

Mechanism in Progressive Lacunar Infarction

A Case Report With Magnetic Resonance Imaging

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Background: The mechanism of a progressive lacunar infarction is not well understood, and changes in ischemic tissue after onset have not yet been clarified clinically.

Objective: To investigate the pathophysiological characteristics of a case of progressive lacunar infarction using diffusion-weighted and conventional magnetic resonance imaging (MRI) scans.

Patient: A 73-year-old woman was hospitalized 18 hours after stroke onset and was diagnosed as having a lacunar infarction in the perforating territory of the left middle cerebral artery. Despite treatment, the hemiparesis worsened, with the peak on the fourth day after onset. Dif-

fusion-weighted and conventional MRI scans provided clues to the pathogenesis.

Findings and Conclusions: In the acute stage, gradual enlargement of the hyperintense lesion, reflecting fresh ischemic tissue, and neurological deterioration were observed by serial examination of diffusion-weighted MRI scans. A conventional coronal MRI scan revealed a 2-layered ischemic lesion, suggesting the involvement of perforating arteries. These findings indicated that hemodynamic impairment of the microcirculation in the perforators was the major cause of the lacunar infarction.

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THE TERM *lacunar infarction* is commonly used as a clinical category for small lesions (<15 mm in greatest diameter) in the territory of the deep and the single perforators.¹⁻⁴ In general, the prognosis for recovery of patients with lacunar stroke is excellent.² However, the chronological hemodynamic alteration in the acute ischemic region is not well known in lacunae. We encountered a patient with a lacunar infarction who showed progressive neurological deterioration after stroke onset and decided to investigate the pathophysiological characteristics of the case by conventional and diffusion-weighted magnetic resonance imaging (MRI) techniques.

The MRI scans were performed with a 1.5-T system (Gyrosan ACS-NT; Philips Medical Systems, Best, the Netherlands). A diffusion-weighted MRI (DWI) scan was obtained using a multishot spin echo planar imaging sequence with a repetition time of 4800 milliseconds, an echo time of 170 milliseconds, and diffusion weighting characterized by a b value of 1200 s/mm².

REPORT OF A CASE

A hypertensive 73-year-old woman had a sudden onset of right-sided hemiparesis at 5 PM January 15, 1998, and was hospitalized at 11 AM on the following day. Examination disclosed a blood pressure of 160/102 mm Hg, a regular pulse of 70 beats/min, and a body temperature of 37.5°C. The findings of the physical examination were otherwise normal. The patient was alert and had dysarthria, mild right-sided hemiparesis (manual muscle test score, 4/5), and Babinski signs. Sensation was intact. Blood chemical and coagulation studies showed no definite abnormalities except for mild elevations in total cholesterol (5.8 mmol/L [224 mg/dL]) (reference range, 3.1-5.7 mmol/L [120-220 mg/dL]), thrombin-antithrombin III complex (330 mg/L) (reference range, 210-300 mg/L), and D-dimer (235 ng/mL) (normal values, <150 ng/mL) concentrations. An electrocardiogram, a chest radiograph, and a transthoracic echocardiogram revealed no abnormalities. The new lesion that was apparently responsible for the right-sided hemiparesis was not detected on a computed tomographic

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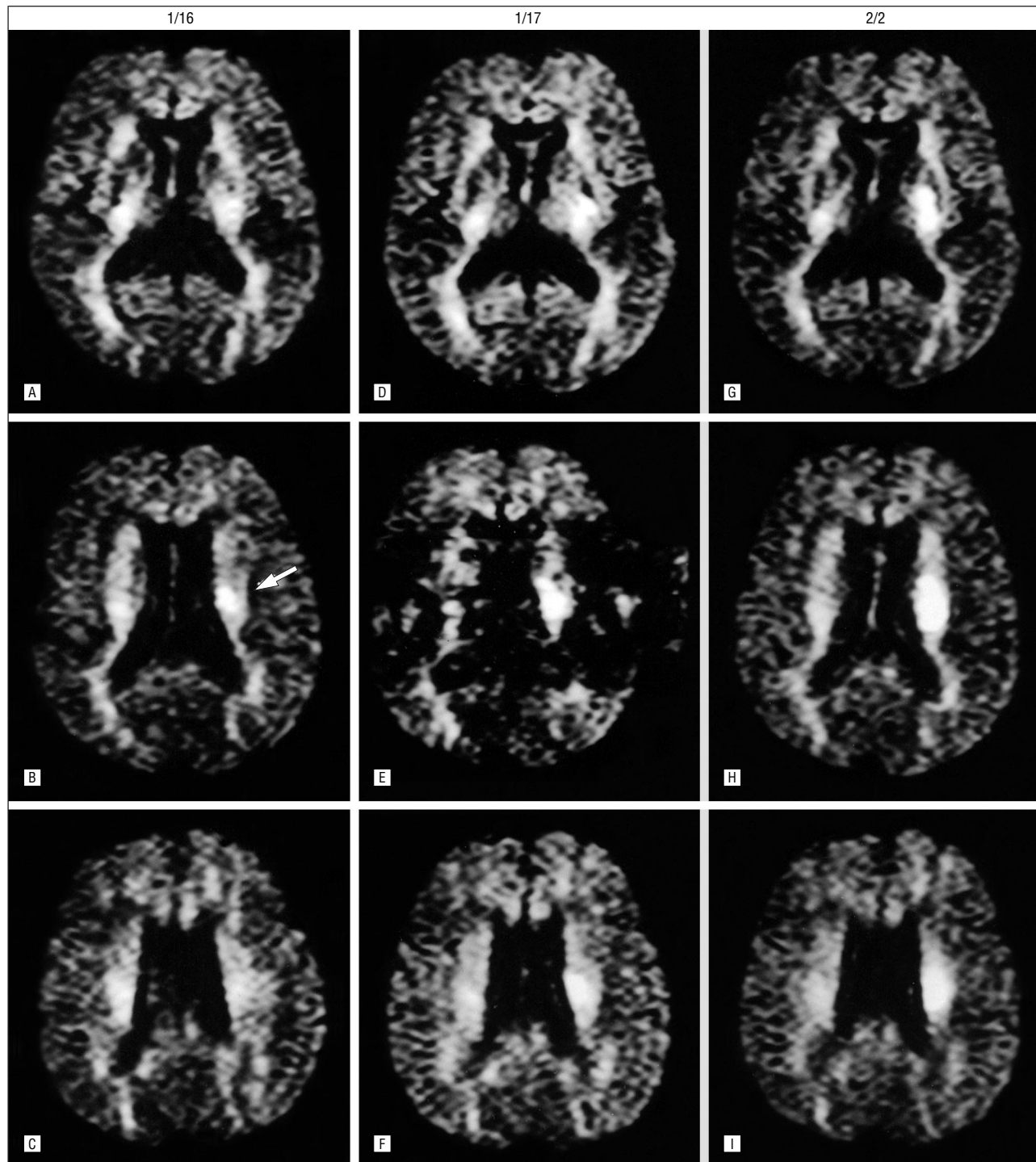


Figure 1. Chronological change of the ischemic lesion on diffusion-weighted magnetic resonance imaging scans obtained during the acute stage (the diffusion gradient is applied in the transverse direction). A through C, A small hyperintensity, reflecting an early ischemic lesion, is demonstrated on admission (B, arrow). D through F, The hyperintensity region has enlarged in both upward and downward directions by the next day. G through I, Approximately 2 weeks later, further enlargement is seen.

scan and a conventional MRI scan on admission. However, the DWI scan obtained 20 hours after onset demonstrated a small high-intensity region in the left corona radiata adjacent to the body of the left lateral ventricle, measuring 12 mm anteroposteriorly and 10 mm transversely at the slice of the maximal size of the lesion, which was supposed to be a fresh infarct area, explaining her neurological disorders (**Figure 1**). This hy-

perintensity was visible on the images with 3 diffusion gradients applied in the transverse, coronal, and sagittal directions. Both carotid and middle cerebral arteries on the magnetic resonance angiogram revealed no significant stenotic change. Treatment with lactated Ringer solution (500 mL/d for 7 days) and ozagrel sodium (Ono Pharmaceutical Co, Osaka, Japan) (160 mg/d for 14 days) was begun after admission. Despite this therapy, the pa-



Figure 2. Conventional magnetic resonance imaging scans obtained approximately 2 weeks after stroke onset. The 2-layered ischemic lesion accompanied by wallerian degeneration is demonstrated (arrows). A, T1-weighted image (repetition time, 595 milliseconds; echo time, 12 milliseconds). B, T2-weighted image (repetition time, 3700 milliseconds; echo time, 90 milliseconds).

tient's hemiparesis worsened, with the peak on the fourth day after onset (manual muscle test score: arm, 1/5; leg, 3/5). On hospital day 14, manual muscle testing showed that the muscle strength of her leg had increased to 4/5, while that of her arm showed a poor recovery (2/5). The hyperintense lesion on the subsequent DWI scans obtained after admission had enlarged and extended upward and downward in parallel with the neurological deterioration (Figure 1). Coronal conventional MRI scans obtained approximately 2 weeks after onset revealed a 2-layered ischemic lesion in the perforating territory of the middle cerebral artery, which was low intensity on the T1-weighted image and high intensity on the T2-weighted image, suggesting the involvement of more than 1 affected perforating branch. The lower margin of the lesion was located at a considerable distance from the basal surface of the brain (Figure 2). The maximal extent of the hyperintense region on the DWI scan in the acute stage (Figure 1, H) corresponded well with that of the infarct lesion displayed on the conventional MRI scan in the chronic stage (25 × 12 mm vs 20 × 10 mm, respectively).

COMMENT

It has been suggested that metabolic disruption following cerebral ischemic insult results in a breakdown of the cell membrane sodium-potassium homeostasis and the subsequent osmotic increase in intracellular fluid at the expense of water in extracellular space, which correlates with cytotoxic edema in the early stage of ischemic injury.^{5,6} This phenomenon is identified on DWI scans as a high-intensity region.^{5,6} Vasogenic edema follows cytotoxic edema and may possibly be a factor in the progression of stroke. However, the signal intensity of vasogenic edema is low on DWI scans and differs from that of cytotoxic edema.⁷ Thus, a high-signal

intensity area on a DWI scan reflects damaged ischemic tissue itself (cytotoxic edema) in the early stage of a stroke.

In our patient, there was no cardiac disease causing embolism or significant stenotic lesions in carotid or middle cerebral arteries on the magnetic resonance angiogram. The cerebral ischemic lesions on the initial DWI scan were smaller than 15 mm in maximum diameter. Therefore, the diagnosis of thrombotic lacunar infarction would appear applicable at admission.

The admission DWI scans demonstrated the damaged ischemic tissue developing in both an upward and a downward direction from the initial ischemic lesion of the corona radiata. Conventional MRI scans indicated that the lower margin of the ischemic lesion, apparently owing to involvement of affected perforating branches, was situated far from the basal surface of the neighboring major vessels. Based on these results, the site of the responsible vascular occlusion on the initial stroke onset would not be adjacent to the originating perforating artery within the intracranial major vessel, but distant from the origin.

Pathological microscopic examination of the lacunae studied by Fisher⁸ showed an occlusive organizing clot with a recent superimposed fibrin-platelet thrombus on a proximal stenosing atheromatous plaque and extension of thrombosis proximally and distally to the site of the occlusion in perforators. Perforating arteries vary greatly in size and have many ramifications.⁹ The maximal diameter of the ramification zone, occupied by all branches, reaches more than 30 mm in perforating arteries with a mean diameter of 470 μm.⁹ The size of the ischemic zone depends on the caliber of the affected artery and on the extent of the ramification.^{9,10} Thus, with regard to the pathogenesis of the infarction in the present case, we speculate that clot propagation, not only proximally but also distally to the initial occlusive le-

sion, produced obstruction of one branch after another arising from a large perforating artery in the acute stage.

The DWI scans indicate that the hemodynamics of microcirculation in the perforating territory continually change in the acute stage of the lacunae. The intensity of the antithrombotic therapy should be taken into consideration when identifying the region where hyperintensity enlarges after stroke onset by serial examination of DWI scans, because there may be a high risk of a large infarction in such cases.

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