MR Spectroscopy of the Motor Cortex in Cervical Spondylotic Myelopathy: Pre and Post Surgery Observations

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Introduction: Cervical spondylotic myelopathy (CSM) is the most common type of spinal cord dysfunction in people over the age of 55.[1] The natural history of CSM is poorly understood and there is inadequate information available for surgeons to accurately predict when and for whom operative management is absolutely indicated.[2] Furthermore, surgery results vary leading to ~35% improvement, ~25% worsening and no change in ~40%. [3-4] Proton-magnetic resonance spectroscopy (^{1}H-MRS) has been used to non-invasively measure metabolic changes in brains of patients with different pathologies. The purpose of this prospective study is to characterize the metabolite level changes, specifically *N*-Acetylaspartate (NAA), creatine (Cr), choline (Cho), myo-inositol (Myo), and glutamate plus glutamine (Glx) due to alterations in cortical function in CSM patients.

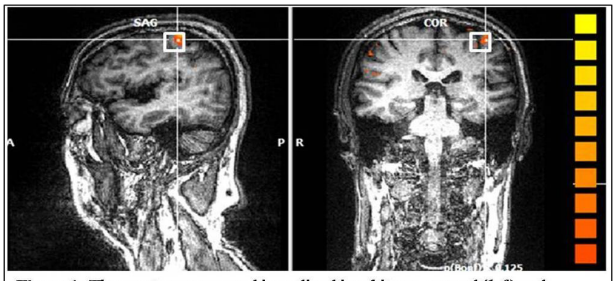

Figure 1: The spectroscopy voxel is outlined in white on coronal (*left*) and sagittal (*right*) images. The voxel is placed in the motor cortex over the site of finger tapping activation.

Methods: Twenty-one patients with CSM (13 males, 18 right-handed, age 52.9±9.9) and 11 healthy controls (6 males, 11 right-handed, age 46.3±12.2) underwent 2 ^{1}H-MRS sessions 6 months apart on a 3.0 T Siemens Magnetom Tim Trio (Erlangen, Germany). Only the CSM group received decompressive surgery after the initial scan. Anatomical MPRAGE images (192 slices, 1 mm isotropic, TR/TE = 2300/3.42 ms, TI = 900 ms) were acquired in each subject. Functional MRI scans of a finger-tapping paradigm were also acquired using an echo planar imaging sequence (field of view = 256x256 mm, 45 slices, 3 mm isotropic, TR/TE = 2500/30 ms, flip angle = 90°, parallel imaging with PAT=2). Areas of activation were used to guide placement of a 20 mm isotropic voxel on the activated region in the motor cortex (Figure 1). Voxels were placed in patients on the side with greater deficit while data from each side of the motor cortex was obtained in controls. Spectroscopic data were localized using PRESS (TR/TE =2000/135 ms, 192 averages, voxel size = 8 cm^3). Spectra were lineshape corrected and any remaining unsuppressed water was removed from the spectrum using Hankel singular value decomposition (HSVD) which required no prior knowledge.[5] Resultant metabolite spectra were fit in the time domain using a Levenberg-Marquardt minimization routine incorporating a template of prior knowledge as previously described (Figure 2).[5-6] Functional assessment was completed by each subject at the time of each MRI scan including Neck Disability Index (NDI), ASIA Neurological Classification of Spinal Cord Injury (ASIA) and Japanese Orthopaedic Association (JOA) questionnaires. NDI, ASIA and JOA scores were compared using a two-tailed Student's t-test with alpha error at 0.05. Metabolite ratios were compared between groups using a two-tailed Student's t-test with alpha error of 0.05. Spearman rank correlation was used to determine the association between the metabolite ratios and questionnaire scores.

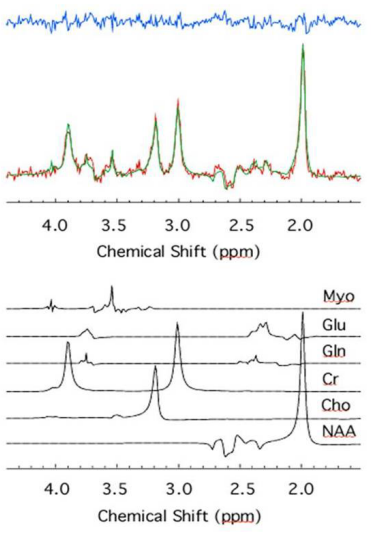

Figure 2: *Top:* The result of fitting (green line) is superimposed on the corresponding in-vivo spectrum (red line) acquired in the motor cortex (8 cc voxel). The residual (blue line) is shown above. *Bottom:* Individual metabolite components used to reconstruct the in-vivo spectrum.

Results and Discussion: No differences in any metabolite ratios were detected between the right side (RS) and the left side (LS) of the motor cortex in control subjects. There was a significant decrease in the NAA/Cr metabolite ratio in the CSM group (1.21±0.30) compared to RS (1.37±0.11; p=0.04) and LS controls (1.38±0.11; p=0.03) suggesting neuronal death or dysfunction in the motor cortex. This decrease was accompanied by increases in the Myo/NAA ratio in the CSM group (0.25±0.07) compared to RS controls only (0.21±0.04; p=0.03) which may be due to the decrease in NAA, but may also indicate glial activation. Post-operatively there continued to be significantly decreased NAA/Cr ratios in the CSM group (1.11±0.19) compared to RS (1.36±0.26; p=0.02) and LS controls (1.39±0.17; p=0.001) indicating continued neuronal dysfunction and/or death. Interestingly, Glx/Cr ratio was decreased in the CSM group (0.36±0.21) compared to RS controls only (0.52±0.13; p=0.04). CSM and control groups were significantly different for the NDI, ASIA and JOA scores pre and post-operatively. CSM group significantly improved their JOA scores post-operatively (p=0.002).

Conclusions: The NAA/Cr and Myo/NAA metabolite ratios may be meaningful biomarkers in the CSM population. Reductions in NAA/Cr are likely caused by neuronal and axonal injury and accompanied by increased Myo/NAA may suggest increased glial activation. A larger cohort and follow-up will be necessary to determine whether MRS findings have prognostic significance.

References: [1] Simeone FA *et al.* The Spine Ed2, p.440-476. Philadelphia, W.B. Saunders, 1982. [2] LaRocca H. Spine 13:854-855, 1988. [3] Fager CA. Clin Neurosurg 25:218-244, 1978. [4] Bishara SN. J Neurol Neurosurg Psychiatry 34:393-395, 1971. [5] Bartha R *et al.* NMR Biomed 12:205-216, 1999. [6] Bartha R *et al.* Magn Reson Med 44:185-192, 2000.