Short TE loalized 1H MR spectroscopy of mouse cervical spinal cord at 11.75T using semi-LASER sequence

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INTRODUCTION: Short TE ^{1}H MR Spectroscopy (MRS) is a valuable tool in the non-invasive assessment of spinal cord (SC) metabolism [1, 2]. However, it is technically challenging due to the small size of the SC structure, the important physiological motion, the magnetic field heterogeneity due to surrounding bony structures, and the significant macromolecular (MM) signals present at short TE spectra. Choosing higher magnetic field offers higher SNR and improved spectral resolution with the disadvantage of increased B_1 and B_0 heterogeneities as well as complicated J-modulation patterns due to chemical shift displacement error (CSDE) [3]. The semi-LASER (Localisation with Adiabatic SElective Refocusing) sequence is less sensitive to CSDE and B_1 heterogeneity effects than conventional sequences such as PRESS [4]. Moreover, the scalar coupling evolution for a strongly coupled spin system is greatly reduced as a result of the application of a train of adiabatic refocusing pulses (CPMG character) [5]. The present work demonstrates the feasibility of an optimized short TE localized ^{1}H MRS based on semi-LASER sequence for the investigation of the mouse cervical spinal cord at very high magnetic field (11.75T).

MATERIAL AND METHODS:

MR acquisition: Experiments were performed on anesthetized C57BL/6 mice (n = 6) on an 11.75T MR system (Bruker), using a transmitter/receiver volume coil (∅ 2cm, L 3cm). The MRS volume of interest (VOI), which is situated at C4 level, was positioned based on fast localization imaging (Fig. 1). Shimming was optimized using fast localized automatic adjustment of all first- and second-order shims (FASTMAP manufacturer sequence [6]). The acquisition parameters were: TE/TR = 19/5000 ms, BW = 4496 Hz, number of samples = 512, and number of averages = 16/256 without/with water suppression. The VOI (2.0x1.8x1.1 mm^3 ≈ 4µl) was selected with a combination of conventional slice selective excitation (Hermitian, 0.5 ms, 10.8 kHz) and two pairs of slice selective adiabatic refocusing pulses (Hyperbolic Secant, 2 ms, 8.8 kHz). Water suppression (WS) was achieved using the VAPOR module which was interleaved with outer volume suppression blocks applied three times to improve localization performance [7]. Navigator signals, which were used as reference signals, were acquired using the same VOI selection module but with a lower excitation flip angle (α=10°). MRS data acquisition was synchronized with breath motion to reduce artifacts arising from movement. Spectra acquisition time was about 30 minutes and the total protocol duration was 60 minutes.

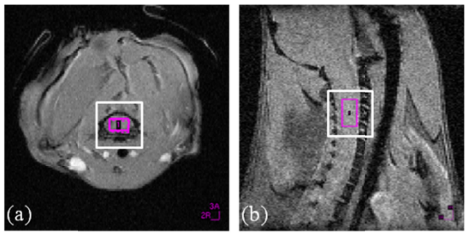

FIG. 1. Location of the selected voxel for *in vivo* ^{1}H MRS measurements (magenta rectangle) in the spinal cord (VOI_{sc}~4µl), using axial (a) and sagittal (b) T_1-weighted images. The white rectangle represent the shim voxel.

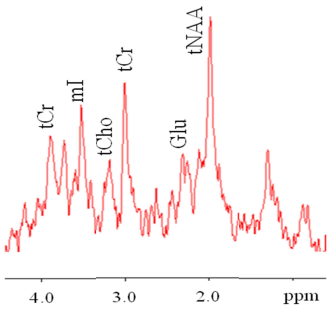

FIG. 2. Typical *in vivo* ^{1}H spectrum of the mouse cervical spinal cord acquired at 11.75T at TE = 19 ms.

MR data quantification: MRS data preprocessing including the metabolite signal normalization, phasing, line broadening, residual water suppression was performed using jMRUI [8] and in-house developed software running under Matlab (The Mathworks Inc, USA). Model fitting was performed in the time domain using QUEST [9]. The metabolite spectra basis set was simulated using GAMMA [10]. Macromolecule spectra were acquired from the same VOI using an inversion recovery technique (TR = 2.5 s, TI = 700 ms).

RESULTS: Fig. 2 depicts a typical short TE SC ^{1}H MRS spectrum. The mean normalized amplitudes of detected metabolites in the SC are presented in Fig. 3.a along with their corresponding Cramer-Rao Bounds (CRBs) (Fig. 3.b). The principal discernable metabolites in SC were tNAA, tCr, tCho, mI, and Glu. These metabolites were quantified with averaged normalized CRBs lower than 15 %.

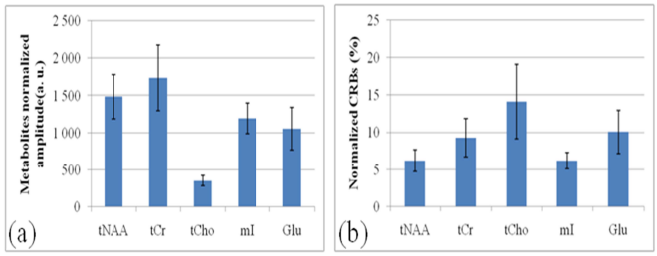

FIG. 3. Normalized amplitude of detected metabolites in spinal cord (a) with corresponding normalized CRBs (c).

CONCLUSION: In this study, the feasibility of *in vivo* short TE ^{1}H MRS of cervical spinal cord at very high field using semi-LASER was demonstrated. This work may open new perspectives to study various pathological conditions such as spinal cord injury and deepen the understanding of the diseases by providing quantitative information complementary to MRI.

REFERENCES: [1] Tachrount et al. MRM (submitted) ; [2] Cook et al. MRM 2004 ; [3] Edden et al. MRM 2006 ; [4] Scheenen et al. MRM 2008 ; [5] Oz et al. MRM 2010 ; [6] Gruetter MRM 1993 ; [7] Tkac et al. MRM 1999 ; [8] Naressi et al. MAGMA 2001 ; [9] Ratiney et al. NMRBiomed 2005 ; [10] Smith et al. JMR 1994