Identifying Epileptic Tissue using Magnetic Resonance Spectroscopy at 7T in Patients with Temporal Lobe Epilepsy

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Introduction: Epilepsy is the most common serious neurological condition, affecting ~6 per 1000 individuals. It is typically treated with anti-epileptic drugs, however ~30% of patients do not respond to drug treatments. These ‘intractable’ patients are often treated by surgically removing epileptic tissue; accurate identification of epileptic tissue is key for ensuring good patient outcomes. The primary tool for pre-surgical localization is Magnetic Resonance Imaging (MRI), however in many cases MRI fails to identify epileptic tissue, as it does not cause a visible structural defect. Magnetic Resonance Spectroscopy (MRS) has been demonstrated as a useful tool for identifying epileptic tissue based on biochemical changes within epileptic tissue [1]. While MRS is sensitive to subtle biochemical changes, this sensitivity is diminished in tissues close to bone, such as the temporal lobe, due to magnetic susceptibility artifacts; these artifacts prevent the accurate measurement of important, but lower concentration metabolites within these regions. This poses a significant challenge, as it prevents comprehensive study of Temporal Lobe Epilepsy (TLE), which commonly presents itself as MR-negative. Newer, more powerful MR systems offer increased SNR, spectral dispersion, and ability to correct for magnetic field inhomogeneities, which in combination can overcome this limitation. The aim of our work is to study the metabolic changes in TLE patients using MRS at 7T in order to identify potential biomarkers that could be used to identify epileptic tissue in MR-negative TLE patients.

Methods: Patients were recruited through the Epilepsy Program at the London Health Sciences Centre University Hospital, after being diagnosed with intractable epilepsy caused by MR-negative TLE following routine clinical procedures. Data collection is ongoing; to date, data has been acquired from 17 patients and 11 age matched healthy controls. All patients were scanned on a 7T Siemens MRI system to acquire T1-weighted anatomical brain images along with H¹ spectra from the hippocampi of each patient. Spectra were acquired using a semis-LASER spectroscopy sequence. Spectroscopic data was then processed using a custom analysis tool (fitMAN) that incorporated line shape correction due to eddy current distortion (QUECC). Each spectrum was fitted in the time domain using a Levenberg-Marquardt non-linear minimization routine. Concentration calculations were made by evaluating the peak areas of our fitted spectrum, followed by normalization of these areas using the signal from Creatine to give concentration as a ratio to Creatine. The calculated concentrations of different metabolites were compared between our patient and control populations using an unpaired, two-tailed t-test corrected for unequal variances. A total of 11 metabolites were examined: Alanine, Aspartate, Choline, Creatine, Glycerol, Glutamate, Glutamine, gamma-Aminobutyric acid, Glutathione, N-acetylaspartate, Myo-Inositol, and Taurine.

Results: Preliminary results show that the concentration Myo-Inositol decreases in our patients vs the control population (p < 0.05). This appears to be consistent with prior work, as Myo-Inositol is a marker for glial cell function, and previous work examining MR-negative epilepsy using imaging found that the MR-negative cases appeared to commonly be caused by low-grade gliosis [2].

Conclusion: Our preliminary results show that 7T MRS may be useful in identifying epileptic tissue in MR-negative TLE using Myo-Inositol, a metabolite MRS at lower field strengths cannot resolve within the temporal lobe. Moving forward, we are working on a more robust data analysis pipeline to improve the accuracy of our concentration calculations, and we aim to incorporate clinical data to evaluate if we can use our readings to confirm lateralization of seizure focus.

References