Evaluation of Diffusion-weighted MR Imaging in patients with Amyotrophic Lateral Sclerosis

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Introduction: Amyotrophic lateral sclerosis (ALS) is a severe disease of the motor neurons. The neurologic examination plays a major role for the diagnosis of amyotrophic lateral sclerosis. The role of neuroimaging was limited, however MR T2-weighted imaging was estimated to have reasonably high sensitivity and specificity (1,2).

In this study, we compare a diffusion-weighted sequence with the conventional T2-weighted sequence in patients with amyotrophic lateral sclerosis and assess the diagnostic value of diffusion-weighted imaging in the ALS patients.

Methods: Twelve patients with confirmed ALS (10 men and 2 women, mean age 56 years) and 12 age-matched control subjects (mean age 54 years) were studied with diffusion-weighted imaging and conventional MR imaging. The diffusion-weighted imaging was based on a steady state free precession sequence (TR/TE=23/2,3,5 msec). The diffusion gradient strength was set to 23 mT. The duration of the applied diffusion gradient $b$ was varied with the TE value, thus producing images with $b$-values of approximately 165, 288 and 598 sec/mm$^2$ (3). The diffusion weighted gradient was applied along the phase encoding direction (left-right). These $b$-values were measured on a tissue equivalent phantom with fluid dimethyl-sulfate-oxide (DMSO) (3). With the known diffusion constant DMSO at 1.2x10$^4$mm/sec, the decay rates derived for $b$-values were derived: for $\delta=2.0$ msec, $b=165$ sec/mm$^2$; $\delta=3$ msec, $b=288$ sec/mm$^2$; $\delta=5$ msec, $b=598$ sec/mm$^2$ (4). T1-weighted imaging (TR/TE=600/15 msec) and T2 weighted Turbo Spin Echo dual echo sequence (TR/TE=2500/25,90 msec) were performed with a slice thickness of 5mm, an acquisition matrix of 256x256, and field of view 230 mm. Identical slices of diffusion-weighted images and conventional MR images were evaluated by two readers blinded to the clinical history of both ALS patients and control subjects.

Results: Diffusion-weighted images showed high signal intensity (higher than gray matter) in the corticospinal tract at the level of the internal capsule in 11 patients with ALS (92%) and 5 control subjects (42%), whereas T2-weighted images revealed the high signal intensity in the corticospinal tract in 11 patients with ALS (92%) and 8 control subjects (67%) (Fig.1, Fig.2). The proton-weighted images disclosed the high signal corticospinal tract in 5 patients with ALS (42%), but not in any of the control subjects. Statistical analysis demonstrated that diffusion-weighted imaging (p=0.027, X$^2$ test) and proton-weighted imaging (p=0.037) were more specific than T2-weighted imaging (p=0.317). Subtle linear low signal intensity was found within the motor cortex in 6 patients with ALS and none of the control subjects.

Conclusion: Diffusion-weighted imaging adds significant specificity to the diagnosis of amyotrophic lateral sclerosis. Both diffusion-weighted imaging and T2-weighted imaging had high sensitivity, but T2-weighted imaging had lower specificity. The proton-weighted imaging suffered from very low sensitivity in our study. Therefore, diffusion-weighted imaging seems a promising tool compared to T2-weighted imaging and proton-weighted imaging in the diagnosis of amyotrophic lateral sclerosis.

References