Title: ^{23}Na-MRI demonstrates a sodium gradient within gliomas as a biomarker of tumour heterogeneity

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Target audience:

Abstract:

Purpose

The increase in mitotic activity within gliomas is associated with a decrease in Na^+/K^+-ATPase activity and gain in concentration of these ions. ^{23}Na-MRI quantifies sodium concentration and can probe cell morphology and membrane function within the tumour microenvironment, as well as heterogeneity. The purpose of this study was to evaluate sodium distribution within glioma and in the surrounding tissue.

Methods

33 patients were imaged on a 3T clinical scanner (GE Discovery MR750) using a Rapid Biomedical (Rimpar) dual-tuned ^{23}Na/^{1}H birdcage head coil. Sodium imaging was performed using an UTE sequence with 3D-Cones readout (nominal isotropic resolution = 3mm; scan time = 12 minutes). Intracellular-weighted sodium imaging was obtained using fluid suppression by inversion recovery (adiabatic inversion, TI = 30ms). Differences between tumour, grey matter (NAGM) and white matter (NAWM) in total sodium concentration (TSC) and intracellular sodium concentration (IW-SC) were tested using the paired samples t-test ($p<0.05$).

Results

33 patients completed the examination (age 57.8±17.5 yrs). TSC in the lesion was 50.2±16.9mM in the High Grade Gliomas (HGG), 43.1±28.6mM in the Low Grade Gliomas (LGG) and 52.3±0.5mM in the metastases. The IW-SC was 22.4±17.4mM in the HGGs; 12.9±8.8mM in the LGGs and 7.5±2.3mM in the metastases. TSC was significantly higher in tumours when compared to NAGM ($p=0.0001$) and NAWM ($p=0.0001$).

Discussion

In all cases, TSC was higher in the entire lesion and in the enhancing tumour compared to the basal ganglia and NAWM. In many cases, the result for IW-SC was reversed, but this trend was not statistically significant; this may represent the fact that most of the sodium in the lesion is contained in the extracellular space which is suppressed in the IW-SC.

Conclusion

We demonstrated a sodium concentration gradient across gliomas that is consistent with the expected underlying histopathology.