

SPECTRAL VARIATIONS OF PROTON METABOLITES INDUCED BY PERTURBED FIELD INHOMOGENEITY IN ¹H MRS

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INTRODUCTION

In clinical brain ¹H magnetic resonance spectroscopy (MRS) studies, metabolite ratios on the basis of creatine (Cr) peak area have been widely used on the assumption that concentration of Cr is relatively conservative compared to other metabolites. The requirement of reference must be not vary with physical condition and disease. In reality, however, a stable internal reference may be unavailable for some patho-physiological conditions.

Nevertheless, this method of relative ratios has contributed to the successful utilization in the interpretation of clinical MRS data.

In the physical condition respect 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.

METHOD

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 cm³ 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 hence 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.

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],

$$S(t) = \sum_{j=1}^N f_j \cdot \int d\bar{m}(r) \cdot \exp[-t/T_{2j}'] \cdot \exp(i\bar{H}_j t + i\bar{H}_j t)$$

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 . \bar{H}_j is the mean value of perturbed inhomogeneous field that is induced by linear shim value, and has not spatial dependency within a localized voxel.

When two arbitrary data sets are collected with different shim values, $I_{m,1}$ and $I_{m,2}$.

The signal changes, $\Delta S(t)_{m-1,m}$ of each metabolite are proportionally given to the sensitivity of each component under the perturbed field variation. where $\Delta H_{m-1,m}$ ($=H_m - H_{m-1}$) represents a perturbed mean field variation.

RESULTS

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

DISCUSSION

The Cr metabolite had a significant correlation, showed extremely a stabilized state and the most insensitive signal change about the perturbed x, y, z directions.

CONCLUSION

The present study suggested that the quantification of relative ratios based on Cr peak was the most desirable as a standard reference. Therefore, our results support the validity of the assumption of ratio method based on Cr peak.