Title: Implementation of density adapted 3-dimensional projection reconstruction MRI sequence for small animal sodium imaging at 3 Tesla

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Structured Abstract:

Introduction: Sodium is one of the most abundant cations in the body. Changes in tissue sodium distribution are implicated in many diseases [1]. In cancer, aerobic glycolysis causes sodium to accumulate in tumour cells [2]. These molecular changes mean sodium imaging could potentially improve characterization of tumour response to treatment. Sodium has previously been imaged preclinically with magnetic resonance imaging (MRI) at high field strengths [3]. Since sodium has limited in vivo concentration, low gyromagnetic ratio, and quadrupolar relaxation, adequate signal-to-noise is difficult to achieve. The objective of my project is to implement a density-adapted 3D projection-reconstruction (DA3DPR) imaging sequence for sodium MRI of rat glioblastoma at 3T. DA3DPR has been demonstrated to achieve improved sodium SNR compared to cartesian imaging sequences. Improved sodium imaging adapted for preclinical studies at 3T lends significance to translation of sodium imaging for clinical use.

Methods: DA3DPR imaging was optimized on a GE Discovery MR750 3.0T MRI. Performance was evaluated at 1-mm and 3-mm isotropic resolution (TE = 8us, TR = 100ms, gradient slew rate = 20 mT/m). Sodium imaging was performed using a curved transmit/receive butterfly RF surface coil. was Cylindrical phantoms of 50 mmol/L saline (physiological sodium concentration) and 1% agarose were imaged and reconstructed offline using MATLAB. Sodium signal intensities were normalized to the sensitivity profile of the coil. For animal model imaging, stereotactic surgery was performed to implant 1x106 C6 cells into the right hemisphere of a Wistar rat brain. Following implantation, rats were imaged with DA3DPR sodium MRI and 3D T2 weighted MRI (CUBE). Images were co-registered manually using 3D Slicer.

Results: Phantom imaging at 3-mm isotropic resolution allowed for the detection of physiological levels of sodium with SNR greater than 20 throughout the volume of a rat head. Animal sodium imaging could be accomplished within 12 minutes. Sodium MRI of a rat glioblastoma shows detectable (SNR>50) sodium signal 14 days after tumour implantation.

Discussion: We have successfully implemented a DA3DPR sequence for sodium imaging at 3-mm isotropic resolution at 3T. This will allow assessment of tissue sodium concentration (TSC) within tumours. In the future, we intend to measure regional changes in TSC throughout the tumour in response to treatment and correlate these observations with those from magnetic resonance spectroscopic imaging of hyperpolarized [13]C-labeled pyruvate.