In vivo liver ^{31}P MRS at 7T: Initial experience

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Purpose/Introduction

^{31}P-MRS provides unique information on hepatic energy metabolism *in vivo*. Alternations in hepatic energy metabolism are indicative for inflammatory and neoplastic liver diseases and were demonstrated in T2DM patients [1]. The major limitation of hepatic ^{31}P-MRS was low signal sensitivity at clinical scanners and from that resulting long acquisition times. Nowadays, several fold higher SNR is available at human whole body 7T MR scanners. The purpose of this study was to test the feasibility of hepatic *in vivo* localized ^{31}P-MRS at 7T in clinically acceptable measurement time.

Subjects and Methods

Data were acquired on a 7T and 3T MR systems (Siemens) using double-tuned surface coils (^{1}H/^{31}P) (RAPID Biomedical, Columbus, OH), with a diameter of 10 cm. During *in vivo* measurements volunteers (n=3) were lying in the lateral position with the lateral lobe of the liver on the surface coil.

A 1D-ISIS slab (TR 1.5s, slab thickness 30mm, TA 1:48 min) with spatial selection by adiabatic GOIA inversion pulses placed approximately parallel to the coil. The other two dimensions were defined by the boundaries of the coil sensitivity. The results were compared to a single voxel 3D-ISIS sequence (55×55×40 mm; TR=3s, 36×2=72 acquisitions, TA 3:37 min) [2] and a hybrid 1D-ISIS/2D-CSI sequence based on [3] with minimal chemical shift displacement error (8×8 voxels, nominal resolution 25×25×30 mm, TR 1.5s, TA 6:14 min). Linewidths were defined as full width at half maximum (FWHM) of γ-ATP. SNR was calculated in frequency domain after applying a matched filter. Contamination was determined from PCr/ATP ratios, which were additionally corrected for known concentration differences.

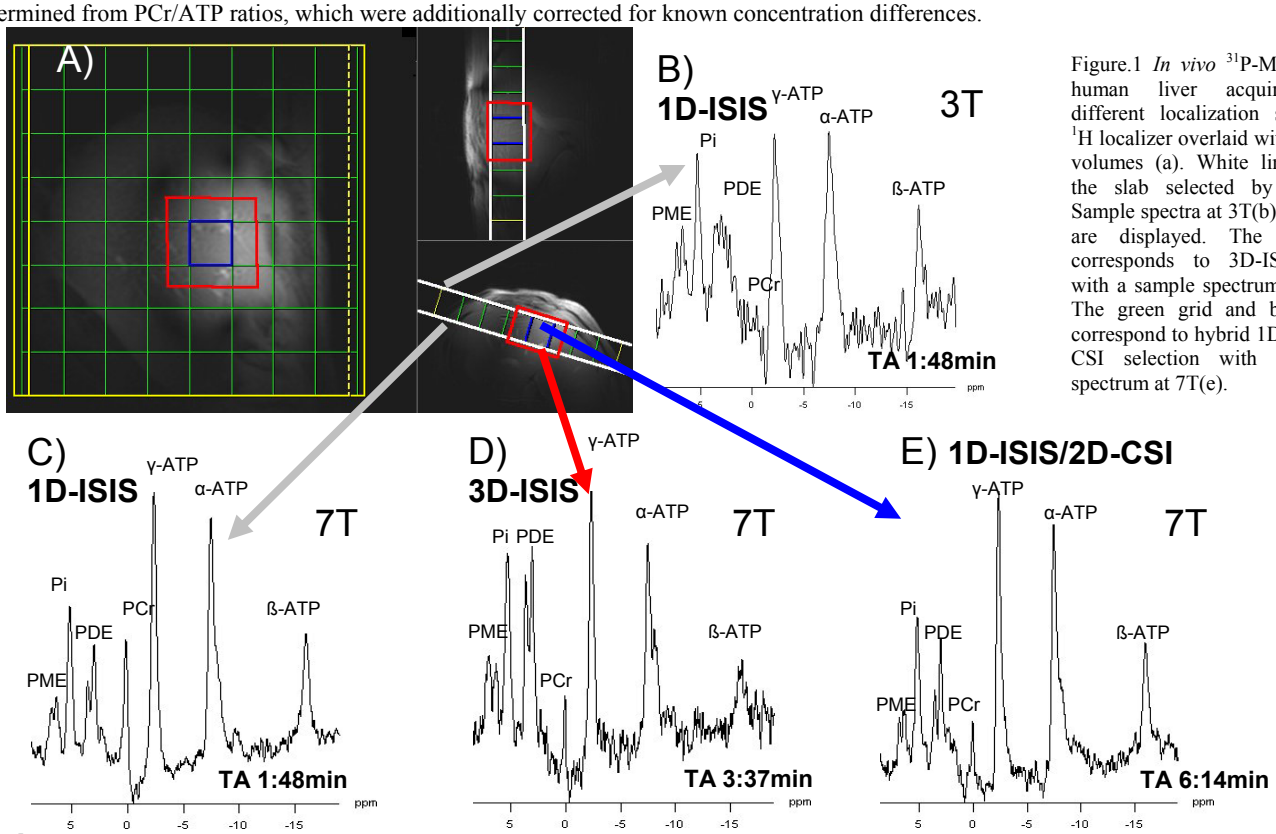

Figure.1 *In vivo* ^{31}P-MRS in the human liver acquired with different localization sequences. ^{1}H localizer overlaid with selected volumes (a). White lines define the slab selected by 1D-ISIS. Sample spectra at 3T(b) and 7T(c) are displayed. The red box corresponds to 3D-ISIS voxel with a sample spectrum at 7T(d). The green grid and blue voxel correspond to hybrid 1D-ISIS/2D-CSI selection with a sample spectrum at 7T(e).

Results

All tested sequences at 7T provided acquisition of spectra with high spectral quality (Fig.1 c-e) in acceptable measurement times. This was demonstrated by significantly increased SNR at 7T ($SNR_{1D\text{-}ISIS}$=38.2 , $SNR_{3D\text{-}ISIS}$= 22.9, $SNR_{1D\text{-}ISIS/2D\text{-}CSI}$=28.7) compared to 3T ($SNR_{1D\text{-}ISIS}$=13.5 Fig. 1b, $SNR_{1D\text{-}ISIS/2D\text{-}CSI}$=9.8) The linewidths were slightly increased at 7T ($FWHM_{1D\text{-}ISIS}$=55Hz, $FWHM_{3D\text{-}ISIS}$= 45Hz, $FWHM_{1D\text{-}ISIS/2D\text{-}CSI}$=48Hz) compared to 3T ($FWHM_{1D\text{-}ISIS}$=40Hz, $FWHM_{1D\text{-}ISIS/2D\text{-}CSI}$=38Hz), but due to higher frequency dispersion at 7T better separation of overlapping PDE, Pi, and PME metabolite signals was achieved. Contamination by PCr in the muscle was at 7T 4.4% for 1D-ISIS, 1.5% for 3D-ISIS and 1% for 1D-ISIS/2D-CSI accounting for difference in concentrations ([ATP] in liver 2.5mmol/l and [PCr] in muscle 20mmol/l).

Discussion/Conclusion

Hepatic ^{31}P-MRS at 7T provides improved data quality in shorter measurement times than at 3T. 3D-ISIS and 1D-ISIS/2D-CSI localization provide excellent localization, whereas 1D-ISIS provides highest SNR in shortest time but higher contamination.

References

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[3] Mlynarik et al. MRM 2006 Nov;56(5):965-70