Single voxel MR spectroscopy with echo times below 2 ms at 16.4 T in the rat brain: first *in vivo* results

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Introduction

In vivo 1H MR spectroscopy (MRS) provides quantitative information about the metabolism in the brain. Single voxel MRS methods localize the signal to the cross-section of three orthogonal spatial slices by selective excitation and refocusing of the magnetization. In this process transverse relaxation effects and modulation caused by J-couplings affect intensity and phase of spectral components with short T_2 relaxation time and of coupled peaks. Decreasing the duration of the localization module yields major advantages in the quantification of metabolites and in the detection of macromolecule signal. Techniques based on stimulated echo selection, like STEAM, were optimized for short duration (< 2 ms) (1). The efficiency of this approach was demonstrated several times by high-quality spectra in the rat brain at 9.4 T (1,2). We present here first results of *in vivo* STEAM spectroscopy with ultra-short echo times in the rat brain at 16.4 T.

Materials and Methods

Experiments were performed on a 16.4 T / 26 cm horizontal bore Magnex magnet attached to a Bruker Biospec spectrometer. The shim system with coils up to the second order can operate at a maximum current intensity of 20 A. The imaging gradient system from Resonance Research Inc. with 1 T/m maximum strength, 270 µs rise time has an inner diameter (id) of 12 cm. The home built linear transceiver surface coil with an id of 22 mm used for signal acquisition has a sensitive region covering the whole brain of a rat. Seven weeks old healthy male CD IGS rats (250 g) were anesthetized by inhalation of 1/1 (v/v) O_2/Air mixture with 3 % Isoflurane. Anesthesia was maintained with 1.5 – 2 % Isofluorane. Body temperature was monitored and an electrical heating pad in direct contact with the animal kept the temperature above 37 °C during the experiments. Stability of the breathing was also monitored with a dedicated unit. The RF-coil was placed at the top of the head. Localized shimming was performed with FASTMAP on a (5 mm)³ voxel with the upper edges touching the skull. Water suppression (WS) was achieved with the VAPOR technique (1). Fine tuning of RF-pulses for WS was done manually. Outer volume suppression was performed in combination with VAPOR as described in (1) by saturating six 10 mm thick slices in direct neighborhood of the selected voxel. RF-pulses in the STEAM sequence were 410 µs long hermite pulses. The total duration of rephasing gradients in the echo periods was 1.1 ms. An effective echo time of 1.92 ms was achieved. Spectra from 5 x 2.6 x 5 mm³ and 4 x 2 x 4 mm³ voxels positioned 1 mm away from the skull were acquired. The short dimension of the voxels was always the one perpendicular to the plane of the coil.

Results

All spectra acquired in six sessions in five different animals (one rat was measured twice) were qualitatively comparable to the spectra shown in (1) and (2). Metabolite singlet peak line widths of 15 Hz (0.021 ppm) in smaller and 20 Hz (0.028 ppm) in larger voxels could be obtained due to the strong shim currents. A representative spectrum from a 4 x 2 x 4 mm³ is presented in Figure 1. Tentative assignment of the peaks was performed based on References (1-3). Peaks in the vicinity of the water resonance at 4.38 ppm and 4.28 ppm were additionally detected and putatively assigned after (3) to protons in N-acetyl-aspartate (NAA) and phosphoryl choline (PC) groups, respectively. However, compared to results in (1) and (2) peaks expected from lactate, alanine and aspartate groups were not unequivocally detectable in spectra from smaller voxels.

Conclusion

Single voxel MRS with ultra short echo times provided reproducible high-quality *in vivo* spectra at 16.4 T in the rat brain. Still, the unusual length of the magnet causes signal loss in the cable between the coil and the preamplifier. Thus, further work on this topic will address the development of an RF-coil with a directly attached preamplifier.

References

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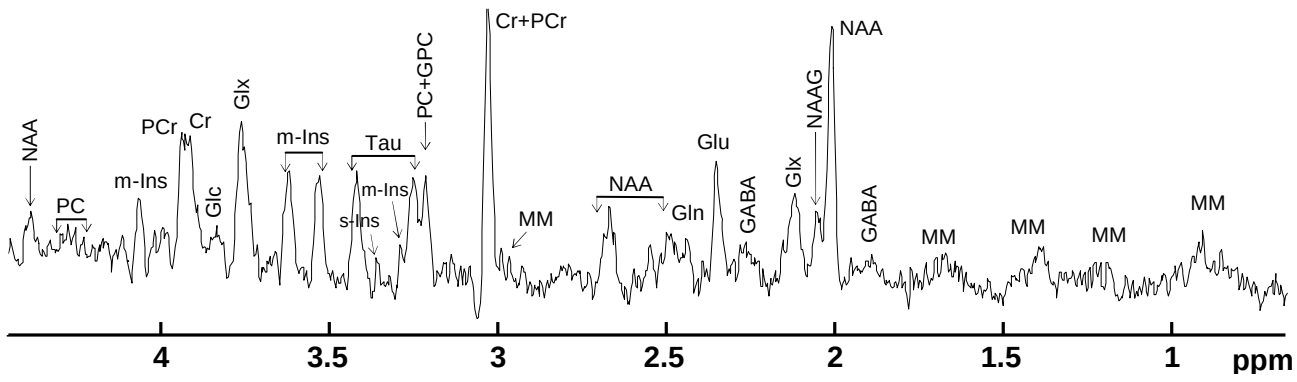

Figure 1: *In vivo* STEAM spectrum from a 4 x 2 x 4 mm³ voxel in the brain of a rat acquired in 17 minutes. The repetition time was 4 s, the echo time 1.92 ms, and the experiment was averaged 256 times. Peaks are tentatively assigned (labels).