Focused RF in high field 1H-MRSI: outer volume suppression by local excitation

V. O. Boer[1], I. J. Voogt[1], H. Kroeze[1,2], B. L. van de Bank[1], A. H. Westra[2], P. R. Luijten[1], and D. W. Klomp[1]
[1]Radiology, UMC Utrecht, Utrecht, Utrecht, Netherlands, [2]MTKF, UMC Utrecht, Utrecht, Netherlands

Introduction

At ultra high B_0 field like 7 Telsa the use of spatial localization methods for in vivo ^{1}H-MRS is hampered by severe chemical-shift-displacement artefacts or long echo times due to limited B_1^+ fields. FIDLOVS [1] has been suggested as an appropriate alternative. It uses outer volume suppression (OVS) combined with pulse acquire FID acquisition and chemical shift imaging (CSI), but its inherent high RF power deposition due to the OVS scheme requires long TR and measurement times. Here we present the use of a low power alternative by using a VAPOR-like lipid suppression with an RF headband; an eight element transmit/receive array to generate focused RF on the skull area for suppression of subcutaneous lipids. Two sets of RF phases and amplitudes are generated to drive the RF headband for both local saturation of subcutaneous lipid signals (fig 1a) and uniform excitation of brain tissue using a quadrature RF-shimset (fig 1b). In this way RF power deposition is reduced significantly compared to a full OVS scheme and the use of a short TR is possible to achieve a high SNR per unit of time for 7T MRSI. A pulse-acquire CSI sequence is used to sample full signal intensity with low chemical shift displacement artifacts at short TE and TR for maximum sensitivity.

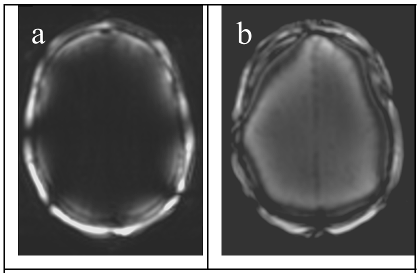

Fig 1. spin echo images acquired with the 8 channel RF headband;
a: excitation close to the elements for OVS
b: excitation of the brain.

Methods

The home-built close fitting RF headband was consisting of 8 small, elliptical transmit/receive elements (3x7cm). The close fit enables maximum RF-transmit and receive efficiency. The coil was driven by 8x1kW amplifiers where phase and amplitude settings were controlled independently. The coil was interfaced to a whole body 7T MR system (Philips, Cleveland, USA). Two series of RF-shim settings were generated. The first RF-shim set was used for excitation of the area of subcutaneous lipids (fig.1a). Since the B_1^+ field close to the transceive elements was very inhomogeneous, a 6-pulse VAPOR-like lipid saturation sequence (fig 2) was designed with optimized timings and flip angles, taking a factor 5 of B_1^+ variation and T_1 variation from 300 to 600 ms into account. The second RF-shim set (fig.1b) was used for traditional B_1^+ and T_1 insensitive VAPOR water suppression [2]. The two VAPOR sequences were merged within the MRS sequence by switching between the appropriate RF shim settings for each RF pulse. A slice selective excitation pulse was combined with CSI for localized pulse acquire ^{1}H-MRSI. (TE/TR=1.41/1500ms, voxel=1cm^3, acquisition time=6min).

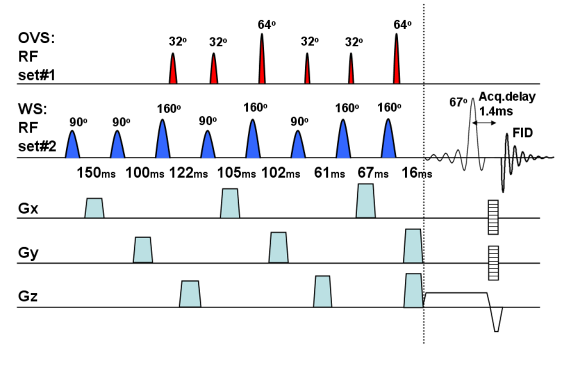

Fig 2. MRSI sequence; an interleaved 8-pulse VAPOR water suppression and 6-pulse VAPOR lipid suppression were used in homogeneous and ring excitation mode respectively.

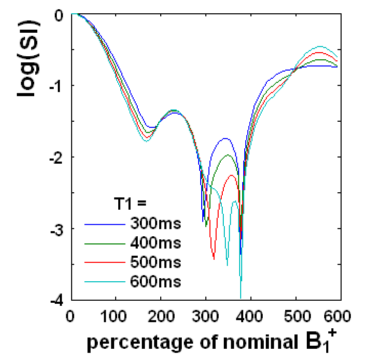

Fig 3. Simulation of suppression efficiency for the 6 pulse VAPOR-like lipid suppression vs the nominal B_1^+

Results

Simulations of the optimized VAPOR-like lipid suppression scheme show at least a factor 10 suppression for a factor of 5 B_1^+ variation to compensate for the high and inhomogeneous B_1^+ field near the coils (fig 3). Experiments without (fig 4a) and with (fig 4b) the ring-mode outer volume suppression show how lipid suppression is approximately a factor 15 (e.g. 6 percent lipid signal remaining in the skull area). Results from the localized spectroscopy close to the skull are shown in figure 4c. No lipid distortions are visible in the spectrum. Figure 4d shows the spectral quality of the MRSI data, the relatively high MM contribution is caused by the high sensitivity of the measurement for short T1 (short TR) and T2 (short TE) components.

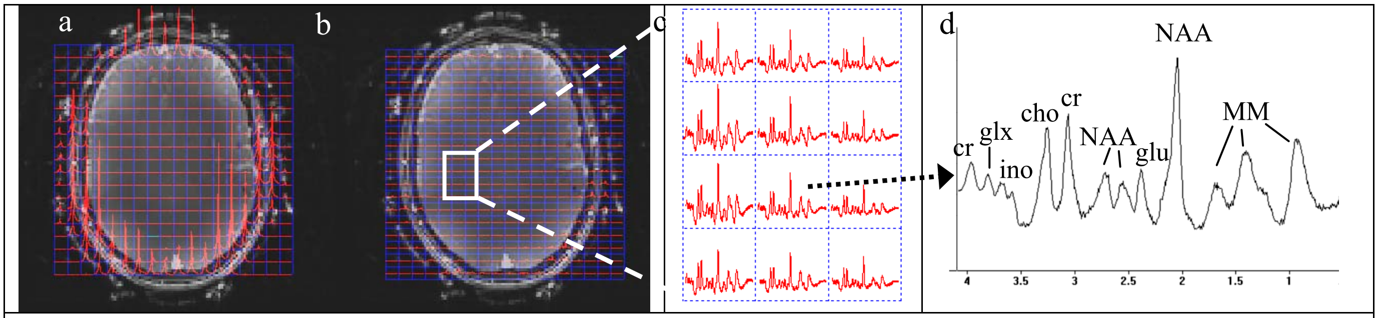

Fig 4. Short TE MRSI dataset without (a) and with (b) the proposed OVS method. On the right an enlarged figure, spectra displayed from 0 to 4 ppm after 1st order phase correction to compensate the small acquisition delay (1.4 ms). 1cc voxels, 6 minutes acquisition time.

Conclusion

An 8 channel RF headband is used for low power lipid suppression with an optimized VAPOR-like sequence. This enables 7T MRSI within short measurement times, with low chemical shift displacement artifacts and with short TE and short TR for maximum sensitivity.

(1) Henning, NMR Biomed. 2009 (2) Tkac, MRM 1999 41(4):649