3D MR spectroscopic imaging using adiabatic spin echo and hypergeometric dual band pulses for metabolic mapping over the entire brain

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Target Audience: MRS sequence developers; Neuroradiologists; Neuroscientists; Neurologists.

PURPOSE: High intensity water and lipid signals in proton magnetic resonance spectroscopic imaging (MRSI) of the human brain hamper metabolic quantification, in particular for cortical areas that are closer to the scalp tissues rich in fat content. Traditional water suppression (CHESS, WET) and outer volume suppression (OVS) of lipids suppression reduce the amplitude of water and lipid signals but in many cases results are not optimal over a large field of view due to B1 and B0 inhomogeneity. Here we combined adiabatic hypergeometric dual-band (HGDB)[1] pulses with adiabatic GOIA[2] spin echo to improve water and fat suppression for 3D MRSI of the entire brain.

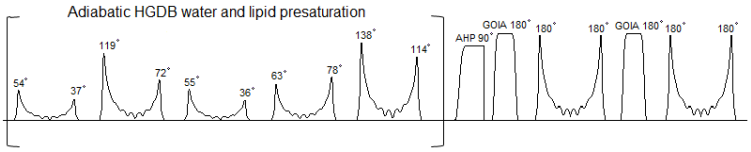

Figure 1: Schematic depiction of the HGDB based pre-saturation (5 pulses) and MEGA editing used with adiabatic spin echo sequence.

METHODS: 3D MRSI data were acquired on a 3T TIM Trio MR Scanner (Siemens, Erlangen, Germany) using a 32-channel head coil. Adiabatic hypergeometric dual band pulses of 44 ms duration (30Hz transition bands, 150 Hz B_{1max}) were used for presaturation and MEGA[3] suppression (Fig. 1). Gradient Offset Independent Adiabatic GOIA-W(16,4)[2] pulses of 3.5 ms duration, 20 kHz bandwidth, 0.82 kHz B_{1max} were used for adiabatic spin echo. Constant-density spiral readout was used to accelerate (k_x,k_y,t) encoding. MRSI acquisition parameters were: TR/TE 1800/113ms, matrix size of 24×24×12 interpolated to 32×32×16, FOV 24×24×12cm. Prospective real-time motion correction and shim update was performed during MRSI acquisition[4]. Four subjects were imaged with an approved IRB protocol.

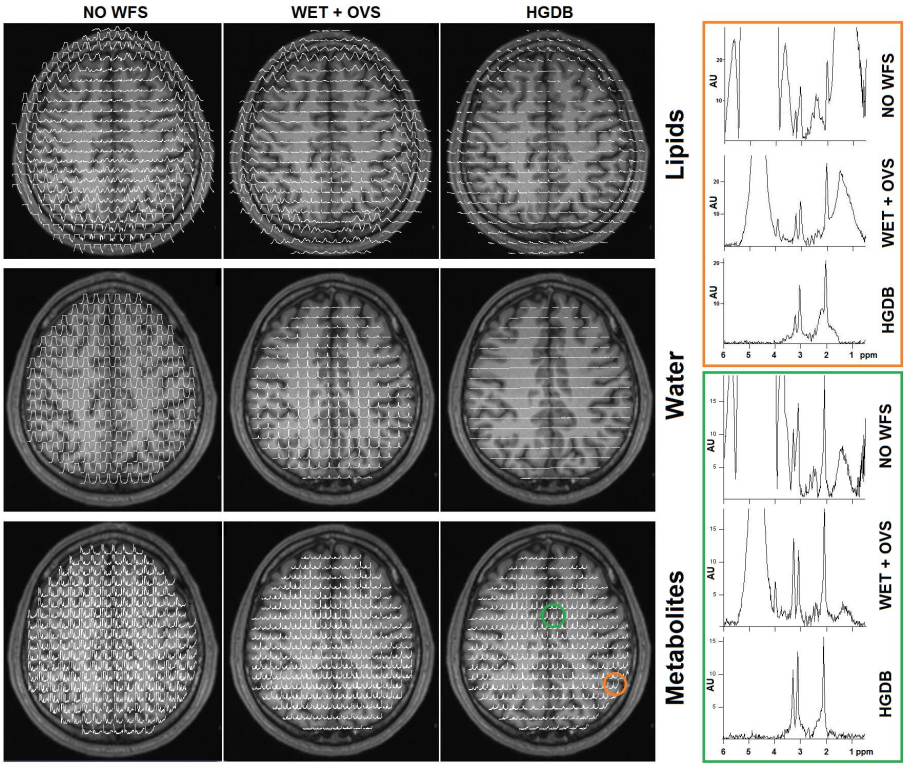

Figure 2: In-vivo MRSI: (left) no water and fat suppression; (middle) standard water suppression (WET) with lipid outer volume suppression (OVS); (right) HGDB + MEGA dual band water and fat suppression. Spectral grids are shown for lipids (0.5 – 2.0 ppm), water (4.0 – 6.0 ppm), and metabolites (1.8 – 4.2 ppm) frequency range. Example of spectra from voxels at the periphery (red) and center (green) of the brain are shown on the right. Spectra are scaled equally for comparison.

RESULTS: HGDB based water and fat suppression was compared to WET[5] with OVS (8 saturation bands), and to no suppression. The HGDB based pre-saturation and MEGA editing completely suppressed water over the entire FOV. A suppression factor close to 100 was obtained for lipids signals at 1.2 and 0.9 ppm. By comparison WET and OVS contained large water and lipid signals. Results are summarized in Fig 2.

DISCUSSION/CONCLUSION: HGDB pulses provide efficient water and fat suppression for full brain 3D MRSI. The HGDB suppression is superior to traditional WET and OVS schemes and it can be combined with adiabatic spin echo to provide a fully adiabatic metabolic imaging sequence that is robust with respect to B1 inhomogeneity at 3T over the entire head.

REFERENCES: [1] Zhu et al, MRM 2010, 63:1486-92; [2] Andronesi et al, JMR 2010, 203:283-293; [3] Mescher et al, NMR Biomed 1998, 11:266-72; [4] Bogner et al, Neuroimage 2013, 88C:22-31; [5] Ogg RJ et al, JMR B 1994, 104:1-10.