Quantitative MR Imaging and Spectroscopy in Childhood White Matter Disorders

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INTRODUCTION

MR imaging is highly sensitive in the detection of white matter lesions. In contrast, it has a limited specificity with regard to the pathology underlying the white matter signal abnormalities. In all types of pathology, the T1 and T2 relaxation times become longer, leading to non-specifically increased signal intensity on T2- and decreased signal on T1-weighted images. Quantitative MR techniques, such as diffusion tensor imaging (DTI), magnetization transfer imaging (MTI) and proton MR spectroscopy (MRS), may provide more insight into the underlying white matter pathologic changes.

PURPOSE

To prospectively investigate whether quantitative MR parameters, including magnetization transfer ratio (MTR), apparent diffusion coefficient (ADC), fractional anisotropy (FA) and 7 MR spectroscopy (MRS) metabolite concentrations, allow discrimination of different types of pathology underlying white matter signal abnormalities.

MATERIALS AND METHODS

We included 41 patients (19 male, 22 female; mean age, 15.4 years) and 41 controls (25 male, 16 female; mean age, 11.3 years). Of the patients, 12 had a hypomyelinating disorder, 14 a demyelinating disorder: metachromatic leukodystrophy (MLD, 10 patients) or globoid cell leukodystrophy (GLD, also called Krabbe disease, 4 patients), 5 a disorder characterized by myelin vacuolation: megalencephalic leukoencephalopathy with subcortical cysts (MLC), and 10 a disorder characterized by cystic degeneration: vanishing white matter disease (VWM). Single voxel spectra were obtained from parietal white matter (4-6 ml, STEAM, TR/TE = 6000/20 ms) and quantified with LCModel. DTI was performed with b-values of 0 and 1044 s/mm^2. MTI was performed with a 3D FLASH sequence. Regions-of-interest, selected for MRS, were transferred to the corresponding slices of the generated ADC, FA and MTR maps to extract quantitative measurements. Linear discriminant analysis (LDA) and univariate analysis of covariance were used for statistical analysis.

RESULTS

LDA showed that 95% of all patients were classified correctly using total creatine (tCr), choline-containing compounds (Cho), myo-inositol (Ins), MTR and ADC. Adding other parameters did not improve this. tCr was the most important MR parameter for classification of the white matter pathology groups. In the hypomyelination group all MR parameters were close to normal with the exception of elevated tCr ($p=0.03$) and Ins ($p<0.001$) and decreased MTR ($p<0.001$). In the demyelination group Cho ($p=0.002$) and Ins ($p<0.001$) were highly elevated. The myelin vacuolation and cystic degeneration groups showed high ADC ($p<0.001$) and variable decreases of all MRS-metabolites. MTR was markedly reduced ($p<0.001$) in the cystic degeneration group.

CONCLUSION

Quantitative MR techniques can discriminate between different types of white matter pathology, and may help classify white matter lesions of unknown origin with respect to underlying pathology.

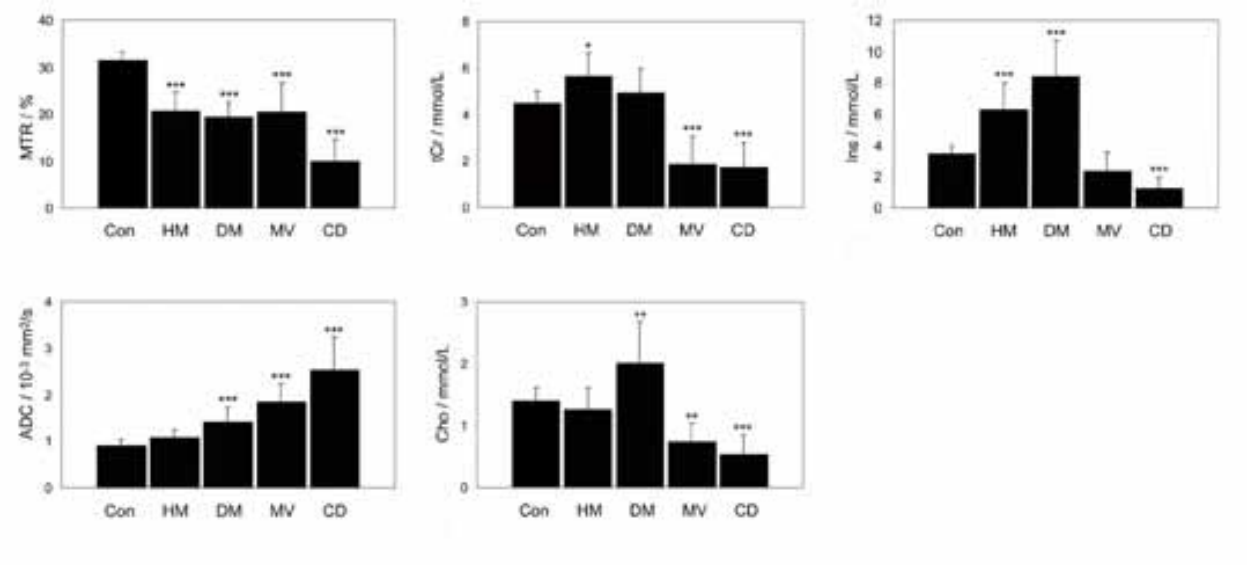

Fig1. Graphs show mean and standard deviations for all four white matter pathology groups, which include hypomyelination (HM), demyelination (DM), myelin vacuolation (MV) and cystic degeneration (CD), and controls (Con) for the five MR parameters that contributed most to the classification: MTR, ADC, tCr, Cho and Ins. Error bars represent standard deviations. Significance levels are indicated for the differences with the control group: *P<0.05; **P<0.01; ***P<0.001.