Highly resolved 2D ISIS CT-PRESS in human brain using enhanced window for shifted echoes

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Introduction

Constant time two dimensional methods have a feature of good peak resolution through ^{1}H decoupling along F_1. We have reported that three diagonal peaks of glutamate (Glu), γ-amino butyric acid (GABA) and glutamine (Gln) around 2.4 ppm were resolved on localized 2D CT-COSY spectra in human brain (1). Compared to CT-COSY method, higher sensitivity can be achieved on CT-PRESS spectra with a feature of spin echo. However, peak resolution is worse, because echo center is shifted on the time domain data (Fig. 1a) and then peaks on a reconstructed spectrum are tilted on the F_1-F_2 plane (2). In this work, we propose a window function for achieving highly resolved peaks on 2D CT-PRESS spectra. We demonstrate highly resolved CT-PRESS spectrum obtained from human brain using this window.

Method

Resolution enhanced window for shifted echoes

Figure 1 shows a schematic of our proposed window. Signal intensity of spin echo is described as $\exp(-|t\text{-TE}|/T_2^*)$ where $|t\text{-TE}|$ denotes absolute of time from TE. In 2D CT-PRESS signals, spin echo center is shifted along t_1 direction and signal intensity of 2D time domain (TD) data is expressed as $\exp(-(TE_{first}+t_1)/T_2)\exp(-|t_2-(TE_{first}+t_1)|/T_2^*)$ (Fig. 1a). In proposed resolution enhanced window, each FID on 2D TD data is multiplied with $\exp(\alpha|t_2-(TE_{first}+t_1)|)$ for correcting shifting echo center (Fig. 1b) and then 2D Lorentzian, Gaussian or sine-bell window is applied for increasing signal to noise ratio (Fig. 1c). Although a condition of $\alpha = 1/T_2^*$ is best for the resolution enhancement, signal to noise ratio is decreased because of increasing noise. To compromise this situation, weaker enhancement with lower values of α should be used.

Experiments

Volunteer studies were performed using a 4.7 T whole-body NMR spectrometer (*INOVA*, Varian). A volume TEM coil with 300 mm diameter was used both for transmission and reception. ISIS version of CT-PRESS sequence (3) was used. In this sequence, water suppression and outer volume suppression are followed by a module for localization; ISIS pulse (x-direction) – 90° slice pulse (y-direction) – 1/2*TE1 – 180° non-slice pulse – 1/2*(TE1+TE2)+Δt_1/2 – 180° slice pulse (z-direction) – {data acquisition}. In volunteer studies, VOI of a 30x30x30 mm^3 was selected in a parieto-occipital region on a scout image. First, line width of 10 Hz was achieved by FASTMAP shimming. This width is equivalent to $T_2^* \sim 30$ ms. After RF power adjustments for slice or water suppression pulses, ISIS CT-PRESS signals were acquired with a measurement time of 20 min. TE1 was 15 ms, TE2 was 17 ms and then TE_{first} = 32 ms. T_{ct} was 124 ms. Spectral widths along F_1 and F_2 were 1 kHz and 2 kHz, respectively. Number of t_1 steps n1 was 150. Relaxation delay was 4 s. After acquiring ISIS CT-PRESS signals, a suitable amount of zeroes were filled in front of the acquisition data to meet the constant time condition. Then, proposed resolution enhancement window was applied to TD data. Enhancement factor α was 5 Hz which is equivalent to 60 ms of twofold T_2^*. After this enhancement, Gaussian of 10 Hz and Lorentzian of 3 Hz were applied along both of t_1 and t_2 directions. Conventional spectra without resolution enhancement were also obtained for comparison.

Results & Discussion

Figure 2 shows a conventional (a) and an enhanced spectra (b). On the conventional spectrum, three peaks of Glu C4H, GABA C2H and Gln C4H were tilted and overlapped. Especially, glutamate and GABA were not resolved. In contrast, these three peaks were resolved on the enhanced spectrum. Although a peak of Glu C4H remained a little tilted because of weaker enhancement, GABA C2H was well resolved compared to the conventional spectrum. On the enhanced spectrum, artifacts due to a NAA singlet arose, but they did not interfere metabolite peaks of Glu C4H, GABA C2H and Gln C4H.

Conclusions

Our proposed resolution enhancement window is useful for 2D CT-PRESS spectra. In *in vivo* measurement of 2D MRS sequence, such as LCOSY and CT-COSY, coherence transfer echoes arise and then this window is effective in good peak resolution.

References

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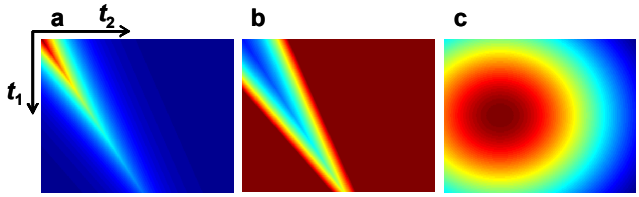

Fig. 1. Schematics of FIDs of CT-PRESS (a) and a resolution enhancement window which consists of an enhancement part (b) and a Gaussian window part (c).

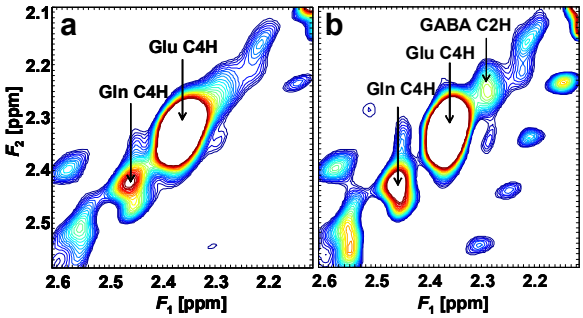

Fig. 2. Human brain spectra reconstructed with a conventional window (a) and the proposed resolution enhancement window.