1H and 31P spectroscopy: High energy metabolism in idiopathic Parkinson syndrome

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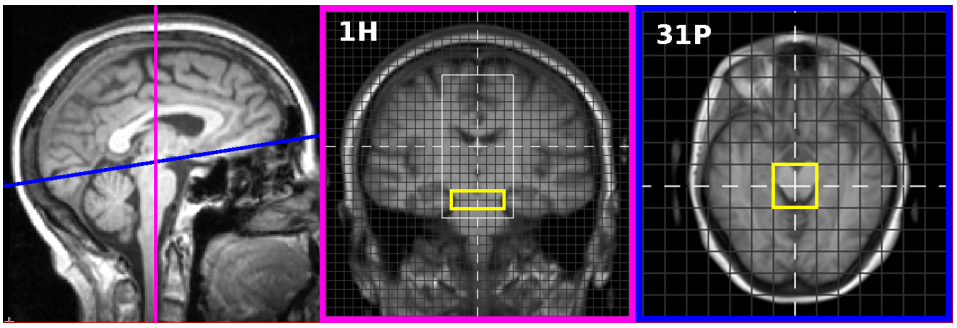
Introduction

Mitochondrial dysfunction is believed to play a pivotal role in the pathogenesis of the idiopathic Parkinson syndrome (IPS) (Shapira, 1995). Since the midbrain is preferentially affected by the disease, we applied ^{31}P and ^{1}H MRSI to monitor changes in energy metabolism of this brain region.

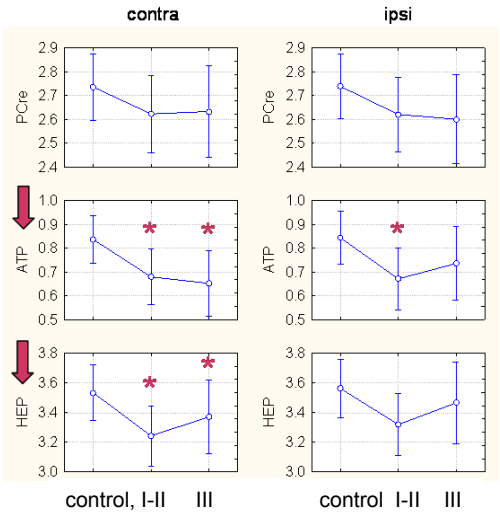
Methods

MRSI of the brain was performed on a 3 Tesla whole body system (Magnetom Trio, Siemens Medical AG, Erlangen, Germany) with a double tuned ^{1}H/ ^{31}P volume head coil (Rapid Biomedical, Würzburg, Germany). ^{1}H MRSI (TR 1500 ms, TE 30 ms, 2 acquisitions, 28 x 28 matrix extrapolated to 48 x 48, 240 x 240 mm^2 FOV, 10 mm slice thickness) of the midbrain was obtained by a coronal slice positioned as shown in Fig.1. For ^{31}P spectroscopy, a 3D MRSI with WALTZ4 proton decoupling was used (60°, TR 2000 ms, TE 2.3 ms, 10 acquisitions,10 x 10 x 8 matrix extrapolated to 20 x 20 x 16, 300 x 300 x 200 mm^3 FOV) oriented as shown in Fig 1. For taking into account partial volume effects originating from the cerebrospinal fluid, the fraction of grey and white matter contributing signal to each voxel were calculated (Hetherington *et al.*, 1996, Mason *et al.,* 1998) based on segmented T1 weighted 3D images of the total brain which were aligned to the MRSI slab followed by digital filtering to mimic the effect of the poor point spread function and resolution caused by the limited number of phase encoding steps (Gasparovic *et al.,* 2006). The resulting parameter maps provided a value for the partial volume of grey and white matter for each MRSI voxel. The ^{31}P spectra were analysed in the time domain with the jMRUI software tool (Version 3.0, http://www.mrui.uab.es) employing a non-linear least square fitting algorithm (AMARES) (Vanhamme *et al.*, 1997). The ^{1}H MRSI spectra were fitted with LCModel (Provencher, 1993). Absolute concentrations were calculated by referring to an independent measurement with a spherical phantom containing a solution of 20 mmol/l creatine and 20 mmol/l phosphate. Correction terms for longitudinal (T1) and transversal relaxations were applied. The selection of corresponding ^{1}H and ^{31}P data for the midbrain are depicted in Fig. 1. Mean values for each metabolite were separately calculated for both cerebral hemispheres. The latter were assigned ipsi- and contralateral to the clinically most affected body side in patients with Parkinson's disease. For healthy subjects, the data of both hemispheres were averaged. Mean values for the tissue fraction of the target area was calculated as sum of grey and white matter fractions. For statistical analysis multivariate ANOVA was used with coil loading and tissue contents as covariates. Concentrations of metabolites related to cerebral energy metabolism (ATP, phosphocreatine (PCr), Pi, ADP (calculated by combining ^{1}H and ^{31}P data)) were analysed for significant difference with ANOVA Side related concentration differences were analysed by multivariate ANOVA with repeated measurements. Multivariate corrections were applied using a posthoc Scheffé test.



Results

Patients with IPS H&Y I-II and H&Y III showed a significant decrease in ATP and high energy phosphates (HEPs = ATP and PCr) contralateral to the clinically affected side. For the ipsilateral side, ATP was significantly decreased, but only in patients with IPS H&Y I-II (Fig.2).



Discussion

MRSI shows a significant decrease in of high energy phosphates in the midbrain of IPS patients. The decrease is more pronounced contralateral to the clinically more affected side (reflects crossing of neuronal tracts). This finding hints to limited energy supply, corroborating the hypothesis of mitochondrial dysfunction in this neurodegenerative disease.