A Modified PRESS Sequence Designed for Lactate Editing

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Introduction

The observation of lactate (Lac) by proton MRS is of value in the study of stroke, dementia, tumors and their response to therapy. Subtraction and multiple quantum filtering methods have been employed to detect Lac (at 1.3 ppm) while suppressing the overlapping signal from lipids; however, the disadvantage of these techniques is that singlet resonances are also suppressed. Although modifications to these methods have been made to allow signal from Lac and singlets to be detected simultaneously while still suppressing fat [1,2], they involve implementing more than one additional RF and gradient pulse. We present in this work an alternative method that achieves the same objective but is less complicated to implement on a whole-body clinical scanner. The technique is based on homonuclear polarization transfer and simply involves adding a 90° hard pulse to the standard PRESS pulse sequence.

Methods

Experiments were conducted on a 3 T Philips Intera whole-body scanner with a transmit/receive birdcage head coil. The modified PRESS sequence is displayed in Figure 1. A preceding hyperbolic secant inversion pulse was applied for water suppression and a train of saturation pulses were employed to eliminate signal in the 1.3 ppm region. To understand the mechanism of the sequence, consider the weakly-coupled AX_3 spin system of Lac, where the A and the X protons resonate at approximately 4.1 ppm and 1.3 ppm, respectively. The excitation pulse forms in-phase A_y magnetization (the X signal is suppressed by pulses preceding excitation). Setting TE_1 to $0.2/J_{AX} \approx 28.8$ ms ($J_{AX} \approx 6.9$ Hz for Lac) creates maximum A antiphase coherence with respect to the three X spins [3]. The added 90° pulse with phase orthogonal to that of the excitation pulse transforms the antiphase A coherence state into X antiphase with respect to A. After a delay $TE_2 = 1/(2J_{AX}) \approx 72$ ms, the antiphase X coherence state is transformed into in-phase observable X_y signal. Thus the total echo time of the sequence is about 101 ms. The additional pulse does not affect signal from the singlets because it is of the same phase as them. Any signal excited by the hard pulse is minimized by alternating the phase of the excitation pulse and that of the receiver between ±x. The repetition time employed was 3 s.

Results

Figure 2 displays spectra obtained from 8 mL of a phantom containing 50 mM Lac and 10 mM creatine (Cr). Spectrum (a) is the response to a PRESS sequence with $TE_1 = TE_2 = 15$ ms. Figure 2(b) shows the result of applying the PRESS sequence with $TE_1 = 28.8$ ms, $TE_2 = 72$ ms and employing presaturation pulses to suppress signal in the 1.3 ppm region. The bottom spectrum is the response to the sequence used in (b) but with the additional $90°_y$ hard pulse applied at the first echo time. It can be seen that the effect of the pulse was to yield Lac signal at 1.3 ppm as a result of polarization transfer from the Lac A spins resonating at 4.1 ppm. However, the signal does suffer a loss by this polarization transfer method (namely a factor of 3) because of the ratio of A protons to X protons. Note that the Cr signal is unaffected by the pulse. Figure 3 shows spectra obtained from a similar phantom but one that also contained a layer of canola oil. The first spectrum is one obtained by a PRESS sequence with TE_1=28.8 ms and $TE_2 = 72$ ms. Figure (3b) shows the effect of suppressing signal in the 1.3 ppm region, and Figure 3(c) demonstrates the result of switching on the $90°_y$ hard pulse. It is clear that Lac signal at 1.3 ppm is "retrieved" via homonuclear polarization transfer while the oil signal remains suppressed.

Conclusion

We have demonstrated that it is possible to suppress signal from lipids while retaining signal from Lac in the 1.3 ppm region simply by implementing an additional $90°_y$ pulse at the first echo time of a conventional PRESS sequence with timings $TE_1 \approx 0.2/J_{AX} \approx 28.8$ ms, and $TE_2 = 1/(2J_{AX}) \approx 72$ ms.

References

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2. J.M. Star-Lack, D.M. Spielman *Magnetic Resonance in Medicine*, **46**, 1233, 2001.
3. M.H. Levitt, Spin Dynamics: Basics of Nuclear Magnetic Resonance. Chichester: John Wiley & Sons, 2001.

Figures

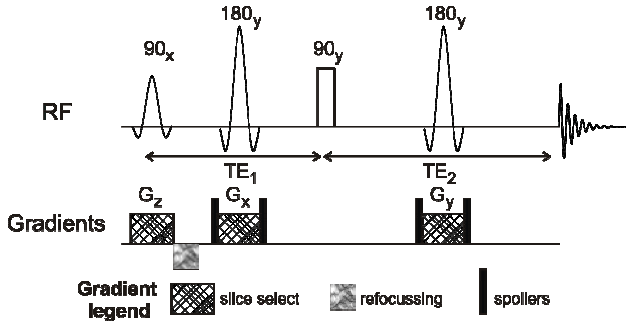

Figure 1: The modified PRESS sequence. $TE_1 = 0.2/J_{AX}$ and $TE_2 = 1/(2J_{AX})$.

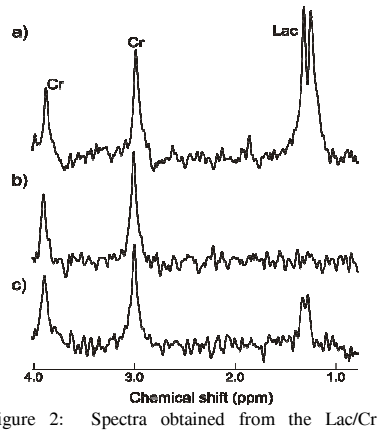

Figure 2: Spectra obtained from the Lac/Cr phantom as a result of (a) applying a PRESS sequence with $TE_1 = TE_2 = 15$ ms, (b) applying a PRESS sequence with $TE_1 = 28.8$ ms, $TE_2 = 72$ ms, and pulses to suppress signal in the 1.3 ppm region and (c) applying the sequence as in (b) but with the additional pulse illustrated in Figure 1.

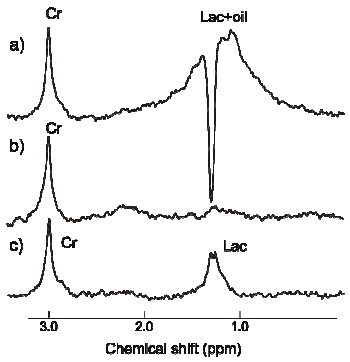

Figure 3: Spectra obtained from the Lac/Cr/canola oil phantom. The spectrum in (a) was acquired with a PRESS sequence with $TE_1 = 28.8$ ms and $TE_2 = 72$ ms, while the sequence employed in (b) contained additional pulses to suppress signal in the 1.3 ppm area. Spectrum (c) demonstrates the effectiveness of the additional $90°_y$ hard pulse in yielding Lac signal by polarization transfer from the A spins.