The reliability of vitamin C (Asc) detection in human brain using standard PRESS on a clinical 3T MR-scanner

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Introduction

The importance of vitamin C (Asc) has been reported in several studies, including the stimulating effect on the immune system and protection against diseases from oxidative stress. The concentration of Asc is sufficiently high to be detectable in brains via MRS, allowing successful applications as recently reported in rats at 9.4T [1] and human subjects at 4T with spectral editing [2] to solve the spectral overlapping of Asc and other metabolites, such as glutamine, glutamate and myo-inositol. The goal of this study is to evaluate the accuracy of the detection in Asc concentration in human brain using standard 3T MRS. First we used the traditional PRESS to acquire the spectra with LCModel [3] analysis to verify the stability of Asc detection. Then three of the *in vivo* spectra were dealt with virtual titration, which added the artificial Asc spectrum into those *in vivo* spectra, to check the accuracy of the concentration evaluation in Asc and discuss the effects to other nearby metabolites.

Materials and Methods

Data analysis covered 76 single voxel spectra (SVS) data sets acquired on a 3T Siemens Magnetom Trio (PRESS, voxel size 8 cm^3, TE=30 msec, TR=3000 msec). These spectra were fitted with LCModel using a standard basis data set with and without vitamin C. In addition virtual titrations were carried out as simulations taking the measured data (FWHM= 0.033, 0.043 and 0.076 ppm) in combination with the artificial added Asc signal of different SNR levels (SNR=5, 10, 20) and concentrations (0.1mM to 2.0mM). These modified data were analyzed via LCModel. Virtual titrations repetitions (10 times on each case of different SNR levels) lead to concentration standard deviations of different metabolites and evaluated effects of SNR on estimation accuracy.

Results

The Asc concentration could be successfully detected in 71 spectra and the relation between the concentration difference and the estimated concentration of Asc is shown in Fig. 1(a). The concentrations of Choline (GPC+PCh) and mI are not affected on both analyses. Glx (sum of glutamine and glutamate) increases if the Asc basis was excluded during the analysis and its concentration difference between both analyses enhances as the Asc concentration increases. Table 1 shows the spectral concentration in the case of FWHM 0.076ppm after virtual titration. The standard deviations of the estimated concentrations become larger with decreasing SNR in all metabolites, and the concentration variation of Asc is less than 10% at SNR= 20. Fig. 1(b) shows good linearity (R^2>0.985) between the artificially added and the estimated Asc concentration in three different cases. The line-width effects of virtual titration on other metabolites are shown on Fig. 1(c). When the added Asc concentration is less than 1.0mM, the concentrations of Glx and mI are almost unchanged in the cases of narrower spectral line width (FWHM=0.033, 0.043ppm).

Discussion and Conclusion

The average Cramér-Rao lower bound (CRLB) of Asc (11%) is larger than that of Glx (7%) and still fits the criteria of LCModel. Hence, the Asc concentration could be reliably detected using standard PRESS. If the Asc spectrum was not included into the standard basis set, over-estimation of Glx concentration occurs. The SNR of the spectrum affects the precision on concentration evaluation, where the lower SNR leads to a more severe variation in the results. The SNR between 10 and 20 would be a reasonable requirement for *in vivo* spectra for Asc detection. Although Fig. 1(b) shows good linearity between the added and the estimated concentration of Asc, different line-widths would influence the results of neighboring metabolites. These metabolites (for example, mI and Glx) would be less affected if the spectra were acquired with better spectral resolution, at least less than 0.043 ppm in our study. Therefore it is of advantage to include Asc into analysis not only to detect and quantify Asc concentration but also to increase accuracy of neighboring metabolites whose concentrations otherwise might be overestimated.

References

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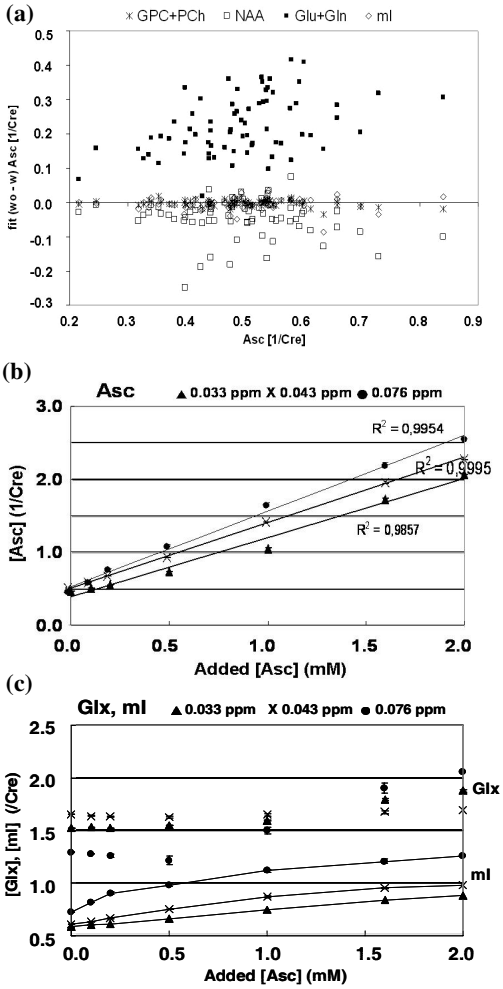

Fig.1 (a) The concentration differences between without and with Asc included in basis set vs. Asc concentration. (b) The estimated concentration of Asc, (c) the estimated concentration of mI and Glx vs. the added Asc concentration with different line-width values.

Std. (1/Cre)	SNR=5	SNR=10	SNR=20
Asc	0.139	0.077	0.045
Glx	0.225	0.055	0.048
mI	0.053	0.037	0.016
NAA	0.062	0.035	0.017
GPC+PCh	0.024	0.013	0.006

Table 1 The concentration standard deviations of several metabolites with different SNR level on added Asc concentration 2.0mM in the case of line-width= 0.076ppm.