Sodium MR imaging in the study of hepatic encephalopathy

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Introduction

A recent study of the mechanisms of hepatic encephalopathy (HE) proposed by Häussinger and colleagues considers hyponatraemia as a precipitating factor in this disease [1]. Using MRI, we attempt to observe a disturbance of the sodium homeostasis in the CNS in HE patients. HE patients and healthy controls were recruited in order to analyse and compare sodium MR images. The structure of interest is the basal ganglia, where noticeable changes have been reported in HE [2]. The method envisaged for sodium data analysis is presented and preliminary results are shown.

Material and methods

Measurements were performed on a 4 Tesla Siemens scanner (Erlangen, Germany) using a dual-tuned ^{1}H / ^{23}Na headcoil (RAPID GmbH, Würzburg, Germany) and appropriately designed MRI sequences for sodium imaging. A 3D multiple gradient echo acquisition (MGE; acquisition parameters: FA = 60°, TR = 30 ms, 8 echoes, first echo 1.52 ms 25% asymmetry, echo spacing 3.58 ms, bandwidth 300 Hz/Px, resolution 5 mm isotropic, FOV 320 x 320 x 160 mm^3, 60 averages, acquisition time 35' performed in 3 steps) was chosen for sodium imaging and a magnetization-prepared rapid acquisition gradient echo sequence (MPRAGE; acquisition parameters: FA = 8°, TI = 700 ms, TR = 1500 ms, bandwidth 200 Hz/Px, resolution 1mm isotropic, FOV 192 x 192 x 176 mm^3, 2 averages, acquisition time 8') was additionally used to obtain structural information. A reference probe containing an isotonic (150 mM/l) salt solution was placed under the head of the patient / volunteer during the scan to provide a common reference. Including shimming and RF calibrations, the overall measurement time for each patient / volunteer was 60 min. Fifteen patients (9 men and 6 women from 43 to 86 years of age) and 5 healthy volunteers (2 men and 3 women from 55 to 77 years of age) have participated to the study to date. In the HE group, the grade of the disease [3] was HE0 in one case, mHE: 5, HE1: 3 and HE2 in 6 cases.

Results

Figures (1a) and (1b) show two transverse images intersecting the basal ganglia of an HE2 patient on the left and on the right of a healthy subject. A visual comparison of these scans does not reveal noticeable changes. To be able to detect small changes, the analysis was refined. The sub-cortical white matter and grey matter, the basal ganglia nuclei were segmented from the corresponding anatomical images in order to evaluate average sodium content in each of these structures. Figures (2a) and (2b) illustrate a typical ^{1}H / ^{23}Na image pair used in this study. Figures (2c) illustrates the distribution of the sodium MR signal in the pallidum for an HE subject (blue bars) and an age and sex-matched healthy subject (red bars). Such a histogram can be produced for each structure of interest and for each subject allowing us to observe the reproducibility of the measurement and possible group effects.
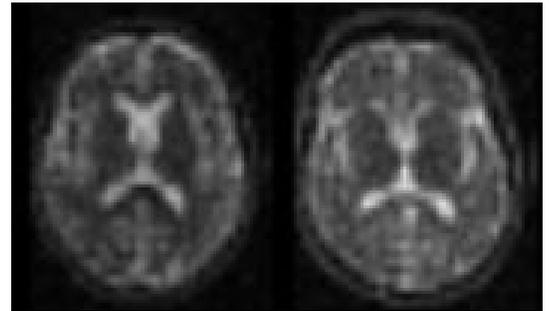

Figure 1 - Transversal images of the basal ganglia in a) a HE2 subject, b) a healthy control.
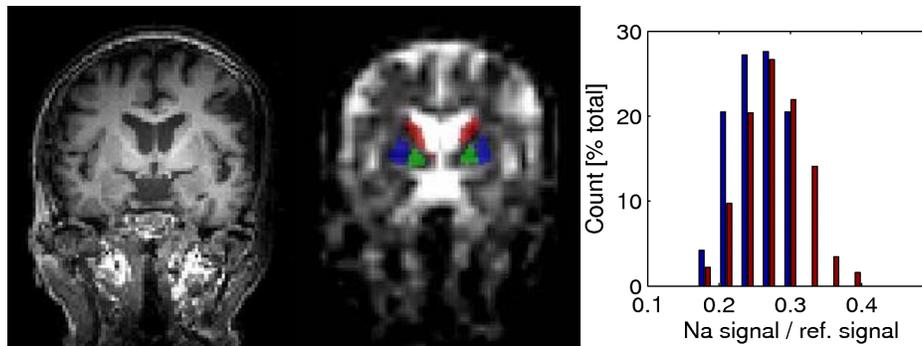

Figure 2 - a) Anatomical image allowing the delineation of brain structures. b) An aligned sodium image where masks of the basal ganglia are superimposed. c) Sodium image histogram in the pallidum in a HE patient (blue bars) and a control subject (red bars).

Discussion and Conclusions

Visual, qualitative observation of the sodium images from HE patients does not show obvious abnormalities such as the hyperintense regions observable in the basal ganglia on proton images of these patients. The method presented in this abstract aims to refine analysis of the sodium images in order to detect expected subtle changes hidden due to a limited SNR in sodium imaging. This method requires an accurate manual segmentation of the structures of interest and necessitates analysis of a large group of patients vs controls. About 20 patients and 20 age matched control subjects are expected to participate to this study in order to conclude whether or not significant changes can be observed in sodium images. A signal change may reveal sodium concentration changes or relaxation time variations [4] and both of these alternatives would have to be envisaged for the interpretation of the results.

References

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