Validation of Human Brain Vitamin C Concentration Measured Noninvasively Using Short-Echo Time ^{1}H MRS at 7 T Versus MEGA-PRESS Edited Spectra

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Introduction

Noninvasive quantification of vitamin C (ascorbate, Asc) concentration using edited ^{1}H MR spectroscopy has been validated in the human brain (1). Quantification of Asc concentration using short echo time ^{1}H MR spectroscopy in the human brain would allow for quantification of the rest of the neurochemical profile and would minimize the influence of T_2 relaxation on signal intensities. Reliable quantification of Asc concentration from short echo time spectra has been demonstrated in the rat brain at 9.4 T (2), in spite of strong overlap with glutathione (GSH), glutamine (Gln) and glutamate (Glu) (2). The purpose of this study was to assess reliability of quantification of Asc concentration in the human brain using short echo time spectra measured at 7 T.

Methods

Short echo time and edited spectra were measured in identical occipital cortex VOI of 8 human volunteers. Ultra-short echo-time (TE = 6 ms) spectra were measured using STEAM (3) and Asc edited spectra were measured using MEGA-PRESS (1) with the 40 ms Gaussian editing pulse at 4.01 ppm. Metabolite concentrations were measured using LCModel and water (STEAM) or creatine (MEGA-PRESS) as an internal reference. All experiments used a 7 T, 90 cm magnet (Magnex), a Varian spectrometer, a surface quadrature transceiver (4) and FASTMAP shimming (5).

Results

LCModel analysis of representative spectra is illustrated in fig. 1. Using STEAM, Asc concentration was measured at 1.2 ± 0.3 µmol/g (mean ± SD) with CRLB ≤ 11 %, and the correlation coefficient between Asc and all other metabolites was never more negative than -0.2. Using editing, the Asc resonance was fully resolved, and Asc concentration was measured at 1.2 ± 0.2 µmol/g (mean ± SD) with CRLB ≤ 8 %. Correlation between the two methods for each individual subject is illustrated in fig. 2.

Discussion and Conclusions

Asc concentrations measured using ultra-short echo time versus edited spectra were in excellent agreement, indicating that the unresolved Asc resonances in the short-echo time spectra were measured accurately using LCModel. Although the limited range of Asc concentrations detected was too small relative to the measurement error to establish correlation, a linear relationship in concentrations measured using the two techniques was apparent (fig. 2). Reliable quantification was facilitated by several features of the short echo time spectra. Highly efficient water and outer volume suppression as well as detection at short TE resulted in a spline baseline that was highly repeatable among subjects and reasonably flat over a broad range of chemical shifts. As such, resonances from several multiplet groups contributed a unique spectral fingerprint for each compound. B_0 inhomogeniety was minimized efficiently and consistently, further improving spectral quality. Quantification of metabolite concentrations from measured spectra was fully automatic, eliminating operator bias. Because T_2 shorten with increasing field strength, quantification of Asc concentration using short echo time spectroscopy is particularly advantageous to signal to noise measured at ultra high field.

References and Acknowledgments: 1) Terpstra et al, Magn Reson Med, 51: 225, 2004. 2) Terpstra et al, Magn Reson Med, 55: 979, 2006. 3) Tkac et al, Appl Magn Reson, 29: 139, 2005. 4) Adriany et al, Magn Reson Med, 125: 178, 1997 5) Gruetter et al, Magn Reson Med, 43: 319, 2000. Supported by NIH: NIA R21AG029582 and BTRR P41RR008079.

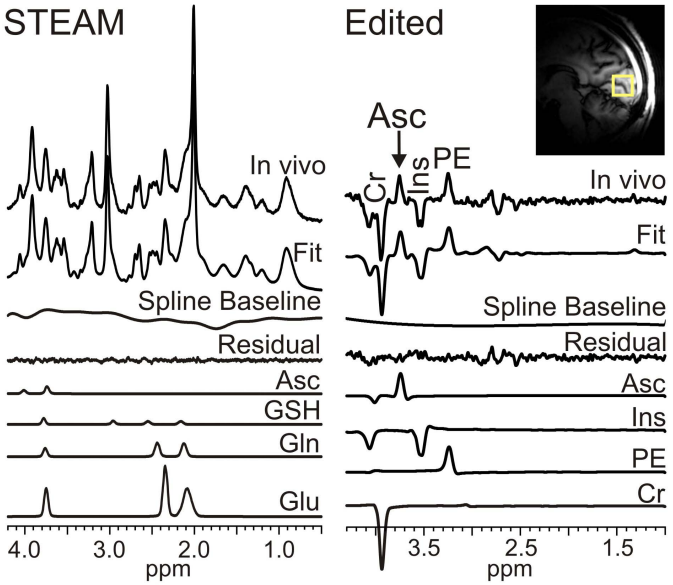

FIG. 1. In vivo STEAM (TE = 6 ms, TR = 5 s, TM = 32 ms, NEX = 160) and MEGA-PRESS edited (TE = 112 ms, TR = 5 s, NEX = 512) spectra measured from the VOI (8 cm^3) outlined in the mid-sagittal TURBOFLASH image and LCModel analysis. Ins = *myo*-inositol, PE = phosphorylethanolamine, and Cr = creatine.

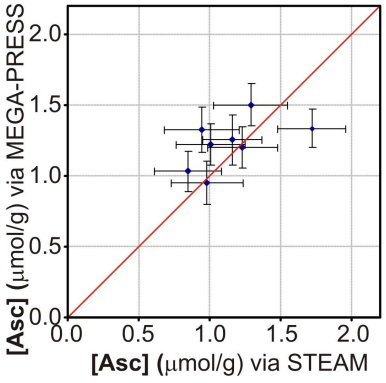

FIG. 2. Asc concentrations measured with ultra-short echo-time STEAM versus MEGA-PRESS edited ^{1}H MR spectroscopy in matched occipital cortex VOI of 8 human subjects.