Two-Dimensional semi-LASER Correlated Spectroscopy with Well-Maintained Cross-Peaks

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Introduction

Two-dimensional (2D) localized chemical shift correlated spectroscopy (L-COSY) [1] is one of the simplest and the most useful methods applied for 2D magnetic resonance spectroscopy (MRS). Compared to the J-resolved spectroscopy [2], COSY allows researchers to determine the connectivity of a molecule by coupled spin and obtain better dispersion and more separated peaks for quantification through J-cross peaks. L-COSY spectra provide more separated peaks for spectral quantification.

COSY pulse sequence is composed of two 90˚ RF pulses. The second 90˚ pulse mixes the spin states and transfers magnetization between coupled spins, which results in cross-peaks. Unfortunately, in L-COSY the bandwidth (BW) of a RF pulses for slice selection is limited, which leads to not only the chemical shift displacement error (CSDE) but also the spatially dependent evolution of J-coupling [3,4]. In this abstract, we demonstrated the second 90˚ RF pulses with limited BWs will result in attenuated cross-peaks in conventional L-COSY spectra. We further demonstrated this effect in localized COSY can be significantly suppressed when the second 90˚ RF pulse is not slice-selective by using a semi-localization by adiabatic selective refocusing (sLASER) method [5,6] for volume localization. It was verified with the peaks of lactate (Lac) in phantom experiments.

Methods

When L-COSY sequence is applied, if a pair of coupled spins have large chemical shift difference, one of the coupled spin pair may not undergo the second 90° RF pulse after the t_1 period due to the finite BW of the RF pulse in a part of the slice selected for its J-coupled partner. As a result, the magnetization between coupled spins cannot be transferred, and cross-peaks cannot be produced. This issue can be solved when the second 90˚ pulse is not slice selective. In this work, a method of slice selection called sLASER (consisting of a non-adiabatic slice-selective excitation pulse and two pairs of adiabatic slice-selective refocusing pulse) and a non-slice-selective 90˚ RF pulse for the second 90˚ pulse was employed to obtain COSY spectra and prevent the cross-peaks from attenuation. The sequence diagram is shown in Fig. 1.

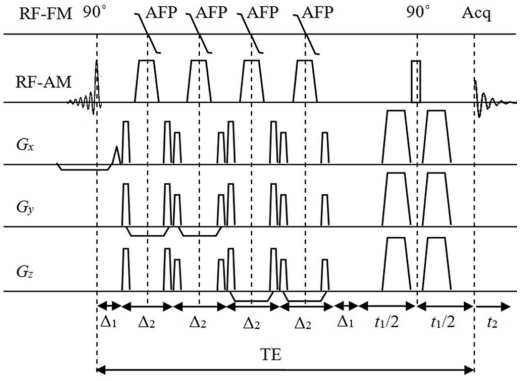

Fig. 1. Diagram of sLASER-COSY sequence

All experiments were performed on a Philips Achieva 3 T whole body scanner. The phantom of GE MRS Braino with some brain metabolites in *in vivo* concentrations was tested with L-COSY and sLASER-COSY sequences. The adiabatic pulse used in the sLASER-COSY sequence is 5.3 ms long with a BW of 4748 Hz. A 30×30×30 mm^3 voxel was positioned at the center of the phantom. All data were acquired with the VAPOR scheme for water suppression. The other parameter are: TR = 1600 ms, 8 averages for each t_1 step, Δt_1 = 0.8 ms, 1024 × 64 points data sampled with spectral widths of 2000 Hz × 1250 Hz in the $F_2 \times F_1$ dimensions, and total scan time = 13 mins and 39 s. The data was zero-filled to 2048× 256 before Fourier transformation.

Results and discussions

Figure 2 shows the L-COSY and sLASER-COSY spectra of GE braino phantom. For Lac, the three equivalent methyl spins at 1.3 ppm are J-coupled with the single methine spin at 4.1 ppm with a J-coupling constant of 6.9 Hz, which results in a doublet at 1.3 ppm and a quartet at 4.1 ppm. Because the cross peak and the diagonal peak of Lac at F_1 =1.3 ppm are completely separated from other peaks, Lac was show as an example. The cross-peaks and diagonal peaks of Lac are marked with the white boxes and green boxes, respectively, in the two spectra. For the Lac signal, the ratios of peak volumes of cross-peaks to diagonal peaks are 0.48 in L-COSY and 0.70 in sLASER-COSY spectra. For other metabolites, most of the cross-peaks are stronger in the sLASER-COSY spectrum than in the L-COSY spectrum too.

This experiment demonstrated that compared with conventional L-COSY, localized COSY can produce well-maintained cross-peaks when the sLASER is used for localization and the second 90° RF pulse is non-slice-selective. Therefore, sLASER-COSY prevents cross-peaks from attenuation as seen in conventional L-COSY due to the spatially dependent magnetization transfer, which therefore facilitates more reliable spectral quantification.

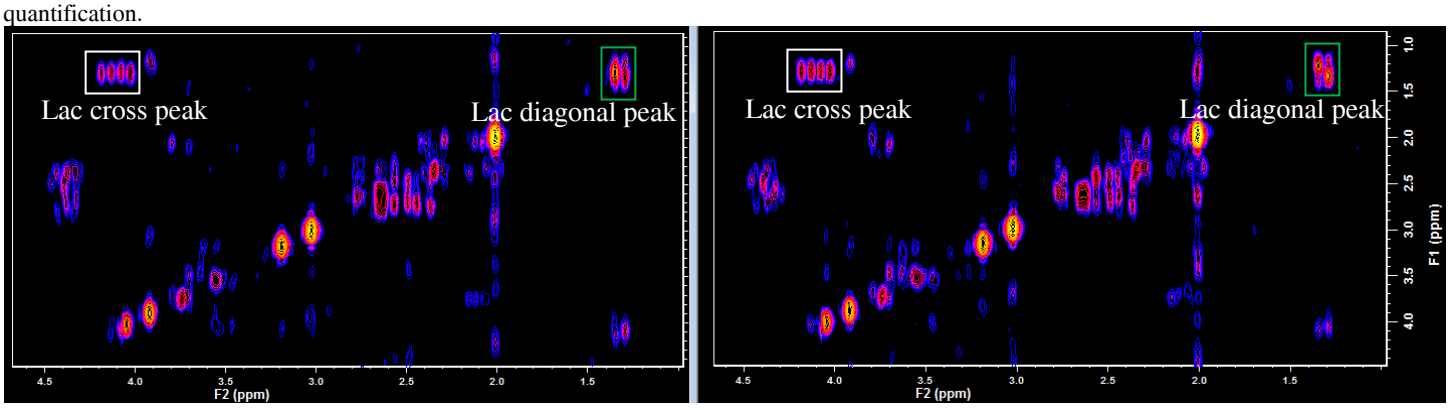

Fig. 2. GE braino spectra. Left: L-COSY; right: sLASER COSY

Reference 1. Thomas MA et al., Magn Reson Med 2001;46:58-67. 2. Thompson RB et al., Magn Reson Med 1999;41:1162-1169. 3. Yablonskiy DA et al., Magn Reson Med 1998;39:169-178. 4. Edden RAE et al., Magn Reson Med 2011;65:1509-1514. 5. Garwood M et al., J Magn Reson 2001;153:155-177. 6. Boer VO et al., NMR Biomed 2011;24:1038-1046.