DIFFUSION WEIGHTED MAGNETIC RESONANCE SPECTROSCOPY IN DIFFERENT STAGES OF HUMAN CEREBRAL ISCHEMIA

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Introduction:

Cerebral ischemia is a principal cause of death and severe disability globally, especially in the industrialized countries. It is ranked the 3rd leading cause of death after heart diseases and cancer [1], and the second commonest cause of adult disability in China [2]. Diffusion weighted magnetic resonance spectroscopy (DW-MRS), which introduces pairs of diffusion gradients to MRS, is useful for evaluation of the intracellular environment. [3]. Previous studies showed that the most abundant metabolites that are detected by ^{1}H-MRS are primarily located in the intracellular compartment of the brain and therefore DW-MRS offers excellent tools to specifically measure the intracellular response to cerebral injury[4]. In this study, the apparent diffusion coefficients of brain metabolites were measured by DW-MRS on a clinical MR scanner for detecting pathological changes in cases of acute cerebral ischemia and subacute cerebral ischemia.

Methods:

Sixteen cerebral ischemia patients (12 males and 4 females) and eleven healthy controls (mean age 61±7.9 years, range 51–73 years) were recruited for this study. Five patients (mean age 57± 3.9 years, range 52–68 years, 3 males and 2 females) had acute cerebral ischemia injury at a stage within 48 h from onset of symptoms, and DWI showed hyper-intensity in the region of the ischemia. Eleven patients (mean age 61±8.7 years, range 51–75 years, 9 males and 2 females) were in subacute cerebral ischemia who had an attack at least 72 h before the test. All subjects had given their permission to be part of the study which was proved by the Investigational Review Board at our hospital. The DW-MRS sequence based on point resolved spectroscopy (PRESS) sequence technique was implemented for this study. The equipment used for the MR examinations was a 3.0T clinical whole-body system (Signa EXCITE HD; General Electric, Milwaukee, WI) with gradients with a maximum amplitude 40 mT/m and a maximum slew rate 150 mT/m/ms. Parameters for the proton MRS PRESS were as follows: TR 2000 ms, TE 144 ms, voxel size 2×2×2 cm^3 (8 mL), spectral width 5000 HZ, and data points 4096. Data were acquired at only two different b-factor values: 45 and 1050 s/mm^2. The total measurement time for a set of DW-MRS series was about 8 min. Post-spectral processing was carried out by SAGE software (GE Medical Systems). Pure water subtraction was used to reduce residual water from each suppressed frame. Because free induction decay (FID) signal varies with phase shift, the phase correction of individual data traces was used to restore phase coherence and avoid signal loss [5]. Phase corrections were performed before the summation of FIDs. Since the integral peak area was more sensitive to the random noise [5], peak height was used to determine the signal intensity of metabolites in this study. The apparent diffusion coefficients (ADCs) value was estimated by the following equation:

$$ADC=-\ln\left[S(b_2)/S(b_1)\right]/(b_2-b_1)$$

Where S (b_1), and S (b_2) are the signal intensities for the two b-values, b_1 and b_2.

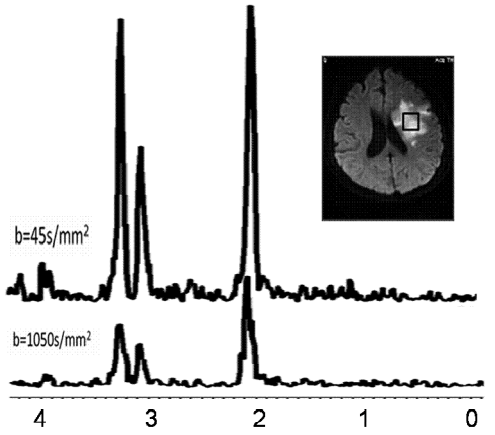

Fig.1 DW-MRS data were obtained from the region of interest (2.0×2.0×2.0= 8ml ROI) located in the region of

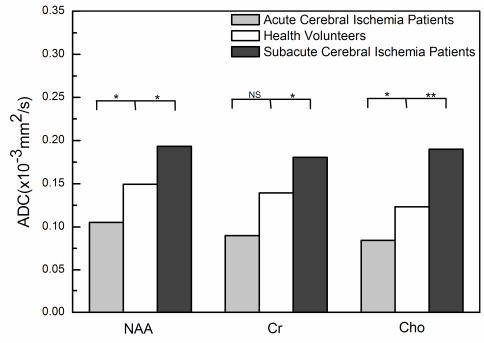

Fig. 2 Mean metabolites ADCs for ROIs across subjects of acute cerebral ischemia, subacute cerebral ischemia and health controls, respectively. Statistically significant differences relative to controls: *P <0.05, **P <0.01, NS for No Significance.

Results:

The ROI for ischemia patients and the corresponding spectra were shown in Fig. 1. The ADCs of three major metabolites, including choline-containing compounds (Cho), creatine (Cr), N- acetyl-aspartate (NAA), in patients and healthy controls were shown in Fig.2. The ADC values obtained from acute infarction patients were about 33.3% lower than those obtained from healthy controls. The Cho ADC values in subacute infarction patients were about 1.5 times the values found in the healthy controls ($p < 0.01$). The Cr ADC values in subacute infarction patients were 28.5% larger than the healthy controls ($p < 0.05$), and the ADC values of NAA were 26.6% larger than the healthy controls, with significant difference ($P<0.05$).

Discussion and Conclusions:

To our knowledge, the apoptosis of the neuron occurs as early as 30 minutes and peaks between 24 and 48 h after onset of MCA occlusion, whereas a fully mature necrotic lesion forms in cortex at 48 h during ischemia [6]. Based on the aforementioned factors, the ADC of the metabolites in the infarct region is time dependent and determined by the combined effects of apoptosis and necrosis. Moreover, most neurons appear shrinking in the core in the acute phase of the infarct, which results in a significant decrease in the ADC of the metabolites. In the later phase of ischemia, a fully mature necrotic lesion occurs in the core of the infarct site and the debris of the brain cell is liquefied, which decreases the viscosity of the extracellular space. As a result, the ADC of the metabolites in the infarct rises. These findings give support to the pathological changes in the intracellular environment for the different stages of cerebral ischemia in vivo.

References:

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