The Susceptibility Vessel Sign of the Middle Cerebral Artery on the T2*-Weighted Gradient Echo Imaging: Semi-quantification to Predict the Response to Multimodal Intra-Arterial Thrombolysis

Sung Won Youn, M.D., Cheolkyu Jung, M.D.2, Byung Se Choi, M.D.2, Jae Hyoung Kim, M.D.2, O-Ki Kwon, M.D.3, Moon-Ku Han, M.D.4, Hee-Joon Bae, M.D.4, Bae Ju Kwon, M.D.5, Moon Hee Han, M.D.6

Purpose: We wanted to determine whether or not the “susceptibility asymmetry index” (SAI) of acute stroke on the T2*-weighted image is related with successful recanalization using multimodal intra-arterial thrombolysis (IAT).

Materials and Methods: The 81 patients who underwent multimodal IAT for middle cerebral artery (MCA) territory acute stroke were included in this retrospective study. The multimodal IAT included intra-arterial urokinase infusion, clot disruption by a microwire, microcatheter and balloon manipulation, and balloon angioplasty and/or stenting for the flow-limiting stenosis. The diameter of the susceptibility vessel sign was measured on the T2*-weighted gradient echo imaging (GRE), and the diameter of the contralateral normal MCA at the corresponding level was measured on magnetic resonance angiography (MRA); the ratio between these two diameters was defined as the susceptibility asymmetry index. The relation between the TICI (Thrombolysis In Cerebral Infarction) score of 2–3 after multimodal IAT and the SAI was assessed. The receiver operating characteristic (ROC) curve analysis was performed on the SAI to predict a TICI score of 2–3 after multimodal IAT.

Results: The mean SAI of 81 patients was 1.66 ± 0.66. Seventy nine percent of the patients had a TICI of 2–3 after multimodal IAT. According to the ROC curve analysis, an SAI less than 1.3 was optimal for predicting the presence of stenotic lesion after recanalization (area under the curve: 0.821, sensitivity: 88.2%, specificity: 69.8%, p = 0.0001), and the SAI ≤ 1.61 (area under the curve: 0.652, sensitivity: 60.9%, specificity: 70.6%, p = 0.0226) could predict a TICI score of 2–3. The TICI score of 2–3 after multimodal IAT was achieved in 88.6% of the cases with a SAI ≤ 1.61 and in 67.6% of the cases with a SAI > 1.61 (p = 0.028).

Conclusion: The lower SAI on T2*-GRE could predict stenotic lesion and successful recanalization after performing IAT.

Index words: Stroke, Magnetic Resonance Imaging, Middle Cerebral Artery, Thrombolytic Therapy
Magnetic resonance imaging of acute ischemic stroke has played a key role in the triage of the candidates who will potentially receive thrombolysis [1]. Several studies on T2*-weighted gradient echo imaging (GRE) have shown its feasibility for the more sensitive detection and the characterization of occluding clots in patients with acute ischemic stroke [2-5]. Several authors have evaluated whether the susceptibility vessel sign on T2*-GRE (GRE-SVS) could discriminate the stroke subtype and if it had a relationship with the recanalization of the occluded artery after thrombolytic therapy [2-7]. It has been suggested that the GRE-SVS was observed in 77.5% of cardioembolic stroke patients [3], and the mean thrombolysis in myocardial infarction (TIMI) grade was higher in the positive GRE-SVS group (81%) than that of the group with a negative GRE-SVS (24%) [5].

Previous studies that have focused on the relationship between a GRE-SVS and the response to intravenous or intra-arterial thrombolysis have analyzed the GRE-SVS as a positive or negative sign without any quantification [2, 4]. A GRE-SVS might partly reflect the composition of the clot rather than its source [8, 9]. In a previous animal study, a plaque-rupture-related thrombosis, which was confirmed histologically to have many platelets and fibrin, exhibited a small degree of paramagnetism on T2*-GRE [10]. However, the analysis of the retrieved thrombi from the acutely occluded cerebral artery supported that the composition of thrombi did not show a difference between the thrombi of cardiac and atheroma origins; the cardiac emboli may be composed of various degrees of erythrocytes, and a platelet-rich thrombi may be covered with fresh erythrocyte-rich materials [11]. Therefore, it was also thought that the degree of a GRE-SVS could have an influence on the response of thrombolytic therapy. Therefore, this current study tried to determine, in a semi-quantitative manner, whether the susceptibility vessel sign of the middle cerebral artery (MCA) seen on T2*-GRE is related with the response to multimodal intra-arterial thrombolysis (IAT).

Materials and Methods

Patients

Our institutional review board approved this retrospective study, and informed consent was waived. From January 2005 to January 2007, 108 patients underwent multimodal IAT for hyperacute stroke. The 12 patients with stroke of the posterior circulation, the 2 patients without preprocedural MR and the 13 patients with involvement of any anterior cerebral artery (ACA) territory were excluded. A total of 81 patients (47 men and 34 women; mean age ± standard deviation (SD), 67.6 ± 12.2 years, range, 37-95 years) who underwent multimodal IAT for MCA territory acute stroke alone were included in this study (Fig. 1). On the diffusion-weighted imaging (DWI), there were 23 patients with basal ganglia or perforator lesion alone, 31 patients with cortical MCA lesion alone and 22 patients with both basal ganglia and cortical lesion. Five had no diffusion restriction, but they had perfusion abnormality. The major indications for intra-arterial thrombolysis included either of the following criteria: 1) an acute stroke with a diffusion-perfusion mismatch more than 20% and 2) a DWI lesion in less than 50% of the MCA territory, less than 6 hours after the onset of symptoms. The presence of intracranial hemorrhage was excluded by noncontrast CT or T2*-GRE.

Fig. 1. Inclusion of the patients who underwent intra-arterial thrombolysis (IAT) for acute middle cerebral artery (MCA) stroke from January 2005 to January 2007. DWI = diffusion-weighted imaging, T2* GRE = T2*-weighted gradient echo imaging, MRA = magnetic resonance angiography, MCA = middle cerebral artery, ICAT = internal carotid artery terminal, p-MCAs = proximal middle cerebral artery, d-MCAs = distal middle cerebral artery, M2 = M2 segment of the MCA, DSA = digital subtraction angiography, IV-IA = intravenous-intra-arterial thrombolysis
Clinical Evaluation and the Stroke Subtype

The last time that the patients were known to be free of a deficit was used as the time of stroke onset. The National Institutes of Health Stroke Scale (NIHSS) score at baseline and 24 hours was assessed by neurology trainees and faculties to measure the stroke severity and the immediate response to multimodal IAT. The modified Rankin Scale (mRS) score was determined to evaluate the functional outcome at 3 months after multimodal IAT.

The stroke subtype was classified as cardioembolism, artery-to-artery embolism, in-situ thrombosis on stenosis or an undetermined etiology (7, 12). The criteria used to identify a cardioembolism were prophylactic use of warfarin in patients with cardiac diseases, atrial fibrillation seen on an electrocardiogram (ECG) and a patent foramen ovale or thrombus on echocardiography. A significant stenosis of the carotid artery as a source for an artery-to-artery embolism was defined as more than 50% stenosis and with another source of embolism not being detected on any imaging studies (12). An in-situ thrombosis on a stenosis was established when more than 50% of the residual luminal narrowing of the MCA stem or branches was detected during IAT before balloon angioplasty and/or stenting (12, 13). The appearance of luminal narrowing had no typical findings of arterial dissection such as a string-beaded appearance and an intimal flap with a false lumen.

Symptomatic hemorrhage was defined as hemorrhagic transformation with an NIHSS score increment of more than 4 within 36 hours of ictus (14, 15).

MRI Protocols and Image Analysis

The acute-stroke magnetic resonance imaging (MRI) consisted of T2* GRE, DWI, three-dimensional (3D) time-of-flight (TOF) magnetic resonance angiography (MRA) and perfusion imaging. Acute-stroke MRI was conducted on two 1.5-T MRI units (Intera, Philips Medical Systems, Best, The Netherlands; and Sonata, Siemens Medical Solutions, Erlangen, Germany). The parameters for T2* GRE were TR/TE: 700 ms/23 ms, flip angle: 18°, slice thickness: 5 mm and matrix: 256 × 205 for the Intera, and TR/TE: 865 ms/26 ms, flip angle: 20°, slice thickness: 5 mm and matrix: 256 × 167 for the Sonata. The parameters for DWI were TR/TE: 4,000–5,000 ms/56–65 ms for the Intera and 4,000 ms/73 ms for the Sonata, b values: 0 and 1,000 ms/mm², slice thickness: 5 mm and matrix, 128 × 128. The parameters for 3D TOF MRA were TR/TE: 23 ms/6.9 ms, slice thickness: 0.5 mm, matrix: 256 × 256 interpolated to 512 × 512, number of slabs: 5, the total number of slices: 140 for the Intera [Philips Medical Systems, Best, The Netherlands], TR/TE: 37 ms/7.2 ms, slice thickness: 1mm, matrix: 512 × 176, number of slabs: 5 and the total number of slices: 140 for the Sonata [Siemens Medical Solutions, Erlangen, Germany].

The diameter of the GRE-SVS was averaged among the value measured with a digital ruler three times with using the two or three-fold magnified images on a picture archiving and communication system (PACS) and the diameter of the contralateral normal MCA at the corresponding level on MRA was measured from the MIP reconstruction using the same method; the ratio between these two diameters was defined as the susceptibility asymmetry index (SAI) (Fig. 2). The site of measurement of the GRE-SVS was only one lesion with the maximal diameter of the GRE-SVS in the largest artery of the occluded arteries. Two neuroradiologists (S.W.Y. J Korean Soc Radiol 2011;64:1-9

Fig. 2. The definition of the susceptibility asymmetry index (SAI). The diameter of the susceptibility vessel sign on the T2*-GRE (A; white double arrow) and that on the contralateral normal middle cerebral artery at the level corresponding to the MRA (B; black double arrow) is measured. SAI = A / B . The patient was the 70-year-old male with acute left MCA occlusion and atrial fibrillation. The SAI was measured as 2.92. After mechanical disruption with wire and balloon, the occluded MCA was not recanalized.
and K.J.H. with more than 5 years and 20 years of experience, respectively) who were ‘blinded’ to the results of cerebral angiography performed the image analysis by working in consensus.

**Intra-Arterial Thrombolysis**

The angiographic assessment for the collateral grade and TICI (Thrombolysis In Cerebral Infarction) perfusion grade was based on the standards for trial design and reporting (16). Successful recanalization was defined as the recanalization with a TICI grade equal to or more than 2A. The site of occlusion was classified as an internal carotid artery terminus (ICAT), a proximal MCA stem without bifurcation involvement (p-MCAs), a distal MCA stem with bifurcation involvement (d-MCAs) or an M2 segment beyond the bifurcation. The methods of multimodal IAT included intra-arterial urokinase infusion, clot disruption by a microwire, a microcatheter and balloon manipulation, and balloon angioplasty and/or stenting for the flow-limiting stenosis. In the case of a suspected stenotic lesion after multimodal IAT, a neurointerventionist judged whether or not to perform subsequent angioplasty case by case (HMH, KBJ and KOK with 24, 6 and 10 years of experience, respectively).

**Statistical Analysis**

The SAI was subjected to receiver operating characteristic (ROC) curve analysis (MedCalc 7.2, MedCalc, Mariakerke, Belgium) for the TICI2-3 after multimodal IAT. Among the variables associated with the SAI on T2* GRE, the continuous variables were subjected to comparison of means by independent t-tests, and cross-table analysis using Fisher’s exact test was performed between the groups with lower and higher SAI values (SPSS for Windows, version 12.0, SPSS, Chicago, IL, USA). The variables were also subjected to comparison of means or cross-table analysis between the groups with and without successful recanalization using multimodal IAT. The data is presented as means ± SD values, and the level of statistical significance was set at p values <0.05.

**Results**

**Clinical Evaluation, the Site of Occlusion and the Stroke Subtype**

The mean ± SD time from stroke onset to MR imaging was 207 ± 108 minutes (range: 52–1006) and the baseline NIHSS score was 13.8 ± 6.5 (mean ± SD). The time from stroke onset to IAT was 274 ± 109 (range: 64–657).

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**Fig. 3.** The receiver operating characteristic [ROC] curve analysis between the susceptibility asymmetry index [SAI] and the presence of stenotic lesion [A], and between the SAI and successful recanalization [B].

A. The SAI ≤ 1.3 is optimal for predicting the presence of stenotic lesion (asterisk: area under the curve = 0.821, sensitivity: 88.2%, specificity: 69.8%, p = 0.0001).

B. Successful recanalization is optimally predicted by a SAI ≤ 1.61 (sharp the area under the curve = 0.652, sensitivity: 60.94%, specificity: 70.59%, p = 0.0226).
The occlusion sites were located at the ICAT in 12 patients (14.8%), the p-MCA in 27 patients (33.3%), the d-MCA in 33 patients (40.7%) and the M2 segment in 9 patients (11.1%). Tandem lesions were observed in nine patients. Six of the nine patients with tandem lesions were related to carotid atherosclerosis and concomitant involvement of the ICAT \( (n=2) \), p-MCA \( (n=1) \), d-MCA \( (n=2) \) and M2 \( (n=1) \), respectively. A concomitant clot in the p-MCA and distal ICA without terminus involvement was found in one patient, and two patients had lesions in the p-MCA and M2.

The stroke subtype was determined as cardioembolism in 58.0% \( (47/81) \), in-situ thrombosis on stenosis in 21.0% of the patients \( (17/81) \), artery-to-artery embolism in 7.4% of the patients \( (6/81) \) and as being of an undetermined etiology in 13.6% \( (11/81) \) of the patients. Those with cardioembolism included 14 patients who had used warfarin as a treatment for cardiac disease, 39 in whom atrial fibrillation was observed on ECG and 29 in whom thrombi were observed on echocardiography.

**The Angiographic Outcome of Multimodal IAT**

An average of 251,600 ± 196,700 IU of urokinase was administered per patient. Abciximab in 18 patients (22.2%) and tirofiban in 10 patients (12.3%) were administered intra-arterially as an adjuvant agent for IAT or before balloon angioplasty or stenting.

Seventy four percent \( (64/81) \) of all the patients had a TICI score of 2–3 after multimodal IAT. Seventy three point four percent \( (47/64) \) of the patients with a TICI score of 2–3 only received intra-arterial urokinase infusion and clot disruption via a microwire and micro-catheter manipulation, and 26.6% \( (17/64) \) underwent clot disruption and angioplasty by balloon alone \( (n=7) \), a balloon and a stent \( (n=7) \) or a stent alone \( (n=3) \). Stenotic lesion after recanalization was detected in 26.6% \( (17/64) \) of the group that had a TICI score of 2–3.

**The Susceptibility Asymmetry Index and Stenotic Lesion After Recanalization**

The mean SAI of the stenotic group was statistically different from that of the non-stenotic group \( [\text{mean SAI } \pm \text{ SD: } 1.12 \pm 0.24 \text{ in the stenotic group and } 1.81 \pm 0.67 \text{ in the non-stenotic group, } p = 0.000] \). Eighteen point five percent of all the patients were negative for a GRE-SVS if a negative GRE-SVS was defined as a SAI equal to or less than 1.0. The SAI less than 1.3 was optimal for predicting the presence of stenotic lesion after recanalization \( \text{area under the curve: } 0.821, \text{ sensitivity: } 88.2\%, \text{ specificity: } 69.8\%, p = 0.0001 \). Eighty-eight point of all the patients were negative for a GRE-SVS if a negative GRE-SVS was defined as a SAI equal to or less than 1.0. The SAI less than 1.3 was optimal for predicting the presence of stenotic lesion after recanalization \( \text{area under the curve: } 0.821, \text{ sensitivity: } 88.2\%, \text{ specificity: } 69.8\%, p = 0.0001 \) (Fig. 3A). A SAI less than 1.3 was observed in 38.3% \( (31/81) \) of all the patients, and a SAI less than 1.3 was observed in 88.2% \( (15/17) \) of the patients with stenotic lesion (Fig. 4). Forty-eight point four percent \( (15/31) \) of the patients with a SAI of
The mean SAI was 1.66 ± 0.66 (range: 0.8 to 3.7). The mean SAI of the group with a TICI score of 2–3 after multimodal IAT was not statistically different from that of the group with a TICI score of 0–1 after IAT (1.61 ± 0.68 versus 1.86 ± 0.59, respectively, \( p = 0.171 \)). If the stenotic group \( (n = 17) \) was excluded, then the mean SAI of the group with a TICI score of 2–3 was also not statistically different from that of the group with a TICI score of 0–1 (1.78 ± 0.69 versus 1.90 ± 0.58, respectively, \( p = 0.525 \)). The SAI equal to or less than 1.6 predicted a TICI score of 2–3 after multimodal IAT, on the ROC curve [area under the curve: 0.652, sensitivity: 60.9%, specificity: 70.6%, \( p = 0.0226 \)] (Fig. 3B). Eighty-eight point three percent (88.6%) of the patients with a TICI score of 0–1 had a SAI equal to or less than 1.6. If the SAI was greater than 1.6, there was no meaningful ROC curve with an area under the curve above 0.5 for the non-stenotic group [area under curve: 0.418].

### Discussion

The susceptibility vessel sign on T2*-GRE (GRE-SVS) has been useful for detecting intra-arterial clots [2–5]. The thrombi from the heart are known as “erythrocyte-rich thrombi”, and they are produced within slow flow, and these thrombi are expected to have a greater GRE-SVS. Some clinical studies have reported that the GRE-SVS is a predictor of cardioembolism [3]. In this study, an SAI less than 1.3 was optimal for predicting stenotic lesion. Forty-eight point four percent of the patients with a susceptibility asymmetry index of less than 1.3 and only 4.0% of the patients with a susceptibility asymmetry index above 1.3 had underlying stenosis. So, the stenotic lesions also had a GRE-SVS for our results, although their SAI was lower than that of the non-stenotic lesions. Some studies have reported that the thromboemboli retrieved from the cerebral arteries of acute stroke patients showed no significant differences in their composition of fibrin, platelets and leukocytes, as compared to that derived from cardiac and atherosclerotic sources [11]. Thus, we can assume that a lesser

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### Table 1. Comparison of the Patients with a Susceptibility Asymmetry Index of Less than and More than 1.61 on the T2* GRE. The Data is Presented as the Percentage [Number] [%\(n\)] or Means ± SDs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Susceptibility Asymmetry Index</th>
<th>( \leq 1.61 )</th>
<th>( &gt; 1.61 )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, % (( n ))</td>
<td></td>
<td>54.3 [44]</td>
<td>45.7 [37]</td>
<td>n.a.</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>66.8 ± 13.4</td>
<td>68.6 ± 10.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td>47.7 [21]</td>
<td>35.1 [13]</td>
<td>0.269</td>
</tr>
<tr>
<td>Baseline NIHSS score</td>
<td></td>
<td>13.89 ± 6.16</td>
<td>13.62 ± 6.93</td>
<td>0.856</td>
</tr>
<tr>
<td>Time lapsed from symptom onset to</td>
<td></td>
<td>227 ± 122</td>
<td>183 ± 85</td>
<td>0.069</td>
</tr>
<tr>
<td>the initial MRI (minute)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collateral grade 3–4, % (( n ))</td>
<td></td>
<td>36.4 [16]</td>
<td>35.1 [13]</td>
<td>1.00</td>
</tr>
<tr>
<td>Total urokinase dosage, IU</td>
<td></td>
<td>262.1 ± 217.4</td>
<td>239.2 ± 171.0</td>
<td>0.598</td>
</tr>
<tr>
<td>Stenosis after IAT, % (( n ))</td>
<td></td>
<td>36.4 [16]</td>
<td>2.7 [1]</td>
<td>( &lt; 0.0001 )</td>
</tr>
<tr>
<td>TICI 2–3 after IAT, % (( n ))</td>
<td></td>
<td>88.6 [39]</td>
<td>67.6 [25]</td>
<td>0.028</td>
</tr>
<tr>
<td>Cardioembolism, % (( n ))</td>
<td></td>
<td>47.2 [21]</td>
<td>70.3 [26]</td>
<td>0.046</td>
</tr>
<tr>
<td>Symptomatic hemorrhage, % (( n ))</td>
<td></td>
<td>11.4 [5]</td>
<td>16.2 [6]</td>
<td>0.537</td>
</tr>
<tr>
<td>3 months mRS ≤2, % (( n ))</td>
<td></td>
<td>54.5 [24]</td>
<td>59.5 [22]</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Note.—%: percentage within the respective group with a SAI lower/higher than 1.61, \( n \): number of patients, IAT: intra-arterial thrombolysis, Collateral grade 3–4: collaterals with either slow or rapid complete angiographic blood flow of the entire ischemic bed, TICI 2–3: Thrombolysis in Cerebral Infarction perfusion categories 2 and 3, Symptomatic hemorrhage: hemorrhage with an NIHSS score that increased more than 3 within 36 hours of ictus, 3 mRS: the modified Rankin Scale at 3 months after IAT (Statistically significant was set at \( p < 0.05 \)).
GRE-SVS, but not negativity for the GRE-SVS, in patients with stenotic lesion would be related to different compositions of a thrombus, so that semi-quantification of the GRE-SVS with the SAI could be more accurate to predict stenotic lesion than a positive or negative GRE-SVS.

The GRE-SVS predominantly reflects the paramagnetic effect of intracellular deoxyhemoglobin, which indicates the acute stage of a thrombus [17–19]. A large decrease of the T2* signal was reported in the presence of serum-rich clots (entrapmed serum) with a heterogeneous structure, which is in contrast to an increased signal in the presence of retracted or serum-poor clots with a homogeneous structure [9]. The extent and intensity of the GRE-SVS can change with recanalization or structural modifications of the thrombus [20]. So, the GRE-SVS seems to reflect the stage and internal structure of a thrombus, including the cellular composition, which may explain the different degrees of a GRE-SVS and the different responses to multimodal IAT.

In this study, we observed that the SAI on T2*-GRE equal to or less than 1.6 is associated with successful recanalization using multimodal IAT. The result of this study could be misunderstood because it is contradictory to the previous report that the patients who have cardioembolism with the MCA susceptibility sign showed a more favorable response to IAT [5]. Kim et al. defined a GRE-SVS as the presence or absence of hypointensity within the affected MCA and this is larger than that within the contralateral MCA, but we grouped the patients according to the semi-quantification of the GRE-SVS as the SAI. So it was difficult to compare between their study and our study. They also treated all the selected patients with IA urokinase infusion only without mechanical thrombolysis and their patients included a large proportion of cases with a negative GRE-SVS [52%] with a low mean postthrombolytic thrombolysis in myocardial infarction (TIMI) grade [5], while our study included 18.5% of all the patients with a negative GRE-SVS if a negative GRE-SVS was defined as a SAI equal or less than 1.0. Therefore, they suggested there was a different response to thrombolitics between the positive and negative GRE-SVSs. The large proportion of negative GRE-SVSs could mean that a larger proportion of underlying stenotic lesions requiring balloon angioplasty could have been included in their study, so that a low TIMI grade seemed to be achieved with a simple IA urokinase infusion. Although it was the limited study, Ueda et al showed the technical feasibility of performing intracranial angioplasty in patients with acute ischemic stroke [13]. They showed a 100% technical success rate of intracranial angioplasty for MCA lesion and 77% improvement in the National Institutes of Health (NIH) stroke score after treatment. We thought that more successful recanalization for the cases that are intolerable to the thrombolytics or those cases with stenocclusive lesion could be achieved by mechanical thrombolysis such as mechanical thrombus disruption, balloon angioplasty and/or stenting in our patients, while simple IA-uurokinase infusion alone was performed in the previous reports [5].

This is first suggestion of the GRE-SVS being a semi-quantitatively measured as the the SAI to reduce the ambiguity of visual inspection, and this is also the first trial to relate the SAI with a response to multimodal IAT. However, there are several limitations in our study. First, this is a retrospective study and the methods of IAT were not randomized, which could have limited the statistical significance. The dosage of urokinase, the use of combined platelet inhibitor, the techniques of mechanical clot disruption and the use of balloon angioplasty and/or stenting for stenotic lesion, which were all chosen case by case for achieving better TICI grades, might have affected the recorded recanalization outcomes. Second, stenotic lesion could be evaluated on DSA only when a TICI score of 2 was achieved. An occlusion from an atherosclerotic origin, if this ever happens, can be missed when a TICI score of 0–1 is noted. Most of all, stenosis cannot be simply postulated to be the results of atherosclerotic narrowing. The stenotic lesions seen on DSA after IAT may include several heterogeneous lesions other than ruptured atheroma, which produces platelet-rich thrombi: unruptured atheroma that caught hold of an embolus, a repeatedly generated or adherent thromboembolus that was resistant to IAT and arterial dissection that is related to wire disruption or as the initial presentation of an acute stroke. The confirmative analysis of plaque was not performed in this study, and the origin of underlying stenosis remains to be classified in further studies. Third, small-sized thrombi could have been missed on the T2* GRE since the scanning thickness used [5 mm] is larger than the diameter of a normal MCA stem. The optimal scan thickness for delineating the entire horizontal MCA should be determined in further studies. Fourth, the length of the vessel with the positive GRE-SVS was not considered, and this could also affect the results of IAT [21].

In conclusion, a lower SAI on T2*-GRE seems to be
related to underlying stenosis of the MCA and a higher recanalization rate. Therefore, the GRE-SVS of acute MCA stroke on T2*-GRE, which is shown as the SAI, may help determine the technical strategy of IAT by anticipating the recanalization due to infusion of intra-arterial fibrinolytics and clot disruption.

References

Sung Won Youn, et al.: The Susceptibility Vessel Sign of the Middle Cerebral Artery on the T2*-Weighted Gradient Echo Imaging
T2* 강조영상에서 보이는 중뇌동맥의 혈관자화징후: 다중방식 동맥내 혈전용해술 후 재개통 예측을 위한 반정량화

대구가톨릭대학교병원 영상의학과
부산대학교병원 영상의학과
분당서울대학교병원 신경외과
분당서울대학교병원 신경과
광동대학교 명지병원 영상의학과
서울대학교병원 영상의학과

윤성원∙정철규2∙최병세2∙김재형2∙권오기3∙한문구4∙배희준4∙권배주5∙한문희6

목적: 급성 뇌경색의 T2* 경사자장영상에서 "자화율비대칭지수(susceptibility asymmetry index, 이하 SAI)"가 다중방식 동맥내 혈전용해술의 재개통율과 관계가 있는지를 알아보고자 한다.

대상과 방법: 중뇌동맥 영역의 급성뇌경색 환자에서 다중방식 동맥내 혈전용해술을 시행한 81명의 환자에 대해서 후향적 분석을 하였다. 다중방식 동맥내 혈전용해술은 동맥내 유로키나아제 주입, 미세철사, 미세도관 및 풍선을 이용한 혈전분해, 혈류장애를 일으키는 협착에 대한 전산 혈관영상술 및 스텐트 설치술을 포함한다. T2* 경사자장영상에서 혈관자화징후의 직경과 자기공명혈관촬영(MRA)에서 상응하는 반대측 정상 혈관의 직경의 비를 자화율비대칭지수로 정의하였다. 동맥내 혈전용해술과 자화율비대칭지수와의 관계를 평가하였다.

결과: 81명 환자의 자화율비대칭지수의 평균 1.66 ± 0.66이었다. 수신자판단특성곡선 분석에 의하면 SAI가 1.3 미만에서 협착성 병변은 잘 예측할 수 있었고 (곡선아래면적, 0.821; 예민도, 88.2%; 특이도, 69.8%, p=0.0001). 자화율비대칭지수 1.61 이하인 경우에 높은 재개통율을 예측할 수 있고(곡선아래면적, 0.652; 예민도, 60.9%; 특이도, 70.6%; p=0.0226), 1.61 초과인 경우 환자의 88.6%의 경우다중방식 동맥내 혈전용해수술 TICI 2-3의 재개통을 시킬 수 있었다 (p=0.028).

결론: T2* 경사자장영상에서 자화율비대칭지수가 낮은 경우에 혈관성 병변을 예측할 수 있고, 다중방식 동맥내 혈전용해술로 좀 더 높은 재개통율을 보일 수 있다.