Characterization of differential metabolic regions in people with Multiple Sclerosis using fast MRSI techniques

Oun Al-iedani[1,2], Jeannette Lechner-Scott[2,3,4], Rodney Lea[2], Saadallah Ramadan[2,5]

[1]School of Biomedical Sciences and Pharmacy, College of Health, Medicine and Wellbeing, University of Newcastle, Australia. [2]Hunter Medical Research Institute, Australia. [3]Department of Neurology, John Hunter Hospital, Australia. [4]School of Medicine and Public Health, College of Health, Medicine and Wellbeing, University of Newcastle, Australia. [5]School of Health Sciences, College of Health, Medicine and Wellbeing, University of Newcastle, Australia.

Abstract

Statement of the Problem: Multiple Sclerosis (MS) is a chronic inflammatory disease that destroys the brain and spinal cord, characterized by demyelination and axonal damage. MS relies heavily on the use of conventional MRI for diagnosis and ongoing monitoring[1,2]. However, reliable markers of disease progression are still needed, therefore, advanced bioimaging techniques such as MR Spectroscopy (MRS)[3,4], which can evaluate neurometabolic changes within white matter lesion (WML) and normal-appearing white matter (NAWM)[5,6]. However, the potential challenges with MRS imaging (MRSI) include performing multi-dimensional metabolic mapping of the brain with high spatial resolution, short acquisition times, and the accurate evaluation of the metabolic composition of WML and NAWM in the whole brain using differential metabolic regions (DMRs) for MS. The project aims to determine the precise nature of NAWM and WML in people with MS (pwMS), compared to healthy controls (HCs). Another target was to develop a multi-dimensional map of the neurometabolic concentrations in pwMS to enable the differentiation of the tissue subtypes. Methodology & Theoretical Orientation: The advanced bioimaging technique (3D-fast MRSI) was applied by a 3T-MR scanner covering most of the brain in 16 pwMS and 13 HCs. Multi-slice-MRSI data was processed using a novel pipeline for multi-dimensional metabolic mapping using fast-MRSI with DMR classifications. Findings: The neurometabolic mapping of DMRs showed that N-acetylaspartate (NAA) in WML was significantly lower than in NAWM-MS (-8%) and HCs (-15%) within deep cortical-WM in both posterior parietal lobes (Figure 1A), while Myo-inositol (m-Ins) levels from WML were significantly increased compared to NAWM-MS and HCs. Results revealed 3 separate DMRs exhibiting a reduction in NAA (9-23%) (Figure 1B). Conclusion & Significance: This advancement in bioimaging (Fast-MRSI with DMRs) may enhance the clinical monitoring of pwMS and the detection of potential NAWM and WML damage which plays a critical role in MS pathology.

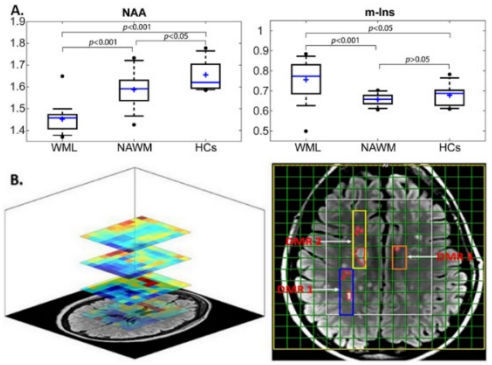


Figure 1. A. Box plot of significant differences in the neurometabolites NAA & m-Ins for WML voxels, NAWM-MS & HC voxels in four slices of one DMR, located within deep cortical-WM in posterior parietal lobes. **B.** Mapping of NAA in single slice and multi-slice of 3 DMRs located in one axial brain slice of an MS patient.

References

1. Rovira A, Auger C, Alonso J (2013) Magnetic resonance monitoring of lesion evolution in multiple sclerosis. Therapeutic advances in neurological disorders 6:298-310.
2. Sajja B R, Wolinsky J S, Narayana P A (2009) Proton magnetic resonance spectroscopy in multiple sclerosis. Neuroimaging clinics of North America 19:45-58.
3. Kapeller P, McLean M A, Griffin C M, Chard D, et al. (2001) Preliminary evidence for neuronal damage in cortical grey matter and normal appearing white matter in short duration relapsing-remitting multiple sclerosis: a quantitative MR spectroscopic imaging study. Journal of neurology 248:131-8.
4. Obert D, Helms G, Sattler M B, Jung K, et al. (2016) Brain Metabolite Changes in Patients with Relapsing-Remitting and Secondary Progressive Multiple Sclerosis: A Two-Year Follow-Up Study. PloS one 11:e0162583.
5. Brief E E, Vavasour I M, Laule C, Li D K, Mackay A L (2010) Proton MRS of large multiple sclerosis lesions reveals subtle changes in metabolite T(1) and area. NMR in biomedicine 23:1033-7.
6. Al-Iedani O, Ribbons K, Gholizadeh N, Lechner-Scott J, et al. (2020) Spiral MRSI and tissue segmentation of normal-appearing white matter and white matter lesions in relapsing remitting multiple sclerosis patients. Magnetic resonance imaging.



Dr Al-iedani (Post-doctoral ECR) has 7 years of experience and expertise in MRI and MR spectroscopy applications in multiple sclerosis research to understand multiple sclerosis (MS) pathology and assess treatment effects using novel and advanced MRS techniques such as fast MRSI. He strives to develop MRI methods to deliver high-quality diagnosis and surveillance for MS clinical management of Australian communities experiencing MS for early diagnosis and monitoring. His research has achieved both international and national impact as evidenced by 15 peer-reviewed papers and review and publication in journals with good citations.

Email:
oun.aliedani@newcastle.edu.au

Notes/Comments: