Investigation of Flip Angle Dependence in Spatially Resolved 2D Correlated MR Spectroscopy

N. Binesh[1], S. Banakar[2], A. M. Thomas[1]

[1]Radiological Sciences, UCLA School of Medicine, Los Angeles, CA, United States, [2]Radiology, LABIOMED at Harbor-UCLA, Torrance, CA, United States

Introduction: In two-dimensional (2D) Correlated Spectroscopy (COSY), dependence of 2D diagonal and cross peak volumes on flip-angle of the coherence transfer rf pulse is well documented (1). Spatially resolved 2D COSY sequence comprised of three slice selective pulses 90°-180°-90° as reported recently (2). In addition to the 3-pulse train localizing the volume of interest (VOI) by selecting the slices along three orthogonal planes, the last mixing 90° rf pulse also facilitated the coherence transfer echo (CTE). As explained by Ernst and co-workers (1), the flip-angle of the CTE pulse influences the overall volumes of both diagonal and cross peaks in a COSY spectrum. However, similar effect of the slice-selective CTE pulse on different 2D diagonal and cross peaks is yet to be explored. The goal of this work was to investigate the flip-angle dependence of the last 90^0 rf pulse in a 2D L-COSY spectrum using a phantom containing six metabolites and to simulate these spectra at arbitrary flip-angles of the CTE pulse.

Materials and Methods: MRI Scanners operating at two different field strengths, Siemens 3T (Trio) and 1.5T (Avanto) were used in combination with respective circularly polarized (CP) extremity (receive) coils. A 27ml voxel was placed at the center of a phantom containing six metabolites: 1) 12.5mM N-acetyl aspartate (NAA), 2) 10mM creatine (Cr), 3) 3mM choline (Ch), 4) 7.5mM myo-inositol (mI), 5) 12.5mM glutamate (Glu) and 6) 5mM Lac. The 2D L-COSY sequence was hard coded for different flip angles from 30^0 to 220^0 using a Siemens IDEA compiler. 2D L-COSY spectra were recorded for each angle using the following acquisition parameters: 1024 complex data points along t_2 dimension, TE=20ms, TR=2s, 96 Δt_1 and 8 averages per Δt_1. The data matrices were transferred to an SGI O2 workstation and processed using Felix 2000. The final matrix consisted of 2048 points by 256 rows after apodization using sine-bell filters, zero-filling and double Fourier transformation. A GAMMA library was used to simulate each metabolite COSY spectrum with flip-angle of the CTE pulse varying from 30^0 to 220^0 (3). For GAMMA simulation, a binomial (1331) followed by hard 180^0 and 90^0 pulses to mimic water suppression and other parameters for simulation were identical to that of an experimental spectrum.

Results and Discussion: The peak volumes under the diagonal and cross-peaks of the 2D L-COSY spectra recorded in the six-metabolite phantom were measured. Fig. 1 shows the variation of the diagonal peak volumes, while Fig. 2A demonstrates the changes in cross-peak volumes for four different metabolites (Lac, NAA, mI and Glu). Since the total cross peak volume is proportional to sin (α), the maximum occurs at $\alpha=90^0$ with increasing and decreasing trends before and after as evident in Fig.2A. On the other hand, the diagonal peak volumes showed increasing trend towards $\alpha=180^0$ and a decreasing trend after. A slightly anomalous behavior between the experimental and simulated results could be due to the fact that the flip angle was calculated experimentally by power adjustment which may not be as accurate as expected.

Conclusion: In agreement with the two-pulse COSY proposed by Ernst and co-workers earlier, the spatially resolved three-pulse COSY showed identical patterns of the diagonal and cross peak volumes while varying flip-angles of the last mixing pulse. It is also evident that the sensitivity of the sequence at $\alpha=180^0$ is as much as PRESS (4) with maximum diagonal peak volumes with zero coherence transfer.

References

1) Ernst RR, Bodenhausen G and Wokaun A. Principles of NMR in one and two dimensions, Oxford Publications (1987).
2) Thomas MA, Yue K, Binesh N, et al. Mag. Reson. Med. 2001:46;58-67.
3) Smith SA, Levante TO, Meier BH and Ernst RR. J Magn Reson 1994; A106:75-105.
4) Bottomley P. US Patent 4 480 228 (1984).
5)

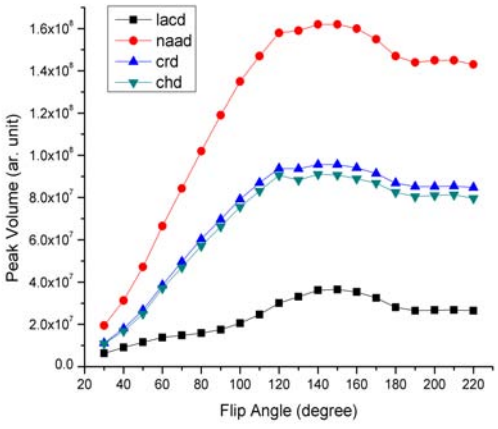

Figure 1. 2D diagonal peak volumes as a function of arbitrary angles of the mixing rf pulse (phantom).

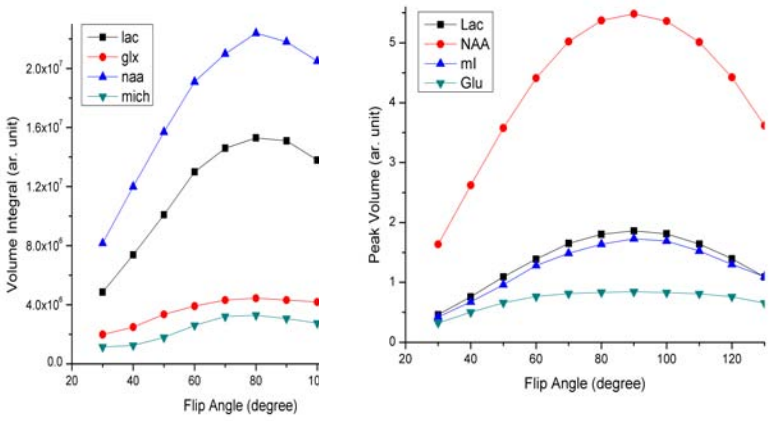

Figure 2. 2D peak volumes of cross peaks of four metabolites : A) phantom (left) and B) simulated (right) as a function of arbitrary flip angles of the mixing rf pulse.