 95% CI, 3.61-96.69; *P* <.001), and low FVHS (OR = 9.91; 95% CI, 2.01-48.93; *P* = .004) as being significantly associated with poor functional outcome. The NIHSS score on admission (OR = 1.17; 95% CI, 1.06-1.29; *P* <.001), TIMI grade 0 or 1 (OR = 7.26; 95% CI, 2.23-23.67; *P* = .001), and low FVHS (OR = 6.99; 95% CI, 1.78-27.46; *P* = .005) were independent predictors of large final infarction. The ASPECTS-DWI score on admission was found to be an independent variable associated with poor outcome in the present model.

**CLINICAL AND IMAGING OUTCOMES ACCORDING TO FVHS AND 24-HOUR RECANALIZATION STATUS**

For these analyses, patients with medium and high FVHSs were gathered and compared with the low-FVHS group. Low FVHS remained associated with poorer functional outcomes and larger final infarcts regardless of recanalization status. Patients with a low FVHS and a TIMI grade of 0 or 1 had the worst neurological and radiological prognoses, whereas those with a medium or high FVHS and a TIMI grade of 2 or 3 had the best outcomes. All patients with a low FVHS and a TIMI grade of 0 or 1 had poor functional outcomes, while 64.7% of patients with a low FVHS and a TIMI grade of 2 or 3 experienced poor functional outcomes (*P* = .02). Patients with a medium or high FVHS and a TIMI grade of 0 or 1 and those with a low FVHS and a TIMI grade of 2 or 3 had comparable outcomes (Table 3).

**COMMENT**

Our results demonstrated that low FVHS assessed on FLAIR sequences constituted an early independent predictor of large infarction and poor 3-month functional outcome for patients with M1-MCA occlusion. In our study, medium or high FVHS is a prerequisite for post-tPA favorable outcomes, regardless of early reperfusion status. The FVHS did not predict artery recanalization.

Increasingly, MRI is being used to evaluate and manage acute ischemic stroke within the first hours and might be more effective than computed tomography. On routine FLAIR sequences, blood vessels are normally dark, reflecting a loss of signal intensity in relation to rapid flow void. In the subarachnoid spaces, FVHs characterize the relative absence of normal flow void. They are consistent with hemodynamic impairment and slow retrograde collateral leptomeningeal blood flow in early ischemic stroke. Thus, FVHS could provide important information on early collateral circulation. Although the most frequent location is within the sylvian fissure, FVHS have been seen within MCA distal branches. Lee et al. found distal FVHS to be associated with large DWI-perfusion-weighted image mismatches for patients with MCA occlusion. Herein, we used a very simple point system to quantify FVHS by counting images showing them on standardized 5-mm-thick FLAIR sequences, focusing 10 FLAIR slices to allow quantification from the proximal temporal territory to distal parietal MCA territory.
including the sylvian fissure area. A rostrocaudal rating on transversal-section FLAIR images allowed an exhaustive assessment of FVH extension in the M1-MCA territory. This score can be obtained on routine MRI. Hence, its feasibility differs markedly from the MRI score that required perfusion analysis in the study by Lee et al. The FVHS interobserver agreement is good and physicians can score images at bedside.

No relationship could be established between FVHS and clinical variables at admission. In the narrow time-

### Table 1. Baseline Clinical and Radiological Characteristics in Patients With Low, Medium, and High Fluid-Attenuated Inversion Recovery Vascular Hyperintensity Scores

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low (n=34)</th>
<th>Medium (n=32)</th>
<th>High (n=39)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>66.1 (13.8)</td>
<td>67.2 (10.2)</td>
<td>66.8 (16.9)</td>
<td>.82</td>
</tr>
<tr>
<td>Men, No. (%)</td>
<td>16 (47.1)</td>
<td>17 (53.1)</td>
<td>22 (56.4)</td>
<td>.27</td>
</tr>
<tr>
<td>Arterial hypertension, No. (%)</td>
<td>24 (70.5)</td>
<td>17 (53.1)</td>
<td>23 (58.9)</td>
<td>.35</td>
</tr>
<tr>
<td>Diabetes, No. (%)</td>
<td>10 (29.4)</td>
<td>10 (31.2)</td>
<td>9 (23.1)</td>
<td>.74</td>
</tr>
<tr>
<td>Hyperlipidemia, No. (%)</td>
<td>5 (14.7)</td>
<td>7 (21.8)</td>
<td>3 (7.7)</td>
<td>.22</td>
</tr>
<tr>
<td>Smoking, No. (%)</td>
<td>4 (11.7)</td>
<td>7 (21.8)</td>
<td>5 (12.8)</td>
<td>.41</td>
</tr>
<tr>
<td>Atrial fibrillation, No. (%)</td>
<td>10 (29.4)</td>
<td>7 (21.8)</td>
<td>11 (28.2)</td>
<td>.78</td>
</tr>
<tr>
<td>Ischemic stroke etiology, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardioembolism</td>
<td>22 (64.7)</td>
<td>21 (65.6)</td>
<td>22 (56.4)</td>
<td>.64</td>
</tr>
<tr>
<td>Atherosclerosis</td>
<td>2 (5.8)</td>
<td>3 (9.3)</td>
<td>3 (7.7)</td>
<td>.88</td>
</tr>
<tr>
<td>Undetermined</td>
<td>10 (29.4)</td>
<td>10 (31.2)</td>
<td>12 (30.7)</td>
<td>.75</td>
</tr>
</tbody>
</table>

#### On admission, mean (SD) [range]

<table>
<thead>
<tr>
<th>BP, mm Hg</th>
<th>Systolic</th>
<th>161.3 (23.5) [110-214]</th>
<th>159.8 (24.1) [110-221]</th>
<th>163.0 (119.2) [123-211]</th>
<th>.84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diastolic</td>
<td>90.2 (16.0) [61-124]</td>
<td>91.8 (16.7) [61-129]</td>
<td>92.7 (14.8) [71-129]</td>
<td>.77</td>
<td></td>
</tr>
<tr>
<td>Temperature, °C</td>
<td>37.2 (3.3) [36.9-38.1]</td>
<td>37.3 (3.3) [36.9-38.1]</td>
<td>37.3 (3.3) [36.8-38.0]</td>
<td>.66</td>
<td></td>
</tr>
<tr>
<td>Glucose, mg/dL</td>
<td>131.5 (41.4) [86.5-234.2]</td>
<td>124.3 (27.0) [88.3-198.2]</td>
<td>122.5 (32.4) [77.5-216.2]</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>Hematocrit, %</td>
<td>42 (3.5) [37-51]</td>
<td>44 (4.1) [38-50]</td>
<td>41 (3.2) [39-52]</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td>NIHSS score</td>
<td>17.1 (4.3) [10-26]</td>
<td>15.5 (6.7) [4-26]</td>
<td>14.6 (5.9) [2-27]</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>Onset-to-MRI interval, mean (SD) [range], min</td>
<td>154 (59) [24-270]</td>
<td>133 (48) [60-270]</td>
<td>146 (60) [45-270]</td>
<td>.41</td>
<td></td>
</tr>
<tr>
<td>Onset-to-tPA interval, mean (SD) [range], min</td>
<td>209 (72.1) [80-360]</td>
<td>190 (54.1) [90-350]</td>
<td>206 (63.5) [105-360]</td>
<td>.26</td>
<td></td>
</tr>
<tr>
<td>≤3 h, No. (%)</td>
<td>13 (38.2)</td>
<td>17 (53.1)</td>
<td>18 (46.1)</td>
<td>.41</td>
<td></td>
</tr>
<tr>
<td>ASPECTS-DWI score at admission, mean (SD) [range]</td>
<td>4.18 (2.27) [0-10]</td>
<td>6.43 (2.13) [1-10]</td>
<td>6.38 (2.24) [1-10]</td>
<td>&lt;.001</td>
<td></td>
</tr>
</tbody>
</table>

#### SI conversion factor: To convert glucose to millimoles per liter, multiply by 0.0555.

### Table 2. Clinical and Radiological Outcomes According to Low, Medium, and High Fluid-Attenuated Inversion Recovery Vascular Hyperintensity Scores

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low (n=34)</th>
<th>Medium (n=32)</th>
<th>High (n=39)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mRS score at 3 mo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD) [range]</td>
<td>4.17 (1.97) [0-6]</td>
<td>2.43 (2.01) [0-6]</td>
<td>2.66 (2.46) [0-6]</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>&gt;2, No. (%)</td>
<td>28 (82.3)</td>
<td>14 (43.7)</td>
<td>17 (43.5)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ASPECTS-DWI score at 24 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD) [range]</td>
<td>3.24 (2.09) [0-8]</td>
<td>5.12 (2.04) [0-10]</td>
<td>5.25 (1.91) [0-8]</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>≤5 at 24 h, No. (%)</td>
<td>30 (88.2)</td>
<td>18 (56.2)</td>
<td>20 (51.3)</td>
<td>.002</td>
</tr>
<tr>
<td>TIMI grade 2 or 3, No. (%)b</td>
<td>17 (50.0)</td>
<td>21 (65.6)</td>
<td>25 (64.1)</td>
<td>.33</td>
</tr>
<tr>
<td>sICH, No. (%)</td>
<td>2 (8.8)</td>
<td>1 (3.1)</td>
<td>2 (5.1)</td>
<td>.54</td>
</tr>
</tbody>
</table>

#### Abbreviations: ASPECTS-DWI, Alberta Stroke Program Early CT Score applied to diffusion-weighted imaging; BP, blood pressure; FVHS, fluid-attenuated inversion recovery vascular hyperintensity score; MCA, middle cerebral artery; MRI, magnetic resonance imaging; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; tPA, tissue plasminogen activator.

### SI conversion factor: To convert glucose to millimoles per liter, multiply by 0.0555.

### Notes:

- Continuous values were analyzed with Kruskal-Wallis test; nominal values were compared with χ² test.

- The TIMI grades are as follows: 0 indicates no recanalization; 1, poor recanalization; 2, partial recanalization; and 3, complete recanalization.

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window analysis (4.5 hours), FVHS was not associated with the interval between stroke onset and admission MRI.

As previously described, high baseline NIHSS score, low baseline ASPECTS-DWI score, and no recanalization were strongly associated with poor 3-month functional outcomes and large final infarction. Patients with low FVHS assessed during the first 4.5 hours were more likely to have poorer clinical outcomes and larger final infarctions. In most studies, about one-third of patients with M1-MCA occlusion do not recruit significant collaterals. Consequently, patients with low FVHS (≤4) could represent our poor collateral circulation group, and our findings could be in accordance with studies that established the importance of collateral supply to predict final infarct volume. Although large baseline infarction was associated with poor outcomes, it was not found to be an independent variable in multivariate analysis when low FVHS was entered in the model. Having FVH has been reported as an early sign of hyperacute cerebral ischemia and may constitute an earlier predictor of final outcome than DWI hyperintensity.

Although it was previously suggested that angiography-assessed robust pial collaterals were associated with a higher thrombolysis reperfusion rate, we found no association between FVHS and TIMI status. Intravenous tPA reperfusion achievement rates in patients with low, medium, or high FVHS were comparable and accorded with smaller studies. The key factor of tPA efficacy against M1-MCA occlusion might rather be the clot.

We assessed the 24-hour reperfusion status, which constitutes a pivotal factor of clinical and radiological outcomes of ischemic stroke. We observed a significant outcome gradient between the 4 different collateral and recanalization status patterns, with patients who have a low FVHS and no recanalization having the worst clinical and radiological outcomes and those with a medium or high FVHS and recanalization achieving the best outcomes. Interestingly, the pattern of medium or high FVHS and no recanalization and the pattern of low FVHS and recanalization did not differ significantly in terms of functional outcomes and infarction sizes. These latter observations enhance the weight of FVHS as a factor predictive of occluded M1-MCA outcomes. The FVHS assessed during the first 4.5 hours may reflect the rapid recruitment of collaterals occurring after M1-MCA occlusion.

In patients with recanalization, adequate collateral circulation helps prevent or limit cerebral infarct extension until recanalization leads to ischemic penumbra reperfusion. In cases with no recanalization, the best outcomes of the medium- to high-FVHS group could be explained by secondary gradual collateral recruitment during the first 24 hours, which might limit infarction size and consequently neurological symptoms. All patients with a low FVHS and no recanalization experienced poor functional outcomes, while two-thirds of patients with a low FVHS and recanalization had poor functional outcomes (P = .02). As a computed tomographic angiography study recently demonstrated, our data highlight the strong interaction between FVHS and recanalization status in predicting clinical and radiological outcomes after M1-MCA occlusion. Thus, reperfusion seems essential in patients with a low FVHS, thereby justifying intensive emergency treatment such as a combined intravenous-endovascular therapy that usually has a higher rate of recanalization than intravenous recombinant tPA alone.

Our study has some limitations. As a retrospective monocenter analysis concerning a homogeneous ethnic, Afro-Caribbean population, potential patient selection bias is possible. Conversely, our study’s power is based on inclusion site homogeneity and systematic recanalization status assessment at 24 hours. The large analyzed cohort provides objective information on the relationship among FVHS, recanalization, and ultimate outcomes.

For patients with early acute ischemic stroke and M1-MCA occlusion, FVHS characterized an independent surrogate marker of functional outcomes. Low FVHS is clearly associated with larger final infarctions and poorer functional outcomes than medium or high FVHS. This association remains constant regardless of recanalization status at 24 hours. An intensive reperfusion approach including endovascular therapy is mandatory for patients with a low FVHS and M1-MCA occlusion.


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