Identification of Recent Lacunar Lesions in Cases of Multiple Small Infarctions by Magnetic Resonance Imaging

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In nine patients with recent lacunar stroke who revealed multiple small lesions in x-ray computed tomography (CT) and magnetic resonance imaging (MRI), CT and MRI enhancement studies were performed on the same day employing iodinated contrast medium and gadolinium-diethylenetriaminepentaacetic acid (Gd-DTPA), respectively. In CT, the injection of contrast medium enhanced recent lesions in only four of the nine patients; furthermore, the effect was weak. In MRI, the injection of Gd-DTPA enhanced recent lesions in all patients except for one who was examined 4 weeks after ictus, and the effect was excellent. Recent infarcts could be identified only by Gd-DTPA-enhanced MRI in four of the nine patients. In patients with multiple small infarctions, identification of recent small infarcted lesions by CT or MRI is sometimes difficult; however, the use of Gd-DTPA in MRI makes it possible to distinguish recent infarcts from other lesions definitively. (Stroke 1988;19:834–839)

It is well recognized that high-field magnetic resonance imaging (MRI) can demonstrate infarcted lesions in the brain more clearly than x-ray computed tomography (CT). MRI in stroke patients, however, often reveals multiple small lesions, whether pathologic or nonpathologic, and the identification of the recent lesions among them is sometimes difficult.

Gadolinium-diethylenetriaminepentaacetic acid (Gd-DTPA) is an excellent contrast agent for MRI. This substance exhibits pharmacokinetic behavior similar to that of the iodinated contrast agents used in x-ray CT and enhances on MRI those lesions that have a disrupted blood–brain barrier (BBB). Recent studies have indicated that Gd-DTPA-enhanced MRI is potentially useful for distinguishing different kinds of brain tumors. The application of Gd-DTPA-enhanced MRI to the diagnosis of cerebrovascular diseases, however, has not yet been sufficiently investigated.

In our present study, we evaluated the usefulness of Gd-DTPA injection for distinguishing recent infarcts from old lesions in cases of multiple cerebral infarction.

Subjects and Methods

During the interval from May 30, 1986, to September 8, 1986, at the Stroke Care Unit of the National Cardiovascular Center, Osaka, Japan, both CT and MRI contrast enhancement studies were performed in 14 patients with recent stroke. Nine patients (six men and three women, aged 51–82 years) had multiple small infarcts as demonstrated by CT and MRI. The clinical diagnosis in these nine patients was lacunar stroke; all had neurologic signs and symptoms compatible with the lacunar syndrome described by Fisher (Table 1). Due to the existence of multiple small lesions in CT and MRI, identification of the recent lesions among them proved difficult in these patients. The relative capabilities of enhanced CT and enhanced MRI for distinguishing recent lesions from the others were therefore compared in these patients.

MRI and CT were performed on the same day between 7 and 28 days after the last ictus. All slices were contiguous, 5 mm thick. CT was carried out employing a CT/T 8800 (GE Corp., Schenectady, New York); the contrast-enhancing agent was 76% meglumine diatrizoate sodium (urografin). MRI was carried out with a 1.5-T superconductive MR prototype system (Magneton H15, Siemens Corp., Cherry Hill, New Jersey). The spin-echo pulse sequence was used, separated into T1-weighted (T1w) as TR, 500 msec and TE, 30 msec [SE(500/30)] and T2-weighted (T2w) as TR, 2000 msec and TE, 90 or 30 msec [SE(2000/90 or 2000/30)] sequences.

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Gd-DTPA-enhanced MRI was performed from 5 minutes after intravenous administration of 0.1 mmol/0.2 ml/kg body wt of Gd-DTPA on T1w images. A low level of Gd-DTPA, such as 0.1 mmol/kg, produces an enhancement effect by reducing the T1 relaxation time much more than the T2 relaxation time. In general, the Gd-DTPA enhancement effect is remarkable at approximately 20–50 minutes after the injection. For this reason, Gd-DTPA-enhanced MRI was examined during this time interval.

### Results

In CT, the injection of urografin enhanced the recent lacunar lesions in four of the nine patients, although the contrast was indistinct and not definitive in all four cases; no enhancement was observed in the other five patients. On the other hand, in MRI, the injection of Gd-DPTA enhanced the recent lesions in all patients except one in whom the examination was performed 28 days after ictus. The enhancement in MRI was clear and far more definitive than that in CT. It is of interest that the enhancement was observed more clearly in the T1w images than in the T2w images. Before Gd-DTPA administration, the T1w images showed fewer lesions of abnormal intensity than the T2w images. After the Gd-DTPA injection, however, the T1w images exhibited enhancement in regions that had displayed no abnormal intensity before injection of Gd-DTPA. The corresponding regions in heavily T2-weighted [SE(2000/90)] images showed a high signal intensity before and after the Gd-DTPA injection, and a small difference in intensity was observed between the two T2w images.

Our Gd-DTPA enhancement study was extremely helpful for making a local diagnosis of recent lesions. In four patients (Cases 1, 2, 5, and 6; Table 1), the recent lesions could be precisely distinguished only by Gd-DTPA-enhanced MRI. Two characteristic cases will be described.

### Case 1

A 57-year-old man with a history of hypertension, diabetes mellitus, and lacunar infarcts recognized dysarthria and difficulty in right hand movement on the morning of August 6, 1986. Neurologic examination on the next day revealed dysarthria-clumsy hand syndrome on the right side. A lesion on the contralateral side in the pontine base or the internal capsule was considered to be responsible for his symptoms. In plain CT, multiple small infarcts including those in the left internal capsule and pons were demonstrated. T2w images also showed multiple infarcted lesions, more clearly than CT (Figure 1, top). The lesion responsible for his recent attack could not be determined from these examinations alone. The enhanced CT revealed no lesion in either the left internal capsule or the pons (Figure 1, middle). However, the Gd-DTPA-enhanced T1w images clearly displayed a lesion in the left internal capsule (Figure 1, bottom). Thus, the recent lesion was clearly identified in Case 1. The Gd-DTPA enhancement was more marked 21 days after ictus than 7 days after ictus.

### Case 6

A 76-year-old woman with a history of hypertension developed speech disturbance and weakness of her right extremities on the morning of September 4, 1986. In the evening of the same day, she was unable to stand up by herself. Neurologic examination on September 5 revealed pure motor hemiparesis on the right side. The weakness was more severe in the lower than the upper limb. A lesion of either the left side of the pontine base or the left internal capsule was suspected to be responsible for such signs. Plain

### Table 1. Clinical Summary of Nine Patients With Multiple Small Infarctions

<table>
<thead>
<tr>
<th>Case/age/sex</th>
<th>Time of examination (days after ictus)</th>
<th>Clinical signs of last ictus</th>
<th>Enhancement</th>
<th>Final local diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/57/M</td>
<td>7</td>
<td>R dysarthria-clumsy hand syndrome</td>
<td>− + +</td>
<td>L internal capsule</td>
</tr>
<tr>
<td>2/65/M</td>
<td>21</td>
<td>− + +</td>
<td>R corona radiata</td>
<td></td>
</tr>
<tr>
<td>3/70/F</td>
<td>8</td>
<td>Dysarthria; R arm, leg weakness</td>
<td>− + +</td>
<td>L internal capsule</td>
</tr>
<tr>
<td>4/58/M</td>
<td>10</td>
<td>R face, arm, leg weakness (severe); dysarthria</td>
<td>− ± + +</td>
<td>R corona radiata</td>
</tr>
<tr>
<td>5/82/M</td>
<td>14</td>
<td>L arm, leg weakness with numbness</td>
<td>± + +</td>
<td>L internal capsule</td>
</tr>
<tr>
<td>6/76/F</td>
<td>15</td>
<td>Dysarthria; R face, arm, leg weakness (face dominant)</td>
<td>± + +</td>
<td>L pons</td>
</tr>
<tr>
<td>7/63/F</td>
<td>19</td>
<td>R face, arm, leg weakness</td>
<td>± + +</td>
<td>L internal capsule</td>
</tr>
<tr>
<td>8/51/M</td>
<td>21</td>
<td>R arm, leg weakness with numbness</td>
<td>− + +</td>
<td>L corona radiata</td>
</tr>
<tr>
<td>9/71/M</td>
<td>28</td>
<td>L face, arm, leg weakness with numbness</td>
<td>− − +</td>
<td>R frontoparietal deep white matter</td>
</tr>
</tbody>
</table>

Age in years; CT, computed tomography; MRI, magnetic resonance imaging; M, male; F, female; R, right; L, left; degree of enhancement: −, none; ±, slight; +, moderate; + +, marked.
FIGURE 2. Magnetic resonance images (MRIs) and computed tomograms (CTs) of Case 6 15 days after ictus. Top: T2-weighted MRI (spin-echo, 2000 msec-30 msec [SE(2000/30)] [left] and SE(2000/90) [middle and right]) without gadolinium-diethylenetriaminepentaacetic acid (Gd-DTPA) showed multiple small infarcted lesions (arrows) involving left internal capsule (arrow A) and left side of pons (arrow B). Bottom: In enhanced CT (right), very small increase in density compared with plain CT (left) was observed in left side of pons.

FIGURE 1. Magnetic resonance images (MRIs) and computed tomograms (CTs) (facing page) of Case 1 21 days after ictus. Top: T2-weighted MRI (spin-echo, 2000 msec-90 msec [SE(2000/90)]) without gadolinium-diethylenetriaminepentaacetic acid (Gd-DTPA) revealed multiple infarcted lesions (arrows) involving left internal capsule (arrow A) and left side of pons (arrow B). Middle: No contrast was seen on enhanced CT (right) compared with plain CT (left) in internal capsule. Bottom: T1-weighted MRI showed no lesion before Gd-DTPA injection, viz., an isointense area in left internal capsule (left). On the other hand, T1-weighted MRI after Gd-DTPA injection demonstrated marked enhancement in posterior limb of left internal capsule (right).
CT showed multiple low-density spots in various regions including the left internal capsule and pons. T2w images also exhibited multiple high-intensity areas that were more numerous and distinctive (Figure 2, top). In enhanced CT, no effect was seen in the left internal capsule. A linear enhancement was observed in the left side of the pons, but the effect was weak (Figure 2, bottom). Gd-DTPA–enhanced MRI showed no enhancement in the left internal capsule (Figure 3, top). On the other hand, Gd-DTPA–enhanced MRI demonstrated marked enhancement in the left side of the pons (Figure 3, bottom).

Discussion
In general, by the injection of contrast agents recent infarcts can be readily identified as enhanced lesions on CT scans. Iodinated contrast agents usually pass through the BBB of acute infarcts and produce excellent enhancement on CT. Such
increased BBB permeability to contrast agents appears to persist for approximately 1 month. Infarcts that are examined within 1 month after ictus can thus usually be identified by enhanced CT.\textsuperscript{13,14}

Recent MRI studies have shown that Gd-DTPA injection produces a visible enhancement of infarcted lesions within 1 month after ictus.\textsuperscript{9,10} This time interval, during which the enhancement is revealed, is approximately the same as that of CT enhancement by iodinated contrast agents. In this respect, Gd-DTPA–enhanced MRI may provide no advantage over iodinated-contrast-medium–enhanced CT. It should be emphasized, however, that enhanced CT is of little use in identifying recent infarcts if they are small.\textsuperscript{15} This is particularly the case if the patient has multiple small infarcts.

In our present study, enhanced CT displayed effects in only four of nine patients with lacunar stroke. Furthermore, the extent of the enhancement in these four cases was very weak. On the other hand, Gd-DTPA injection produced excellent enhancement of the recent lacunar lesions in almost all cases. In our study, Gd-DTPA injection failed to reveal a recent lesion in one case, although this failure was probably attributable to the fact that the infarct was rather old and the BBB permeability was thus likely to be improved. Insofar as the identification of recent lacunar infarcts is concerned, Gd-DTPA–enhanced MRI seems to be an extremely powerful and useful technique. MRI in patients with multiple sclerosis has shown that Gd-DTPA injection can enhance new or active lesions very clearly, although it also enhanced asymptomatic lesions to some extent.\textsuperscript{16} On the other hand, in our present study, Gd-DTPA enhanced only a single lesion in each patient, and these single lesions were considered to be responsible for the signs and symptoms of the recent stroke. Thus, in our study, no false-positive enhancement was observed. However, our sample is so small that further investigation of similar cases with multiple small infarctions is needed to conclude whether false-positive enhancement does occur.

Rothrock et al\textsuperscript{17} reported that in plain MRI acute lacunar lesions were demonstrated only in T2w images. In our present study, recent lacunar lesions were also demonstrated only in the T2w images of plain MRI. These findings are important since MRI often displays multiple small spots including non-pathologic lesions, such as état crible.\textsuperscript{2} Minute lesions demonstrated in both T2w and T1w images may be regarded as representing either old infarcts or nonpathologic lesions.

In our present study, adverse effects of Gd-DTPA were never observed. Gd-DTPA seems to be more beneficial than the iodinated contrast media of CT in terms of the volume needed for enhancement: the amount of Gd-DTPA required for each patient is 10–20 ml, which is much less than the 80 ml or more required for the iodinated media. This means that Gd-DTPA is safer for patients who have complications of heart or renal disease. The results of our present study suggest that Gd-DTPA–enhanced MRI is safe and useful for identifying recently infarcted lesions, whereas multiple small infarction may represent one of the major indications for Gd-DTPA–enhanced MRI.

References

2. Awad IA, Johnson PC, Spetzler RF, Hodak JA: Incidental subcortical lesions identified with gadolinium-DTPA magnetic resonance imaging in the elderly. II. Postmortem pathological correlations. Stroke 1986;17:1090–1097

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