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MR Magnetization Transfer Measurements in Temporal Lobe Epilepsy: A Preliminary Study

Paul S. Tofts, Sanjay Sisodiya, Gareth J. Barker, Stephanie Webb, David MacManus, David Fish, and Simon Shorvon

Summary: MR magnetization transfer ratio was measured in both hippocampi of three patients with temporal lobe epilepsy, and in two control subjects. The magnetization transfer ratio in each section was significantly lower on the affected side than on the contralateral side and in control subjects. Magnetization transfer ratio measurements are relatively fast and precise; this preliminary study shows that they may provide useful presurgical information.

Index terms: Magnetic resonance, magnetization transfer; Hippocampus; Epilepsy

In temporal lobe epilepsy, magnetic resonance (MR) measurements of tissue structure (spectroscopy and T2) have been valuable as aids to volumetric measurements in determining the side of seizure focus before surgery. However, spectroscopy is slow, and has poor signal-to-noise ratio and spatial resolution, whereas T2 measurements from multiecho data have poor coverage of the brain. Magnetization transfer ratio (MTR) measurements (1) can quickly be made of most of the brain, with high spatial resolution and precision. MTR gives an indication of the amount of water that is bound to macromolecular proteins, probably contained in cell walls; in white matter, it is thought to relate to the amount of myelin (2). In multiple sclerosis, its reduction correlates with disability (3). We made a preliminary investigation of whether hippocampal MTR is altered in temporal lobe epilepsy.

Methods

Two control subjects and three patients were studied on a 1.5-T MR scanner. All of the patients had medically refractory chronic partial epilepsy, with typical temporal lobe symptoms and electroencephalographic findings consistent with left mesial temporal seizure onset. Coronal MR images, spin-echo 1650/32/0.75 (repetition time/echo time/excitations) with 18 5-mm contiguous sections (two interleaved blocks of nine sections, 256 × 128 matrix, 24-cm field of view), were collected, with and without magnetization transfer saturating pulses, using an interleaved sequence written for our MR system (Barker GJ, Tofts PS, Gass A, "An Interleaved Sequence for Accurate and Reproducible Measurement of Magnetization Transfer," presented at the second meeting of the Society of Magnetic Resonance, San Francisco, Calif, 1994) to minimize the effects of movement, in 22 minutes. The saturating pulse was a three-lobed hanning-apodized sinc pulse, with amplitude 18 μT, effective tip angle of 3600°, bandwidth of 62 Hz, and applied 2 kHz off resonance. The order of section collection was doubly interleaved, according to the manufacturer's standard software, to allow contiguous sections to be collected free of cross-talk. For each phase encode, echoes were collected with and without the saturating pulse, and thus, perfectly registered images were obtained corresponding to the presence and absence of saturation. From these images, MTRs (2) (in percent units [pu]) in these regions of interest (ROIs) were calculated, free from movement artifact, using the equation:

$$MTR = (SI \text{ without saturation} - SI \text{ with saturation})/(SI \text{ without saturation})$$

where SI indicates signal intensity. ROIs were drawn in the six or seven sections passing through the hippocampus, using the display software Dispimage (from D. L. Plummer, University College London) and mean MTR values in these ROIs calculated. Hippocampal volumes were measured from a routine volumetric acquisition (4).

Results

The hippocampal volume ratios confirmed diffuse hippocampal asymmetry, which was interpreted as hippocampal sclerosis, with the left side smaller than the right in all cases. This is

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From the NMR Research Unit and Epilepsy Research Group, Institute of Neurology, Queen Square, London, United Kingdom.
Address reprint requests to Dr Paul Tofts, Institute of Neurology, Queen Square, London WC1N 3BG, United Kingdom.

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MTR measurements in temporal lobe epilepsy

Subject	Age, y	Duration of Epilepsy, y	MTR, pu, mean ± SD		Hippocampal Volume, L/R
			R	L	
Control 1	28	. . .	29.6 ± 0.9	29.6 ± 0.4	98%
Control 2	30	. . .	30.0 ± 0.6	30.2 ± 0.5	97%
Patient 1	28	17	30.6 ± 1.2	28.4 ± 0.6	81%
Patient 2	35	8	30.8 ± 0.5	28.2 ± 1.3	49%
Patient 3	49	44	30.1 ± 1.1	26.5 ± 1.2	56%

concordant with the electroencephalographic findings. MTR values were reproducible by the same observer (mean difference between repeated measurements 1 week apart for one observer in 64 ROIs was 0.6 pu). Partial volume effects in the MTR measurements were minimized by using ROI boundaries well within the outline of the hippocampus. Tissue homogeneity within the ROIs was good (mean standard deviation in 38 patient ROIs was 3.2 pu; in 26 control ROIs, 2.5 pu). MTR values in controls covered a narrow range (the coefficients of variation were 1–3%). Control values were also symmetric (a paired t test over 13 sections showed no significant difference between left and right sides, $P > .5$). In patients, the MTR was reduced diffusely, as shown in the Table, being lower on the affected side in each section of each patient (a paired t test over 19 sections showed a significant difference between sides, $P < .005$).

Discussion

MTR is a sensitive measure, and we expect that relatively subtle tissue alterations should be detectable with magnetization transfer imaging, because the mean reduction in the affected side (2.8 pu) is much larger than the standard deviation in the control values (0.5 pu). The precise mechanism for reductions in the MTR in the smaller hippocampus, which is largely gray matter, is not yet clear, although it could be related to gliosis. MTR measurements give good spatial resolution and coverage, and are relatively precise and fast to make. They provide quantitative information on tissue structure that is complementary, in temporal lobe epilepsy, to hippocampal volume measurements. This preliminary investigation suggests that MTR measurements may prove to be more clinically useful than other MR measures, such as T2 mapping and spectroscopy.

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