Optimized detection of lactate at 3 Tesla using the PRESS Sequence

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Introduction

Lactate is often elevated in brain ischemia, mitochondrial diseases and other neurological disorders (1, 2). In proton spectroscopy, the methyl (CH_3) signal of lactate (at 1.3 ppm) may sometimes be difficult to distinguish from overlapping lipid signals. One way to differentiate lactate from lipid is to use echo times (TE) of 136-144 msec (1/J, J≈7 Hz), where, under ideal conditions, the lactate methyl doublet will be inverted due to scalar (J) coupling. However, at high magnetic field strengths, the chemical shift difference between the lactate methyl and methine (CH) resonances may become similar to the bandwidth of the slice selective pulses used for spatial localization. This alters the modulation of the lactate methyl group, often resulting in inefficient inversion and/or detection (3). This abstract presents theoretical and experimental results that demonstrate that lactate detection can be optimized by the use of high-bandwidth, frequency-modulated 180˚ refocusing pulses in the PRESS sequence.

Material and Methods

Single-voxel PRESS spectroscopy (2x2x2 cm) of a 5mM lactate and 12.5 mM NAA phantom was performed on a Philips Intera 3T system with a six channel SENSE receive head coil. RF pulses were transmitted on the body coil which has a maximum RF field of 14 mT (≈ 600 Hz). Spectra were acquired at an echo time of 144 ms (TE_1 = 30, TE_2 = 114 ms) and a recycle time of 1000 ms. Conventional refocusing in the PRESS sequence was achieved with a seven-lobe sinc-gauss pulse, of length 17 ms and bandwidth 500 Hz. High bandwidth refocusing was achieved with a frequency-modulated (FM) pulse, "fmref07" (4), of length 20 ms and bandwidth 2.0 kHz.

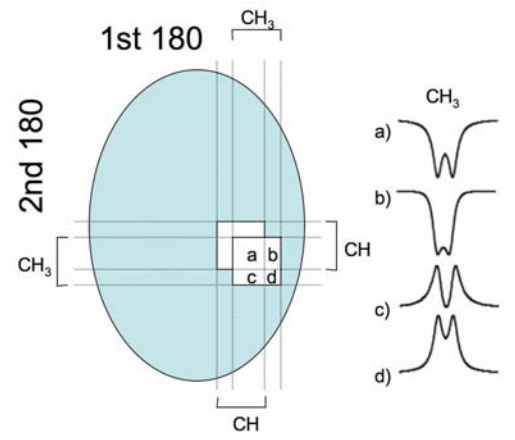

Figure 1

Table 1. Region	"Effective TE"	Sinc-Gauss	"fmref07"
a	144	8%	67%
b/c	114/30	20/20%	15%/15%
d	0	52%	3%

Simulated spectra were based on the summation of lactate doublets, calculated assuming the lactate methine resonance (4.1 ppm) experienced both (Figure 1 - region a), either (b,c) or neither (d) 180˚ refocusing pulse. By considering the bandwidth of RF pulses and the chemical shift difference between the lactate resonances (360 Hz at 3T), the percentage of the detected localized volume experiencing each combination of pulses can be estimated (Table 1). The methyl doublet can then be simulated for each "effective" evolution time, and a weighted sum performed to calculate the expected form of the final spectrum.

Results

Using the lower bandwidth sinc-gauss pulses, the lactate signal is reduced in amplitude and is not inverted (Figure 2a). The higher bandwidth FM pulses result in increased lactate signal, with signal inversion as expected (Figure 2b). The amplitude of the NAA peak is also slightly increased because of the improved slice profile of the FM refocusing pulses. The four-compartment model correctly predicts the sign, relative intensity, and apparent splitting of the lactate signal.

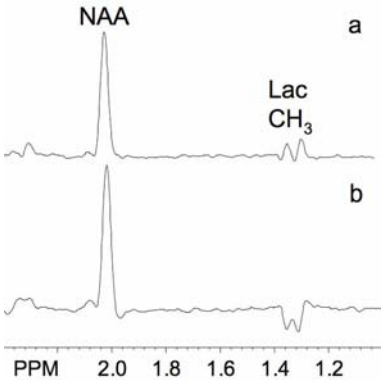

Figure 2

Discussion

There are several pitfalls associated with efficient detection of lactate *in vivo* using localized spectroscopy based on spin echoes, including J-modulation effects and possible formation of multiple-quantum coherence (if the flip angles deviate from 180˚) (3). For the PRESS sequence used here at 3T, the lactate signal intensity, as a percentage of the available total, is –40% for the low bandwidth and 70% for the high bandwidth pulses. It is worth noting that when the pulse bandwidth is twice the chemical shift difference between the spins, the lactate signal will be nulled under these conditions. For optimal lactate inversion at 3T using PRESS, it is therefore important that high bandwidth refocusing pulses are used.

References

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