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Case Report

Metachromatic Leukodystrophy: Diffusion MR Imaging Findings

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Summary: Herein the case of a 10-month-old boy with metachromatic leukodystrophy is reported. Diffusion MR imaging performed with an echo-planar trace sequence revealed a cytotoxic edema-like pattern (high signal intensity on b = 1000 s/mm^2 images and low apparent diffusion coefficient values) in the affected white matter in the absence of an ischemic condition. This finding was unchanged at a 6-month follow-up, as revealed by diffusion MR imaging. A gradient-echo diffusion sequence, reverse fast imaging in steady-state precession, revealed hyperintense changes at the corresponding regions. It is likely that the cytotoxic edematous pattern (restricted diffusion pattern) reflected restriction of mobility of the water molecules within abnormal portions of the myelin sheath, because impaired myelin breakdown and reutilization are known features of metachromatic leukodystrophy.

Metachromatic leukodystrophy is caused by a deficiency of arylsulfatase-A resulting in impaired myelination (1–8). Diffusion MR imaging features of the condition have not been reported previously. We report diffusion MR imaging of metachromatic leukodystrophy performed by using the echo-planar and gradient-echo sequences.

Case Report

The patient was a 10-month-old boy presenting with progressive spasticity. An MR imaging examination was performed on a 1.5-T MR unit (Magnetom Vision; Siemens, Erlangen, Germany) with a gradient strength of 30mT/m. T2-weighted images revealed hyperintense changes, mainly involving the deep white matter, and atrophy (Fig 1A). Diffusion MR imaging was performed by using the echo-planar trace sequence (5700/139 [TR/TE]; acquisition time, 22 s) with averaging of the three gradients. On b = 1000 mm^2/s images, which were heavily diffusion-weighted images, hyperintense changes were evident in the deep white matter and had a signal intensity pattern similar to that of cytotoxic edema (Fig 1B). On automatically generated apparent diffusion coefficient (ADC) maps, the ADC values obtained by region of interest evaluations were low at the corresponding regions (eg, 0.55×10^{-3} mm^2/s), compared with the peripheral regions of the parenchyma (eg, 0.95×10^{-3} mm^2/s) (Fig 1C).

A diagnosis of metachromatic leukodystrophy was confirmed by revealing decreased activity of arylsulfatase-A in leukocytes and increased urinary sulfatides. After 6 months, the patient was reexamined by diffusion MR imaging. The same echo-planar trace sequence was used, and hyperintense changes were again observed on b = 1000 mm^2/s images (Fig 2A), as were low ADC values in the deep white matter. A gradient-echo diffusion sequence, the reverse fast imaging in steady-state precession sequence, was obtained at the same session. For the reverse fast imaging in steady-state precession sequence (21.6/5 [TR/TE]; acquisition time, 2 min 48 s), high pixel values were evident in the deep white matter, compared with the peripheral regions of the parenchyma (Fig 2B). (ADC value calculation is not possible with reverse fast imaging in steady-state precession.)

Discussion

It has been reported that in cases of metachromatic leukodystrophy, the decreased activity of arylsulfatase-A accounts for failure of myelin breakdown and reutilization: hence, dysmyelination (1–8). On the diffusion MR images in the current case of metachromatic leukodystrophy, a cytotoxic, edematous pattern (restricted diffusion pattern) was evident in the deep white matter in the absence of an ischemic condition. The distribution of the lesions (Fig 1B) and their unchanging pattern on 6-month follow-up diffusion MR images (Fig 2A) strongly suggested that the lesions were directly related to the disease process. Restricted diffusion was manifested by hyperintense changes on heavily diffusion-weighted (b = 1000 s/mm^2) images (Fig 1B) and low ADC values (eg, 0.55×10^{-3} mm^2/s) on ADC maps (Fig 1C) of the echo-planar trace sequence. In addition, on the gradient-echo diffusion-weighted images, obtained using reverse fast imaging in steady-state precession, high signal intensity and high pixel values were evident in the deep white matter (Fig 2B) and were similar to those seen on b = 1000 s/mm^2 images, which again indicated definite abnormality in these regions. However, absolute ADC value calculation is currently not possible with the reverse fast imaging in steady-state precession sequence.

A similar diffusion MR imaging pattern on echo-planar diffusion images of patients with phenylketonuria was recently reported by Phillips et al (9). In that study, patients with phenylketonuria had highly restricted diffusion of water molecules with high signal intensity of the white matter on b = 1000 s/mm^2 images in association with low ADC values on ADC maps (between 0.56 and 0.63×10^{-3} mm^2/s (9). The authors concluded that this restricted diffusion pattern in cases of phenylketonuria reflected impaired myelination, and protons within partially that de-

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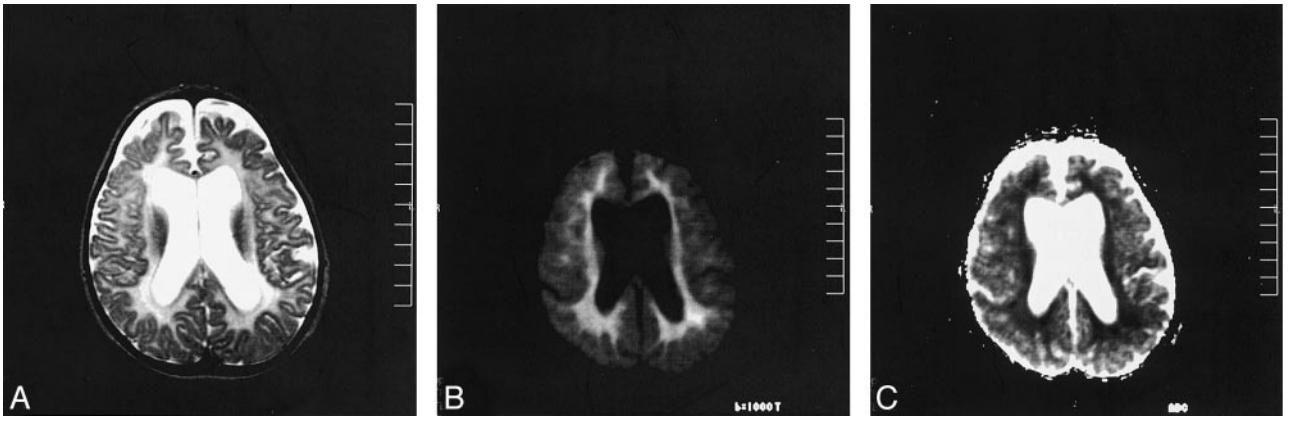

FIG 1. Images obtained at initial examination, performed when the patient was 10 months old.

A, T2-weighted image reveals hyperintense changes in the deep white matter and atrophy.

B, A b = 1000 mm^2/s (heavily diffusion-weighted) image from an echo-planar trace sequence reveals hyperintense changes similar to those of cytotoxic edema.

C, Corresponding ADC map reveals a low signal intensity and low ADC value (0.55×10^{-3} mm^2/s) in the deep white matter compared with the peripheral regions of the parenchyma, including peripheral white matter and the cortex (0.95×10^{-3} mm^2/s).

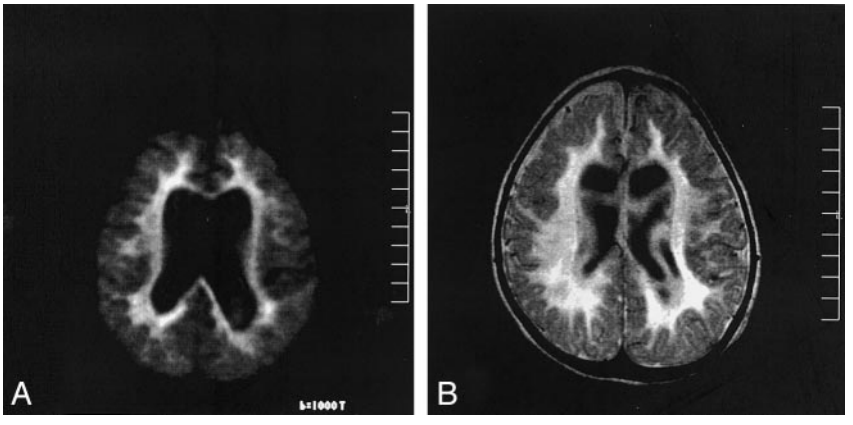

FIG 2. Images obtained during follow-up, when the patient was 16 months old.

A, A b = 1000 mm^2/s (heavily diffusion-weighted) image from echo-planar trace sequence reveals same hyperintense lesions.

B, Gradient-echo diffusion sequence (reverse fast imaging in steady-state precession) reveals high signal intensity and high pixel values (165) in the deep white matter, compared with the peripheral regions of the parenchyma (99).

stroyed portions of the myelin sheath may not be as mobile as those in normal parenchyma (9). On the other hand, in a recent experiment, Branco (10) showed that transition of water from the solid to the gel state contributes to the signal intensity on diffusion MR images, and in the gel state, high signal intensity is observed on b = 1000 s/mm^2 images (this should result in low ADC values). Considering the observations by Phillips et al (9) and the experiment by Branco (10), in the current case of metachromatic leukodystrophy, the restricted diffusion pattern probably was consistent with some disintegration of the white matter secondary to impaired myelination, and restriction of mobility of the water molecules within abnormal portions of myelin sheath resulted in a diffusion MR imaging pattern similar to that of cytotoxic edema.

Conclusion

In a case of metachromatic leukodystrophy, an echo-planar trace sequence revealed a cytotoxic edematous pattern (restricted diffusion pattern) in the deep white matter in the absence of an ischemic condition. This pattern, manifested by high signal intensity on b = 1000 s/mm^2 images and low ADC values, probably reflected restriction of mobility of the water molecules within abnormal portions of the myelin sheath, considering that impaired myelin breakdown and reutilization are known features of metachromatic leukodystrophy. Hence, dysmyelination is a feature of metachromatic leukodystrophy. A gradient-echo diffusion sequence, reverse fast imaging in steady-state precession, revealed hyperintense changes at the corresponding regions similar to those seen on b = 1000 s/mm^2 images. Further diffusion MR imaging studies of dysmyelinating disorders could contribute to our understanding of the imaging properties of these diseases.

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