Comparison of Metabolite Quantification in the Human Brain at 4 and 7 Tesla

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INTRODUCTION

Short-echo ^{1}H NMR can be used to measure a high number of metabolites ("neurochemical profile"). The specific advantage of increasing B_0 however, has not been demonstrated. The aim of the present study was to quantify the potential gains of ^{1}H NMR spectroscopy in humans by increasing the B_0 from 4 to 7 Tesla.

METHODS

All studies were performed in a strictly paired fashion (10 volunteers) in a 4T (Oxford) and a 7 T (Magnex) magnet, each equipped with a Varian INOVA console. The location of voxels, number of scans, localization method (ultra-short echo STEAM), VAPOR water suppression, shimming (FASTMAP) and the used quadrature half-volume RF coil design was identical [1]. Quantification of spectra was performed relative to tissue water signal and using LCModel analysis, including an experimentally measured macromolecule spectrum [2].

RESULTS AND DISCUSSION

At both B_0, excellent spectral quality was achieved due to the high number of scans and use of surface coil transceiver (Fig. 1). The higher B_0 resulted in two striking differences, namely the poorer resolution of homonuclear J-coupling and the apparent decrease in linewidth especially for J-coupled resonances. Both effects were clearly discernible for e.g. Glu H4 (2.36ppm) and explained by the B_0-independence of the J-coupling.

LCModel analysis resulted in a highly consistent neurochemical profile (Fig. 2 bottom), whereas the Cramer-Rao lower bounds (CRLB) were decreased by ~2-fold (Fig. 2, top), implying that at 7T, a 2-fold smaller VOI can be measured than at 4T without a decrease in SNR. For some compounds, notably Glu, Gln, Cr, and PCr, the decrease in CRLB was ~2.4-fold. The supralinear decrease in CRLB can be explained by the increased spectral resolution especially for J-coupled resonances.

CONCLUSIONS

We conclude that the neurochemical profile can be reproduced at 4 and 7 Tesla and that increased B_0 leads to substantial increases in sensitivity for ultra-short echo time MRS, which should aid in the study of individual patients in small brain areas.

References: [1] Tkac et al, Magn Reson Med 46, 451 (2001); [2] Pfeuffer et al, J Magn Reson 141, 104 (1999).

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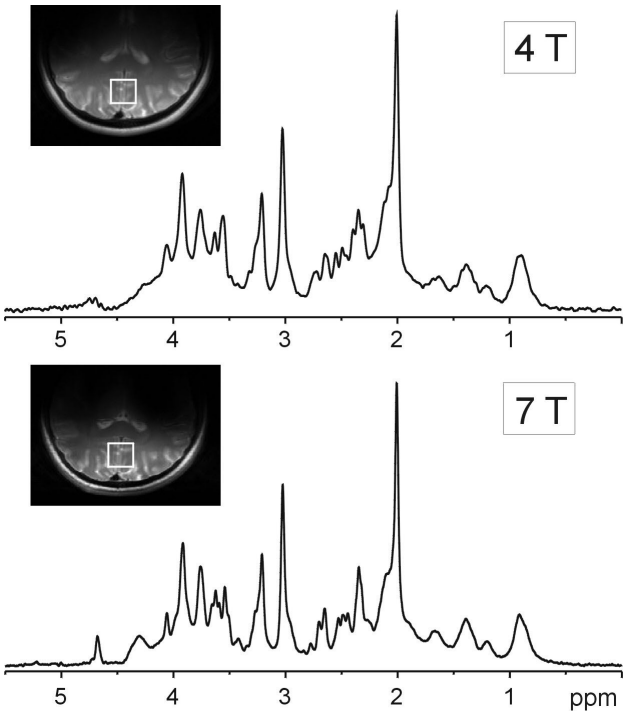

Fig. 1 *In vivo* ^{1}H NMR spectra measured from occipital lobe at 4 T and 7 T. STEAM, TE = 4 ms (4 T), TE = 6 ms (7 T), VOI = 8 ml, NT = 160. Identical processing.

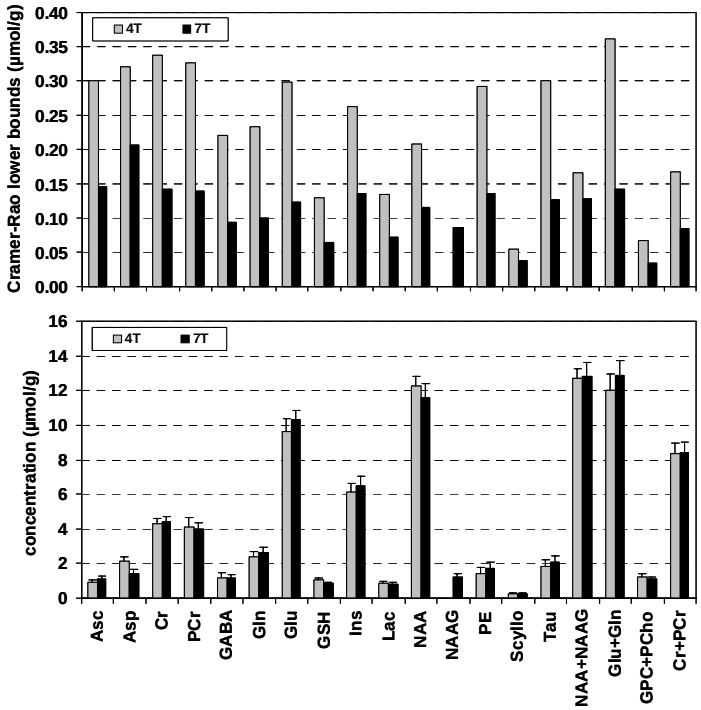

Fig. 2 Concentrations of brain metabolites in occipital lobe of the same 10 subjects measured at 4 T and 7 T and corresponding Cramer-Rao lower bounds of the LCModel fit. Error bars denote SD.