Patients with acute neurological symptoms: simultaneous evaluation of carotid MPRAGE and brain MRI

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Purpose

Backgrounds

Ischemic stroke is a major cause of morbidity and mortality in old age population. Atherosclerosis at carotid arteries is well known risk factor of ischemic stroke and transient ischemic attack. Many factors such as intraplaque hemorrhage, lipid core, necrotic core, ulceration and fibrous cap disruption may contribute to carotid atherosclerotic plaque instability. According to the American Heart Association, atherosclerotic plaque can be classified histopathologically as follows (1-2).

* Modified AHA Classification of atherosclerotic plaque
- Type I-II : Type I-II: near-normal wall thickness, no calcification
- Type III: diffuse intimal thickening or small eccentric plaque with no calcification
- Type IV-V: plaque with a lipid or necrotic core surrounded by fibrous tissue with possible calcification
- Type VI: complex plaque with possible surface defect, hemorrhage, or thrombus
- Type VII: calcified plaque
- Type VIII: fibrotic plaque without lipid core and with possible small calcifications

The type VI plaque, especially intraplaque hemorrhage is associated with ipsilateral acute ischemic stroke of transient ischemic attack(3). In former days, to detect a carotid source, patients usually undergo carotid duplex ultrasound scan, CT angiography and conventional MRA. Recently Carotid intraplaque can be accurately detection with magnetization-prepared rapid acquisition with gradient-echo (MPRAGE) sequence (4-6).

Purpose

The purpose of our study was to assess the associations between cerebral ischemic events and intraplaque hemorrhage identified by MPRAGE sequence in patients with acute neurologic symptoms.
Methods and Materials

Patients selection

After the addition of the MPRAGE sequence to the routine brain MRI/MRA protocol since April 2012, 116 patients were evaluated with routine brain MRI/MRA protocol including brain diffusion weighted imaging (DWI) and carotid MPRAGE sequences over 3 months. 116 patients provided 232 carotid artery and paired brain images for analysis. Twenty-two arteries were excluded due to poor image quality, forty-six arteries were excluded due to absent of acute neurologic symptoms and 38 arteries were excluded due to extracarotid stenotic lesions. 126 arteries were eligible for data analysis.

Image analysis

MPRAGE detected intra plaque hemorrhage was defined by at least 1 image slice with at least 200% higher signal intensity compared to sternocleidomastoid muscle(4). DWI was used to determine whether acute cerebral ischemic event was present and ipsilateral diffusion restriction with decreased signal on ADC map defined as ischemic event. Carotid plaque was detected using contrast enhanced MR angiography. Detected plaque lesions categorized into two groups, according to North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria. Low grade stenosis group was defined by 0%-50% stenosis and high grade stenosis group was defined by 51%-99% stenosis. Images of the carotid artery and brain for this clinical study were obtained on a Achieva 3.0 T MRI.

Image parameters

Image parameters of MPRAGE sequence were as follows

- TR / TE / TI= 8.7 / 5.3 / 800 ms
- Field of view = 140 x 140
- Matrix= 256 x 256
- Voxel= 0.5 x 0.5 x 1 mm³
- Slice thickness= 2.0 mm

Statistical analysis

Fisher exact test was used for statistical significance of associations between carotid MPRAGE signal and DWI stroke status. The relative risk of cerebral ischemic event in MPRAGE positive plaque was evaluated.
Results

Of 126 arteries, 32 (25.4%) had a carotid artery plaque based on contrast-enhanced MR angiography. Of these 32 arteries, 23 had carotid artery stenosis less than 50% and 9 arteries had stenosis more than 50%.

In all 126 carotid arteries, MRI-predicted intraplaque hemorrhage was found in 7.9% (10/126) (refer to Fig 1.) and high-signal intensity on DWI was found in 14.3% (18/126). Combined lesion with ipsilateral high-signal intensity on DWI and IPH on carotid MPRAGE sequence was found in 3 lesions (3/136, 2.5%). The calculated relative risk is 2.6 (p=0.119) which means the risk of ischemic event with diffusion restriction in MPRAGE positive patients is 2.6 times higher than MPRAGE negative patients. (refer to table 1, figure 2)

Of 32 patients with carotid artery plaque, MR-predicted IPH was found in 31.3% (10/32) and matched lesions with high-signal intensity on DWI and MPRAGE was found in 9.4% (3/32). Relative risk between carotid MPRAGE-positive signal and ipsilateral high-signal intensity on DWI in arteries with carotid artery plaques was 6.6 (p = 0.079). It means, when we confine within the stenotic arteries, patients with MPRAGE positive lesions have 6.6 times higher risk of developing a cerebral ischemic event. (refer to table 2)

According to NASCET criteria, the stenotic lesions classified into two groups. The low grade stenosis group was 26 and the high grade stenosis group was 9. MR-predicted IPH was significantly higher prevalence in high-grade stenosis group (4/26 vs. 6/9, p = 0.023). (refer to table 3)
Fig. 1: MPRAGE sequence image of high signal intensity in Rt carotid artery demonstrates intraplaque hemorrhage.

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**Fig. 2:** 73 year old male patient with Dysarthria undergo routine MRI/MRA protocol, there are high signal intensity on both carotid arteries combined with diffusion restriction on Rt thalamus.

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### MPRAGE-predicted IPH of Total Carotid Arteries

<table>
<thead>
<tr>
<th>MPRAGE- predicted IPH</th>
<th>Total 126 carotid arteries</th>
<th>DWI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( + )</td>
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<tr>
<td>( + )</td>
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<td>3</td>
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<tr>
<td>( - )</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td><strong>Relative risk</strong></td>
<td></td>
<td><strong>2.6</strong></td>
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<tr>
<td><strong>P value (2-tailed)</strong></td>
<td></td>
<td>0.119</td>
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</tbody>
</table>
Table 1: In all 126 carotid arteries, MRI-predicted intraplaque hemorrhage was found in 7.9% (10/126) and high-signal intensity on DWI was found in 14.3% (18/126).

Table 2: Of 32 patients with carotid artery plaque, MR-predicted IPH was found in 31.3% (10/32) and matched lesions with high-signal intensity on DWI and MPRAGE was found in 9.4% (3/32).
**MPRAGE and DWI Findings as Degree of Carotid Artery Stenosis**

<table>
<thead>
<tr>
<th></th>
<th>&lt; 50% stenosis (n = 26)</th>
<th>&gt; 50% stenosis (n = 9)</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPRAGE-predicted IPH</td>
<td>4 (17.4%)</td>
<td>6 (66.7%)</td>
<td>0.023</td>
</tr>
<tr>
<td>DWI restriction</td>
<td>2 (8.7%)</td>
<td>2 (22.2%)</td>
<td>0.642</td>
</tr>
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</table>

**Table 3:** MR-predicted IPH was significantly higher prevalence in high-grade stenosis group (4/26 vs. 6/9, \( p = 0.023 \)).

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Conclusion

Carotid MPRAGE-positive signal was associated with an increased risk of territorial cerebral ischemic events as detected objectively by brain DWI. The relative risk of stroke was increased in high-grade stenosis categories.
References


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