Spectral Changes of Proton Metabolites Induced by Perturbed Field Inhomogeniety in ^{1}H MRS

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I. INTRODUCTION

In the clinical ^{1}H magnetic resonance spectroscopy (MRS) studies, relative ratios on the basis of creatine (Cr) peak have been widely used under the assumption that the concentration of Cr is relatively conservative compared with other metabolites. The requirement for a standard reference has to be independent on the various physical conditions and diseases. In reality, however, a stable internal reference may be unavailable for some patho-physiological conditions. Nevertheless, this method of relative ratios has been successfully contributed to the interpretation of clinical MRS data [1].

In the physical condition with perturbed field inhomogeneity, this present study quantitatively investigated what extent was minutely the above assumption trusted and evaluated the sensitivity of each proton metabolite in the perturbed field inhomogeneity variation.

II. THEORY

After water suppression, the free induction decay signal, S(t) of the j-th metabolite in the presence of local magnetic field inhomogeneity can be described in the time domain [2],

$$S(t) = \sum_{j=1}^{N} f_j \cdot \int dr\,\rho(r) \cdot \exp[-t/T'_{2,j}] \cdot \exp(i\,\omega_j t + i\gamma\overline{H}_j t),$$

where $\rho_j(r)$ is the j-th metabolite spin density of the spectrum at point r = (x, y, z) and T'_{2j} is the transverse relaxation time including standard deviation inhomogeneity affecting each metabolite's spectral broadening of that component.

Also, the pulse sequence parameters such as TR, TE are included into the weighting function f_j. H_j is the mean value of perturbed inhomogeneous field that is induced by linear shim values, and has not spatial dependency within a localized voxel.

When two arbitrary data sets are collected with different shim values, I_{m-1} and I_m. The signal changes, $\triangle S(t)_{m-1,m}$ of each metabolite are proportionally given to the sensitivity of each component under the perturbed field variation

$$\Delta S(t)_{m-1,m} \propto \Delta \bar{H}_{m-1,m}$$

where $\triangle H_{m-1,m}$ ($=H_m - H_{m-1}$) represents a perturbed mean field variation.

III. MATERIALS and METHODS

A liquid phantom for 1H MRS was prepared by mixing distilled water with chemical components of human brain metabolites.

A localized, water-suppressed ^1H MRS phantom study was performed on a 1.5T MRI/MRS system using a STEAM pulse sequence. Spectral parameters were 20 msec TE, 2000 msec TR, 128 averages, 2500 Hz spectral width, and 2048 data points. All ^1H MRS spectra were obtained from a localized 2x2x2 cm^3 voxel in the isocenter of phantom. For this experiment, linear shim values were manually selected to make inhomogeneous physical environments as DC offsets to x, y, z gradient amplifiers. These shim values affected the MRS signal and the peak area integration. A Marquardt algorithm was employed to quantify MRS spectra. Resonance peak assignments were NAA, 2.0 ppm; Cr, 3.0 ppm; Cho, 3.2 ppm, and these major peaks were used for data analysis. Statistical analysis (Pearson bivariate correlation) was performed between signal intensity and peak area.

RESULTS and CONCLUSIONS

Significant correlation between signal intensity and corresponding peak was established in Cr (r = 0.61, p = 1.2×10^{-4}) and Cho (r = 0.57, p = 3.5×10^{-4}). In case of NAA, however, there was no correlation in the equivalent physical condition (r = 7.9×10^{-7}, p = 0.99). Also the Cr metabolite appeared the most stabilized SNR among other metabolites (i.e., NAA, Cho).

In Figure, the Cr metabolite was significantly correlated with the inhomogeneity, showed an extremely stable state and the most insensitive signal change about the perturbed x, y, z directions. Thus, the present study suggested that the quantification of relative ratios based on the Cr peak was the most desirable

as a standard reference. Therefore, our results support the validity of the assumption of ratio method based on the Cr peak.

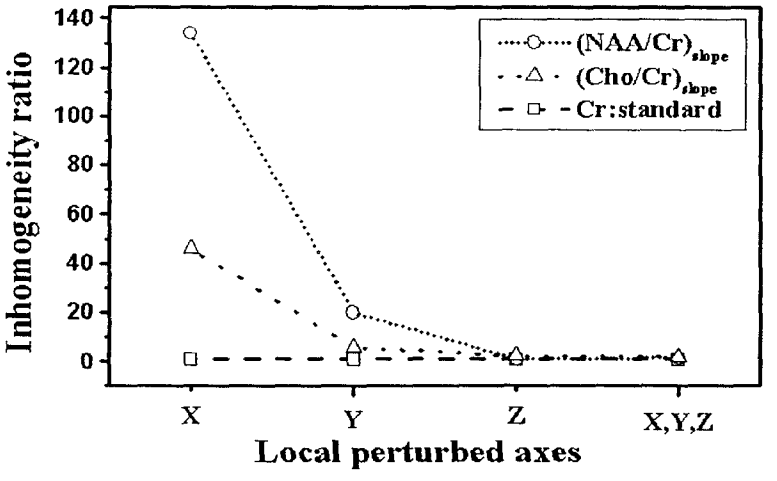

Figure. Inhomogeneity ratios depend on the local perturbed axes. The Cr metabolite was the most insensible compared to Cho and NAA in the inhomogeneous physical conditions.

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