# Improvement in lactate signal yield at 3 Tesla using slice-selective broadband refocusing pulses

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## *Introduction*

Localized measurement of lactate is hampered by chemical shift displacement errors and anomalous J-modulation, particularly at high $B_0$ field. Slice-selective broadband universal rotation by optimized pulses (BURBOP) has been developed with high bandwidth and low sensitivity to $B_1$ mis-calibration (1). We examine the effect on lactate yield of incorporating these pulses into conventional and lactate-edited PRESS, in comparison with Shinnar-Le Roux (SLR) refocusing pulses.

## *Methods*

Experiments were performed on a 3 Tesla HDx scanner (GE Healthcare, Waukesha WI, USA) using either a quadrature transmit-receive head coil or an 8-channel receive head coil with body coil transmission. All experiments used PRESS localization (TE 144ms, TR 2s); some additionally applied BASING pulses for J-difference editing of lactate (2). Spectra were recorded from an approximately 27-ml volume of interest in the centre of a 16-cm diameter GE MRS Head Sphere (containing 5mM lactate, 12.5mM N-acetyl aspartate (NAA) and glutamate, 10 mM creatine, 7.5mM myo-inositol, 3.0mM choline, and 0.1% Gd). The default SLR pulses with 5.2ms duration had a maximum $B_1$ of 23 μT for a 180° flip angle and a bandwidth of 1385 Hz: for conventional PRESS, this $B_1$ was matched with BURBOP pulses of 6.6ms duration and a bandwidth of 2946 Hz. In the BASING sequence, a pulse width of 8ms was used, with lower maximum $B_1$ (19 μT) and bandwidth 2437 Hz. SAR was within safety limits for all acquisitions. Comparisons were made between spectra acquired with and without the overpress (OP) scheme (3), which excites voxel dimensions larger than prescribed by a factor of 20% in the left-right and anterior-posterior directions and 40% in the superior-inferior direction, then suppresses the transition bands using very selective spatial saturation pulses. Peak areas of the lactate doublet at 1.3ppm and the NAA singlet peak at 2.0ppm were integrated using the SAGE software package (GE Healthcare, Waukesha WI, USA) and corrected for their relative concentrations (5.0 and 12.5 mM, respectively) to calculate the apparent lactate yield. The apparent yield was corrected for the relative $T_2$ of lactate and NAA, estimated from phantom measurements at echo times of 288, 576, and 864 ms (when the lactate doublet was in phase), and $T_1$, estimated using inversion recovery with delays of 48, 100, 200, 400, and 800ms.

## *Results and Discussion*

Lactate signal was consistently observed to be higher when using BURBOP pulses than SLR, and when using the overpress scheme than not (Fig. 1). However, the signal of uncoupled metabolites also was increased by about 20% when using overpress, as expected since this technique recovers signal lost to chemical shift displacement. Therefore the lactate yield in comparison to NAA was higher when using BURBOP pulses without overpress than SLR pulses with overpress (Table 1). The benefit of using the overpress scheme is smaller for BURBOP since the pulses have a higher bandwidth and therefore intrinsically reduced chemical shift displacement (e.g. for PRESS in Table 1 the relative increase in yield is 12% for BURBOP vs. 67% for SLR). It may be best to use BURBOP without overpress in the interests of minimizing SAR and allowing voxel placement close to the scalp. The yield correction factor was 11% for $T_1$ (833 ms for lactate and 625 ms for NAA) and 3% for $T_2$ (430 ms for lactate and 467 ms for NAA).The signal yield of lactate was lower when the BASING pulses were added, partly due to technical difficulties in matching the bandwidth for this pulse sequence and partly due to signal cancellation when subtracting the spectra with editing pulses on and off. The best yield obtained was 97% of the theoretical maximum for conventional PRESS and 85% for BASING.

Figure 2 shows that lactate signal was not only higher using BURBOP refocusing pulses in comparison to SLR, it was also more robust to mis-calibrated $B_1$. Lactate area remained stable for relative $B_1$ over a range of approximately 75-115% the prescan-determined optimum setting. It also fell off less sharply for more extreme mis-calibration when using BURBOP than SLR (particularly at higher $B_1$ settings). These data confirmed that similar improvements in lactate yield with BURBOP were obtained using the 8-channel receive coil with transmission on the body coil (Fig. 2) or the quadrature head coil (Fig. 1, Table 1).

## *Conclusion*

We have implemented optimized broadband refocusing pulses in PRESS, with and without J-editing for lactate. Lactate signal yield of up to 97% of the theoretical maximum was obtained, with good robustness to $B_1$ variation. Validation experiments in brain tumours are planned following further optimization of the J-editing sequence.

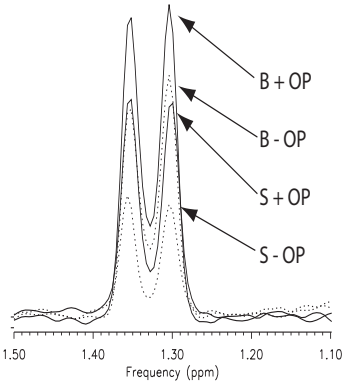


***Figure 1***: Lactate signal using BURBOP (B) or SLR (S) refocusing pulses, with and without overpress (OP). Spectra were acquired using PRESS localization and a quadrature head coil.

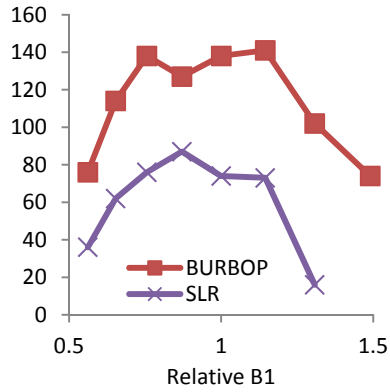


***Figure 2***: Lactate signal when $B_1$ was varied from the prescan-determined optimum for BURBOP and SLR refocusing pulses.

***Table 1***: Yield of lactate relative to NAA for SLR vs. BURBOP pulses, with and without overpress (OP) and J-difference editing (BASING).

| | PRESS | BASING |
|---|---|---|
| BURBOP + OP | 0.97 | 0.85 |
| BURBOP - OP | 0.87 | 0.71 |
| SLR + OP | 0.72 | 0.62 |
| SLR - OP | 0.43 | 0.40 |

## *References*

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