IN VIVO DETECTION OF LACTATE AT 7T USING LONG TE SLASER AND MEGA-SLASER

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INTRODUCTION: Lactate (Lac) is an important marker of anaerobic glycolysis in many brain disorders. In ^{1}H MR spectra, Lac can be distinguished from lipids at 1.3ppm by setting TE to 1/J (~144 ms) so that J coupling with a second peak at 4.1 ppm results in inversion of the Lac doublet relative to other resonances. At ultra-high field, improved signal to noise ratio (SNR) is available, but the J modulation of the Lac signal is complicated by the chemical shift displacement artefact (CSDA) which often leads to significant signal cancellation[1]. The feasibility and reproducibility of detecting lactate at 7T ($B_{1,max}$=15μT) using long TE sLASER and MEGA-sLASER (spectral editing) sequence is unknown. ***Aim*:** 1) To optimise the sLASER sequence to minimise CSDA at 7T; 2) To compare the accuracy and reproducibility of the optimised sLASER and MEGA-sLASER methods for Lac measurement.

METHODS: ***Optimisation:*** To account for the effect of CSDA on the Lac signal at 1.3 ppm, this signal was simulated as the sum of signals detected in each of 4 spatial compartments corresponding to two J-coupled Lac spin groups experiencing different refocusing pulses in the sLASER sequence[2] (Fig. 1). This showed that the theoretical efficiency ($S_{Lac}/S_{Lac,noCSDA}$) in detecting the 1.3 ppm Lac resonance was greater using offset independent trapezoidal (OIT, BW~4.8 kHz) adiabatic inversion pulses than using the hyperbolic secant (HS, BW~1.7 kHz) pulses at TE = 144 ms (65.4% vs. 4.3%). For spectral editing, a pair of narrow bandwidth MEGA editing pulses (sinc, 8.3 ms, FWHM=120 Hz) was used to selectively refocus the 4.1 ppm Lac resonance.

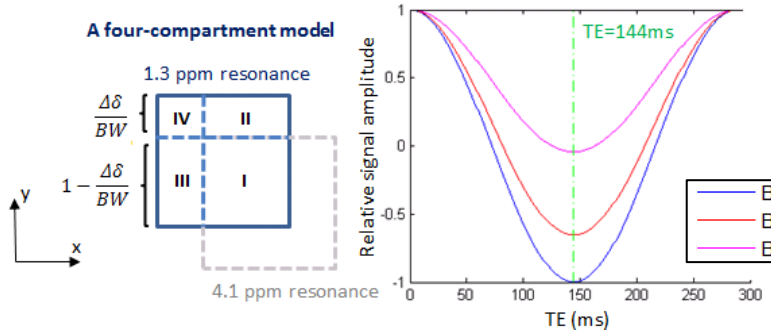

Fig 1. The normalised amplitudes of the 1.3 ppm Lac signal for TE of 0-288 ms were simulated based on the four compartment model for three different RF bandwidths.

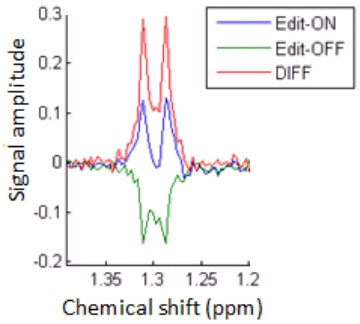

Fig.2. Edit-ON, Edit-OFF and DIFF *in vitro* spectra of lactate signal at 1.3 ppm

MR measurements All MR measurements were performed on a 7T Philips Achieva system. ***In vitro experiment:*** A phantom of 1mM Lac, pH=6.54 was scanned to measure the editing efficiency, $Eff_{edit}=S_{Lac,DIFF}/(2S_{Lac,ON})$, of the optimised MEGA-sLASER sequence (TE/TR=144/5000 ms, NSA=32, voxel size=3x3x3 cm^3, ON:4.1 ppm &OFF:9.7ppm, wide bandwidth OIT inversion pulses) and the efficiency of the sLASER sequence ($Eff_{sLASER}=S_{Lac,sLASER}/S_{Lac,ON}$). ***In vivo experiment:*** 5 healthy subjects (age range: 23-28) participated in this study with ethical approval from University of Nottingham Medical School Ethics Committee. ^{1}H MRS data were collected from a 3x4x3 cm^3 voxel in the median occipital cortex (OCC) using a MEGA-sLASER spectral editing sequence (ON:4.1ppm & OFF:9.7ppm) and a simple sLASER sequence (TE/TR=144/5000 ms, NSA=64, scan time=5.67mins) with the same scan time. ***Data Analysis:*** For MEGA-sLASER data, the 1.3ppm Lac signal (S_{Lac}) in DIFF (ON-OFF) spectra and 3 ppm Cr signals (S_{Cr}) in SUM spectra (ON+OFF) were quantified by Lorentzian peak fitting and integration in MATLAB. [Lac]/[Cr+] was calculated as $S_{Lac}/(S_{Cr}\,Eff_{edit})$. For sLASER data, the 1.3 ppm negative Lac and the 3 ppm tCr signals in the same spectrum were quantified and [Lac]/[Cr+] was calculated as $S_{Lac}/(S_{Cr}\,Eff_{sLASER})$. The mean inter-subject CV% was calculated.

RESULTS: Using an optimised sLASER without spectral editing, it was possible to observe an inverted 1.3 ppm Lac signal at 7T both *in vitro* (Fig. 2) and *in vivo* (Fig.3). The editing efficiency (Eff_{edit}) of MEGA-sLASER for detecting Lac was measured to be 1.58, which was larger than 1 because $S_{Lac,ON}$ detected was low. The reproducibility of Lac detection in OCC using MEGA-sLASER was found to be better than for sLASER (11% vs. 17%), as the quantification of MEGA-sLASER data was relatively more consistent due to a cleaner baseline and better peak shape at 1.3 ppm (Fig. 4). However, there was no significant difference in [Lac]/[Cr+] measured by MEGA-sLASER and sLASER (0.032±0.003 and 0.037±0.006). This suggests that there was no significant residual lipid signal at 1.3 ppm overlapping with the Lac signal in the spectra acquired with sLASER at TE=144ms.

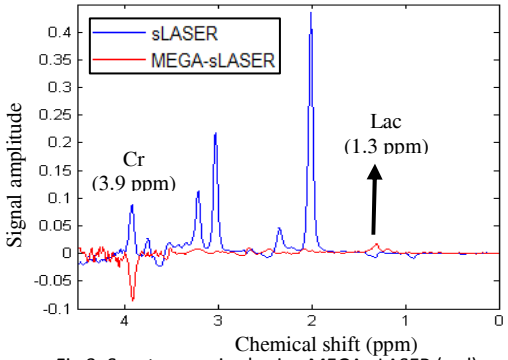

Fig.3. Spectra acquired using MEGA-sLASER (red) and sLASER (blue).

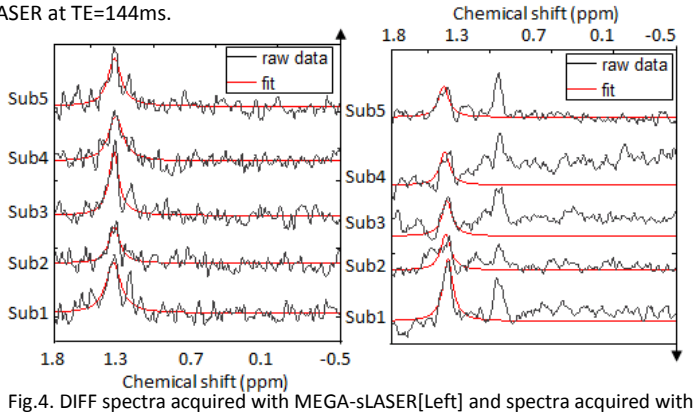

Fig.4. DIFF spectra acquired with MEGA-sLASER[Left] and spectra acquired with sLASER after inversion [Right] and the Lorentzian fits for each subject.

CONCLUSION: This study demonstrates that it is feasible to determine brain Lac concentration at 7T with conventional long TE approaches (TE=144 ms) at 7T with and without spectral editing, in a short acquisition time (~6 mins), using the optimised sLASER sequence. In addition, this work suggests that MEGA-sLASER gives better reproducibility than sLASER for brain Lac detection at 7T.

REFERENCES: [1] Edden R. et al. MRM. 2006;56 :912-917. [2] Lange T., et al. AJNR Am J Neuroradiol. 2006;27:895-901.

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