Tissue Sodium Concentration in Pediatric Brain Tumors as Measured with 23Na MR Imaging: Initial Experience

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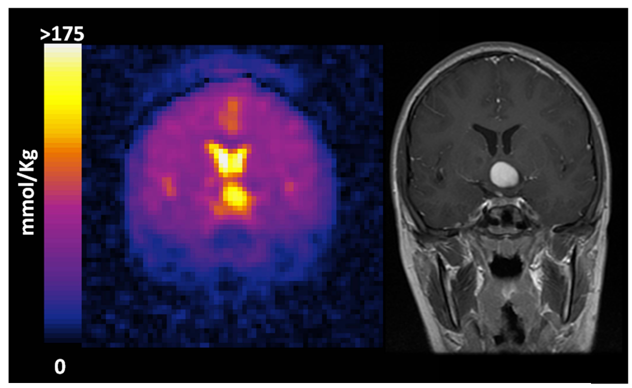
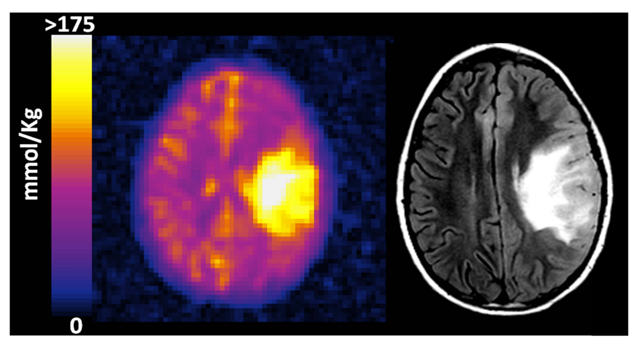
Purpose: To use sodium 23 (^{23}Na) MR imaging to noninvasively quantify total tissue sodium concentrations and to determine if sodium concentration is altered in a spectrum of pediatric brain tumors.

Material and Methods: Ten pediatric patients(8 years to 18 years of age; median age 11 years) were prospectively recruited over a one year period to undergo a total of 12 sodium MR imaging session using a 3T Seimens TIM Trio magnet. Absolute tissue sodium concentration in the brain was measured on quantitative three dimensional 23Na MR images which were co-registered with proton MR images. Concentration was determined in normal appearing grey matter (GM), white matter (WM), CSF (cerebral spinal fluid) , and the vitreous humor in all of the patients. In addition, sodium concentration was calculated in in tumors and determined from 23Na signal intensities measurements from regions that either demonstrates (1) contrast enhancement and/or (2) non-enhancing FLAIR hyperintensities. Absolute sodium concentrations were derived by taking the total sodium signal of the image divided by the mean of a relatively stable, known reference concentration (eye), and multiplied by the empirically derived molar concentration of the reference region [1]. Manually drawn ROIs were used to delineate the tumors, and average tissue sodium concentrations were calculated from the normalized images. The pediatric brain tumor population consistent of 5 diffuse infiltrative glioma (including brainstem gliomas); 2 supratentorial pilocytic astrocytomas (optic pathway/tectal) ; 3 residual treated tumors (recurrent germ cell tumor, GBM and anaplastic ependymoma). Serial conventional MRI clinical imaging data was available for most of the cases. There was correlative diffusion imaging, perfusion imaging, single voxel short echo MR spectroscopy and F 18- FDG PET available from clinically acquired scans at selected time points.

Results: Mean concentration (in millimoles per kilogram wet weight) was 64 +12 mmol/kg for GM, 66+ 11 mmol/kg for WM, 176+29 mmol/kg for CSF and 140+.03 mmol/kg for vitreous humor. Significant differences in sodium concentration were seen when comparing brain tumor lesions to normal appearing GM, WM and CSF ($p< 0.05$). The pediatric tumor measurements ranged from 45 mmol/kg to 193 mmol/kg. The two tumors with the highest sodium concentration was a recurrent pilocytic astrocytoma (146 mmol/kg) (Figure 1) and a Grade III astrocytoma/gliomatosis (193 mmol/kg) (Figure 2). There was marked regional heterogeneity in the sodium signal in the diffuse astrocytoma cases with areas of sodium concentration greater than 100 mmol/kg, predicting areas for progressive tumor activity.



Discussion: ^{23}Na MR imaging can be used to quantify absolute concentration of sodium in pediatric brain tumors. There is overall increase in sodium concentration in the brain tumors when compared to normal appearing grey and white matter. Marked regional heterogeneity in the sodium signal within the diffuse astrocytomas and also among tumors of similar grade suggest that sodium MR may be useful to predict aggressive behavior and/or distinguish true progression from pseudo-progression.



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References:

[1] Constantinides *et. al*. "Noninvasive Quantification of Total Sodium Concentrations in Acute Reperfused Myocardial Infarction Using ^{23}Na MRI", MRM 46:1144-1151(2001).