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A Fast Method for Mapping pH using Magnetic Resonance Imaging

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Introduction: Magnetization Transfer (MT) is a Magnetic Resonance Imaging (MRI) contrast enhancement technique that exploits the exchange of magnetization between pools of free-water protons and protons bound to macromolecules in tissue [1]. Chemical Exchange Saturation Transfer (CEST) MRI is a direct application of MT, which can noninvasively image dilute CEST agents (including amide molecules), enabling the assessment of tissue characteristics, such as pH [2-4]. Detection of pH variations in the brain has been shown to be valuable for delineation of tissue-at-risk compared to tissue with reduced cerebral blood flow, following an acute ischemic stroke [5-7]. This work aims to create a CEST based pH mapping acquisition that is fast (<5min) and is able to cover the entire brain with high resolution (<2mm), for the identification of ischemic tissue-at-risk.

Methods: Our method employs a basic 3D gradient recalled echo as a foundation for the CEST pulse sequence. The custom CEST technique utilizes 30 offset radio-frequency preparation pulses to effectively saturate amide molecules required for pH mapping. Image acceleration has been implemented through 4D-Poisson distributed under-sampling in concert with compressed sensing [8]. Our lab has previously demonstrated quantitative MT image acceleration with up to 4x acceleration, and has shown that 8-12x times may be achievable for CEST imaging [9].

Results: When implemented on the GE 3T scanner, the CEST pulse sequence will achieve an accelerated image acquisition with minimal artefacts compared to the fully sampled images. This will be accomplished with a large FOV (22 cm x 14 cm x 16 cm) and isotropic 2 mm resolution. Accelerated imaging for both 3D, and ultimately 4D, is expected to execute in 5 minutes or less for a total of 30 volumes.

Discussion and Future Work: We have designed a pH mapping sequence for ischemic stroke that is fast and high resolution. Next steps include validation on a phantom with varying pH from 5.8 to 7.0. In-vivo validation will be achieved via scanning of approximately 10 patients with cerebral ischemia.

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