A $^1$H MRS study at 3.0 Tesla of the anterior cingulate cortex in patients with borderline personality disorder and healthy controls

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Introduction:
The anterior cingulate cortex (ACC) has been implicated in the pathophysiology of borderline personality disorder (BPD). Several studies have reported anatomical and functional abnormalities in this region in BPD patients [1]. Only one study, however, has so far evaluated the ACC region with $^1$H MRS in BPD patients [2]. In our study we aimed to determine the absolute concentrations of the metabolites in the ACC region in unmedicated female patients with BPD compared to healthy controls.

Methods:
In vivo single voxel $^1$H MRS was performed at a 3T whole body MR scanner (Siemens, Erlangen, Germany) in 20 female BPD patients and 22 group-matched healthy controls (HC). We acquired a sagittal 3D mprage data set and reconstructed the coronal and transverse planes parallel and perpendicular to the long side above the corpus callosum. Our voxel position in the ACC region is very well defined: We placed the single voxel (15x30x12 mm$^3$) on the anterior edge of the corpus callosum and directly above it centered on the interhemispheric fissure (see figure 1).

Fig. 1: Sagittal (left) and reconstructed coronal (middle) and transverse (right) images for voxel placement at the ACC

Spectra were acquired with a PRESS sequence using the following parameters: TE = 80 ms, TR = 3000 ms, BW 2400 Hz, 2048 data points and 100 averages. An echo time of 80 ms was chosen to obtain a good separation of glutamate (Glu) from other metabolites [3]. Spectroscopic data from the ACC region are available for 20 patients (age 29.8 ± 8.2) and 22 group-matched healthy controls (age 27.9 ± 8.3). To quantify the psychopathological dimensions of anxiety, depression, impulsivity, borderline symptoms and dissociation all participants filled in the state-trait-anxiety-inventory (STAI), beck-depression-inventory (BDI), barratt impulsiveness scale (BIS), borderline symptom list (BSL) and the questionnaire for the assessment for dissociative symptoms (FDS). All participants were free of psychotropic medication. The MRS data were evaluated with LCModel [4] using a simulated basis data set for TE = 80 ms for all quantified metabolites (see figure 2). Spectral fits were accepted when the standard deviation of the fit was 20% or less. Last but not least a fully automated segmentation of the high resolution T1 weighted 3D images into grey matter (GM), white matter (WM) and cerebrospinal fluid (CSF) using SPM 2 algorithms and MATLAB 6.5 [5] was performed for each individual to determine the composition of the spectroscopic voxel.

Results:
All metabolites such as N-acetylaspartate (NAA), total creatine (tCr), total choline (tCho), glutamate (Glu) and myo-inositol (mI) passed the quality control (SD ≤ 20%). The main finding of this pilot study is a significant decrease of NAA, Glu and tCr in the ACC of female patients with BPD compared to healthy controls (see figure 3). As expected patients scored significantly higher on measures of anxiety (STAI), depression (BDI), impulsivity (BIS), severity of borderline symptoms (BSL) and dissociative symptoms (FDS). We found no significant correlation between neurochemical concentrations and psychometric findings. The segmentation of the ACC voxel corrected for chemical shifts of the individual metabolites resulted in a mean amount of 69.39% GM and 20.32% Liquor.

Discussion:
NAA is the most prominent peak in the spectrum of metabolites and represents a marker of neuronal functionality and viability. Decreased NAA may indicate disturbed neuronal functioning in the ACC of BPD subjects. Another study investigating the ACC region with MRS in BPD patients with comorbid attention-deficit hyperactivity disorder (ADHD) found increased NAA levels [2]. The authors argue that increased NAA might be due to ADHD and thus can not be extended to patients with BPD without comorbid ADHD. Tebartz van Elst et al. found decreased NAA in the left dorsolateral prefrontal cortex of patients with BPD [6]. The second main finding is a significantly lower level of Glu in patients with BPD. Glu is the most important excitatory neurotransmitter in the brain. A decrease of ACC Glu supports recent models of glutamatergic dysfunction in BPD [7]. Another important finding of our study is a lower level of tCr in the ACC of BPD patients. tCr represents a marker of the energy metabolism of neurons. A decrease of tCr may point to a dysfunction in energy metabolism in the ACC of BPD patients. In summary, these results might be associated with disturbed metabolism in a key region for affect regulation and emotional information processing.

References:

Fig. 3: Boxplots of NAA (left), Glu (middle) and tCr (right) concentrations in mmol/l in the ACC of healthy controls and patients with BPD