First Results of Proton Decoupled and NOE enhanced ^{31}P MRSI of the Human Brain at 3T Exhibit Correlations with Age

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Introduction

The primary objective of this study was to audit a possible benefit of the field strength of 3T as compared to 1.5T for the determination of metabolites of the human brain cell membrane turnover with phosphorous (^{31}P) magnetic resonance spectroscopic imaging (MRSI) using nuclear Overhauser enhancement (NOE) and full proton decoupling. To our knowledge, there is no report in the literature of fully decoupled human brain ^{31}P-MRSI at 3T up to date. Secondly, we aimed to corroborate age correlations from RINEPT edited, 3D localized ^{31}P spectra of the human brain [1,2] obtained at 1.5T [Ende et al., abstract this meeting].

Methods

A cohort of 6 healthy volunteers (age 35 ± 9 years (mean ± SD), 4 female) participated in this study. Measurements were performed on a Siemens 3T Trio scanner with TIM technology (Siemens Medical Solutions, Erlangen, Germany) with a double resonant ^{31}P-^{1}H circularly polarized head coil (Rapid Biomedical, Wuerzburg, Germany). A 2D ^{31}P-MRSI slice was axially positioned containing frontal cortex, basal ganglia, thalamus and cerebellum (see Fig. 1). Measurement parameters: FOV 320 mm, slice thickness 30 mm, 8 x 8 weighted encoding zero filled to 16 x 16, spatial Hamming filter, nominal voxel volume 48 ml, TR 1500 ms, flip angle 40°, 96 acquisitions, 256 ms acquisition, bandwidth 4 kHz, NOE enhancement and full decoupling on the proton channel (WALTZ-4). Postprocessing parameters: Spectral Hanning filter, zero filling to 2048 spectral points, phase and baseline correction. In addition, one of the volunteers was also measured on a Siemens 1.5T Vision Plus scanner equipped with a second channel and a double resonant ^{31}P-^{1}H circularly polarized head coil (Rapid Biomedical). All measurement parameters were identical to the above, except: 8 x 8 elliptical encoding, 32 acquisitions. MRSI acquisition time was 21 minutes on both scanners. The shim of the MRSI slices was manually optimized.
The spectra were fitted using spectroscopy processing software supplied by the manufacturer. The following metabolites were assessed: phosphoethanolamine (PE), phosphocholine (PC), glycerophosphoethanolamine (GPE), glycerophosphocholine (GPC), phosphocreatine (PCr), inorganic phosphate (Pi), and adenosine 5'-triphosphate (ATP). Additionally, broad unspecified membrane phospholipids (PL) and uridine diphosphate sugars (UDP) were added. Data analysis was done by the use of SPSS for WINDOWS release 14. For the correlation analyses values of $p < 0.05$ were considered statistically signifcant.

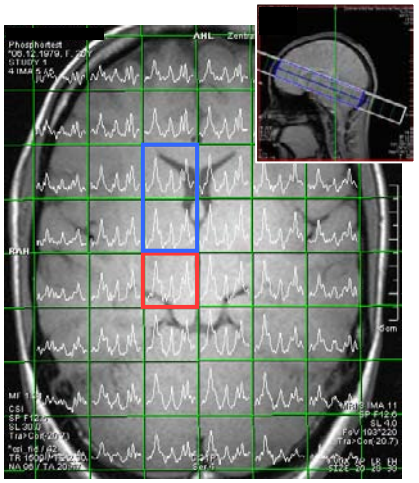

Figure 1: 2D localized ^{31}P spectra in the spectral range of the phosphomono- and phosphodiesters (1 ~ 9 ppm). The inset shows the positioning of the MRSI slice. A full spectrum is given in Fig. 2a). Regions analyzed in Fig. 3 are marked in corresponding color.

Results

Fully proton decoupled and NOE enhanced 2D localized ^{31}P spectra of the human brain were measured at 3T (N = 6) and 1.5T (N = 1). With a TR = 1.5 s SAR limits were well within the allowed limits. Superior spectral resolution of phosphomono- and phosphodiesters in the spectral range 1 ~ 9 ppm was obtained at 3T (Fig. 1 & 2). Fitted sample spectra at 3T and 1.5T are shown in Fig. 2 a) and b). At 1.5T, PE and PC, and GPE and GPC could not consistently be separated from each other. These first preliminary data convincingly corroborated the significant positive correlation of the ratio GPE / PE with subject age obtained at 1.5T [Ende et al., abstract this meeting] in the right thalamus and pons (Fig. 3, R = 0.913, p = 0.011) and in the right basal ganglia region as well (Fig. 3, R = 0.873, p = 0.023) in this small subjects cohort and without the use of spectral editing techniques.

Discussion

The results demonstrate superior spectral resolution of phosphomono- and phosphodiesters in the human brain at 3T as compared to 1.5T leading to reliable separation of especially PE, PC, Pi, GPE, and GPC. In addition, broad contributions underlying these resonances at 1.5T originating from unspecified phospholipids are strongly reduced at 3T, facilitating and improving spectral fitting. The replication of significant correlations of GPE/PE with subject age in the thalamus, pons, and basal ganglia region strongly suggest that proton decoupled and NOE enhanced ^{31}P MRS at 3T is capable of detecting alterations in metabolites of cell membrane turnover in clinically available scanners. More sophisticated techniques like RINEPT at 3T may increase the significany of the results even more.

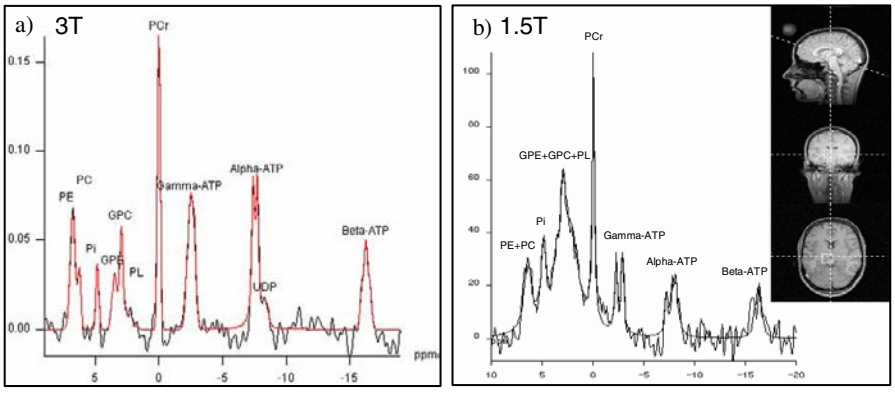

Figure 2: Localized ^{31}P MRSI sample spectra with line fit obtained at a) 3T and b) 1.5T originating from one volunteer (f, 26y) in the same anatomical location, measured on two subsequent days. MRSI slice positioning was done image guided using anatomical landmarks.

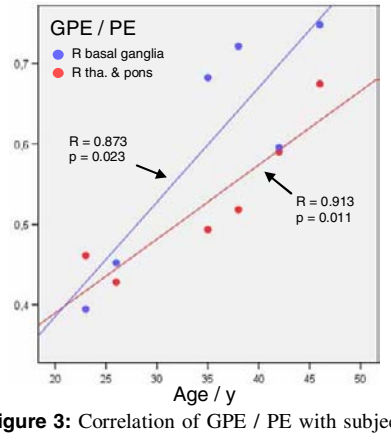

Figure 3: Correlation of GPE / PE with subject age in voxels containing right basal ganglia, and right thalamus and pons (N = 6).

References

[1] T. Wokrina, G. Ende, Proc. ISMRM, Miami, 347 (2005).
[2] T. Wokrina, M. Ulrich, G. Ende, Proc. ISMRM, Seattle, 2081 (2006).