**Improved detection of homonuclear coupled spins with constant-time PRESS and broadband refocusing pulses**

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**Introduction**

Constant-time point-resolved spectroscopy (CT-PRESS) [1] is a single voxel technique that simplifies the spectral pattern and permits the detection of J-coupled resonances with high signal-to-noise ratio by using effective homonuclear decoupling [2]. The technique relies on non-selective refocusing, i.e., effective homonuclear decoupling is only achieved if the RF pulses refocus all the resonances in a J-coupled spin system. However, this cannot be achieved throughout the volume of the selected voxel due to the chemical-shift displacement error (CSDE) caused by the limited bandwidth of the slice-selective RF pulses, leading to signal loss for coupled resonances. In this study a broadband slice-selective 180° refocusing pulse (S-BURBOP) [3] was designed and implemented into CT-PRESS. It was evaluated and compared to a conventional Shimam-Le Roux (SLR) pulse on a phantom and in vivo on healthy volunteers.

**Methods**

The S-BURBOP pulse was designed using numerical optimization based on optimal control theory [3]. The robust pulse reached broadband 180° universal rotation within a range of ±20% B1 errors. Typically the bandwidth of refocusing pulses is increased by reducing the flip angle and scaling the pulse to the maximum available B1 field [4]. We therefore compared the S-BURBOP pulse to the default SLR pulse with 167° and 180° flip angles (Table 1). In theory the 167° flip angle leads to a 5% signal reduction compared to 180° pulses.

CT-PRESS consists of a PRESS module in which the last refocusing pulse is shifted in subsequent acquisitions to encode chemical-shift information in the second time dimension (t2). The time interval between excitation and data acquisition is kept constant throughout the experiment. Therefore the evolution of J-coupling is the same for each chemical-shift encoding step and the line splitting is suppressed in the frequency dimension f2 corresponding to t2. Following a CHESS water suppression module, CT-PRESS was applied with 65 time shifts of Δt/2 = 1.6 ms (TR = 2s, 25mm cubic voxel). The average echo time (t1) of 139 ms was optimized for the detection of Glutamate (Glu) [5]. Experiments were performed on a 3T GE Signa system with a quadrature birdcage coil on a spherical phantom and on three healthy volunteers (approved by the institutional review board). 1D spectra were extracted by integrating over an interval of 0.20ppm around the diagonal of the 2D spectrum in magnitude mode.

**Results**

CT-PRESS measurements were performed with the default SLR refocusing pulse of the GE PRESS sequence and repeated with both refocusing pulses replaced by the S-BURBOP pulse (Table 1). The spectra were normalized to the maximum peak of the methyl resonance of Creatine (Cr) at 3.03ppm. Independent of the refocusing pulse, the spectra showed the same signals from Cr (3.91ppm), Choline (Cho) and N-Acetyl Aspartate (NAA 2.01ppm) as illustrated in Fig. 1 and Table 2. For the examined SLR pulses the signals of coupled resonances were similar. The signals from Glx (Glu+Gln 3.76ppm), Glu (2.35ppm), and Lactate (Lac 1.31ppm) were significantly larger with S-BURBOP compared to SLR. In two out of the three volunteers, the S-BURBOP pulse led to the detection of Glutamine (Gln) C3 resonance at 2.11ppm, which was below the detection threshold when using the SLR pulse.

**Discussion and Conclusions**

CT-PRESS significantly simplified the spectra due to effective homonuclear decoupling. Compared to the SLR pulse the broadband width of the S-BURBOP pulse reduced the chemical-shift displacement, which increased the signal of J-coupled resonances with large chemical-shift differences such as Glu, Gln, and Lac. The spectrum of volunteer C measured with S-BURBOP showed some signal at <1.5ppm. It was probably due to excitation of lipid signal from the scalp far from the PRESS voxel and could be avoided with outer-volume suppression pulses. The larger bandwidth comes at the cost of larger pulse energy (Table 1) and therefore the application of S-BURBOP may be limited to measuring with long repetition times. S-BURBOP pulses are insensitive to ±20% B1 errors and are consequently robust against experimental imperfections.

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