Sodium MRI and 1H MRS in the Diagnosis and Monitoring of Primary Brain Tumors

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INTRODUCTION

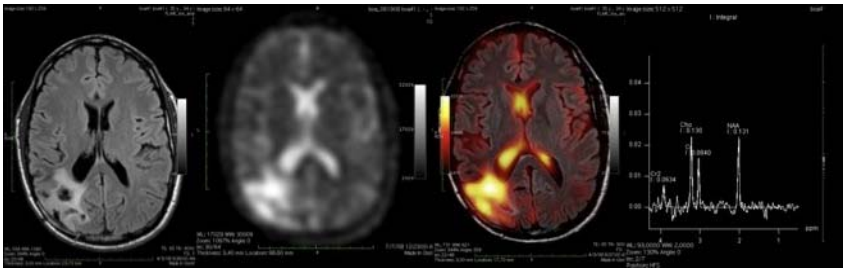
Proton magnetic resonance spectroscopy (MRS) has gained increased acceptance as a means for the diagnosis and monitoring of therapeutic response for primary brain tumors. This pathology is well known for is heterogeneous presentation and therapeutic response, which can sometimes make it challenging to provide a definite, image-based evaluation. MRS can help differentiate among tumor types and their response to therapy [1], but it is sometimes limited in its volume of coverage because of the requirement to have good main magnetic field homogeneity during data acquisition. Sodium MRI has been proposed as a means to monitor diseased tissue in the human brain because of the large sodium shifts that result during several pathological conditions in the central nervous system, including cancer. Sodium MRI is less sensitive to main magnetic field inhomogeneities, have better signal-to-noise ratio (SNR) than proton MRS and can be performed over the volume of the entire brain in relatively short data acquisition times (including shimming). In this abstract we demonstrate the concurrent use of sodium MRI and proton MRS for the characterization of primary brain tumors.

METHODS

Data Acquisition: Proton MRS and sodium MRI data sets (n=34) were acquired *in vivo* on whole body TIM Trio 3 Tesla scanners (Siemens AG, Erlangen, Germany) using a dual-tuned (^{23}Na/^{1}H), dual-quadrature, four-port birdcage RF coil (Advanced Imaging Research, Cleveland, Ohio) and/or a twelve-channel, receive-only RF coil. Proton chemical shift imaging (CSI) data were collected during the same imaging session using a spin echo excitation with an effective echo time of 135ms. Outer volume suppression pulses were used to minimize the effects of subcutaneous lipids on the spectra. An 8x8 matrix was used for data acquisition and online fitting was used to calculate the relative peak amplitudes. Sodium MRI was performed using a twisted projection imaging [2] sequence. The TPI images were reconstructed off-line using in-house image reconstruction software. All studies included the use of standard imaging sequences in order to provide anatomical referencing and a comparison with conventional imaging schemes. All studies were performed in accordance to an approved Institutional Review Board (IRB) protocol.

RESULTS

A representative example of the type of images obtained during this study is presented in figure 1 where Fluid-Attenuated Inversion Recovery (FLAIR), sodium, fused (FLAIR + Sodium) and MRS results are presented for a high-grade (anaplastic astrocytoma) brain tumor. The tumor is clearly depicted in the FLAIR image of figure 1a and the changes in proton metabolites of the spectra in figure 1d. Sodium signal intensity is clearly elevated in the corresponding partition from the 3D data set presented in figure 1b. Quantitative analysis of this image showed an increase of more than 90% in tissue sodium content over the volume where the CSI spectrum was taken. Increases in tissue sodium content were also readily observed in less aggressive tumor types such as oligodendrogliomas, though these were not as marked as for the high-grade tumors (~80%).



(a) (b) (c) (d)

Figure 1: *FLAIR, Sodium, fused and CSI images for a high-grade (anaplastic astrocytoma) brain tumor acquired at 3T.*

CONCLUSIONS

Our findings support the belief that sodium MRI can be easily performed in a clinical environment as an useful complement to proton MRS. Because of sodium's relative insensitivity to magnetic field inhomogeneities at 3T, its 3D nature, and its ease of quantitation, this technique could be an invaluable tool in cases where poor field inhomogeneity limits the interpretability of proton MRS scans. Finally, sodium MRI is easily performed over the volume of the entire brain and yields results that exhibit the same quantitative trend as those from proton MRS (i.e., signal increases in relation to tumor type).

REFERENCES: [1] Chernov, et al., *Brain Tumor Pathol.*, **23**,19, 2006. [2] Boada, F.E. et al., *Magn. Res. Med.*, **37**, 706, 1997.

This work was supported in part by the PHS Grant R01CA106840.