# MR spectroscopy in the spinal cord of patients with traumatic injuries

Andreas Hock[1], Nassos Petrou[2], Peter Zweers[2], Erin L. MacMillan[3], Roland Kreis[3], Peter Boesiger[1], and Anke Henning[1]

[1]*University and ETH Zurich, Institute for Biomedical Engineering, Zurich, Switzerland,* [2]*Diagnostic radiology and neuro-radiology, Swiss Paraplegic Centre, Nottwil, Switzerland,* [3]*University of Bern, Dept. of Clinical Research, Bern, Switzerland*

**Introduction:** Magnetic resonance spectroscopy (MRS) enables determination of metabolite concentrations in a predefined region of interest in the human body both noninvasively and in vivo. It allows for early detection of pathological processes affecting the central nervous system and may identify clinically relevant biomarkers that predict response to different therapy options for personalized patient treatment. The latter is of specific interest in patients with traumatic injuries in the spinal cord. Recently, several methodological developments with regard to shimming, localization, lipid suppression and flow and motion correction largely improved the applicability of $^1$H MRS in the human spinal cord in the clinical environment (1-2). However, patients with spinal cord injury may show increased susceptibility changes due to haemorrhage, cerebrospinal fluid (CSF) drainage and/or patient immobilization by implants. **The aim of this investigation** was to demonstrate the feasibility of $^1$H MRS in the spinal cord of patients with traumatic injury and to characterize specific changes in the metabolic fingerprint in this patient group.

**Methods:** Spinal cord $^1$H MRS measurements were performed in 3 spinal cord injured patients (see table 1 for details) and 16 controls at 3T. The $^1$H MRS protocol comprised inner volume saturated PRESS localization, ECG-triggered 2$^{nd}$ order FASTERMAP shimming (2), $F_0$ determination and spectral acquisition, and metabolite cycled (MC) non-water suppressed spectral acquisition for single shot frequency alignments (1) (Achieva, Philips Healthcare, Best, TE = 30 ms, TR = 2000 ms, voxel size = 1.2 ml, 256 to 512 averages,). Spectroscopy voxels were placed in the cervical spinal cord as shown in Fig. 1. Despite of the relatively long scan time needed for high resolution scout images and high SNR $^1$H MRS acquisitions of around 40 minutes, in one patient two spectra at C1-2 and C3-4 level could be acquired during the same scan session with a total scan time of 1 hour. MRS data were quantified by LCModel (3) using a basis set of 20 metabolite spectra simulated with GAMMA (4) and Gaussian filtered by 4 Hz and zero-filled for visual clarity.

**Results and Discussion:** It was possible to acquire good quality spectra in all three patients and all volunteers, although spectral quality (SNR & line width) is slightly reduced in the patients (table 1) most likely due to implants and hemorrhages. Fig. 1 shows all patient spectra (Fig. 1 A-D) and an exemplary spectrum of a control volunteer (Fig.1 E). Patients show a reduced N-acetyl-aspartate (NAA) / Creatine (Cr) ratio compared to controls (table 1). Since NAA is often reported as a marker of the neuronal density (5) the reason for the reduced NAA / Cr ratio might be a reduction of the neuronal density due to syringomyelia, nerve cell damage, cord degeneration or cavity formation. The Choline (Cho) / Cr ratio seem to be stable and myo-Inositol (mI) / Cr might be increased in this patient group (table 1) potentially due to gliosis. However more patient measurements are needed to verify these findings.

**Conclusion:** $^1$H MRS acquisitions in the spinal cord of patients with traumatic injury are presented for the first time using the metabolite cycling technique. The reduced NAA / Cr ratio might be a marker for the degree of the pathologic alteration, which potentially enables monitoring of the etiopathology and/or optimizing patient treatment.

**Literature:**

1. Hock A. et al., Proc Intl Soc Mag Reson Med 2011;406.
2. Hock A. et al., Proc Intl Soc Mag Reson Med 2010;5042.
3. Provencher S. W., Magn Reson Med 1993;30(6):672-679.
4. Smith S. A. et al., J Mag Reson 1994;106(1):75-105.
5. de Graaf R. A., *In vivo* NMR Spectroscopy 2008(2nd Edition).

**Fig. 1**

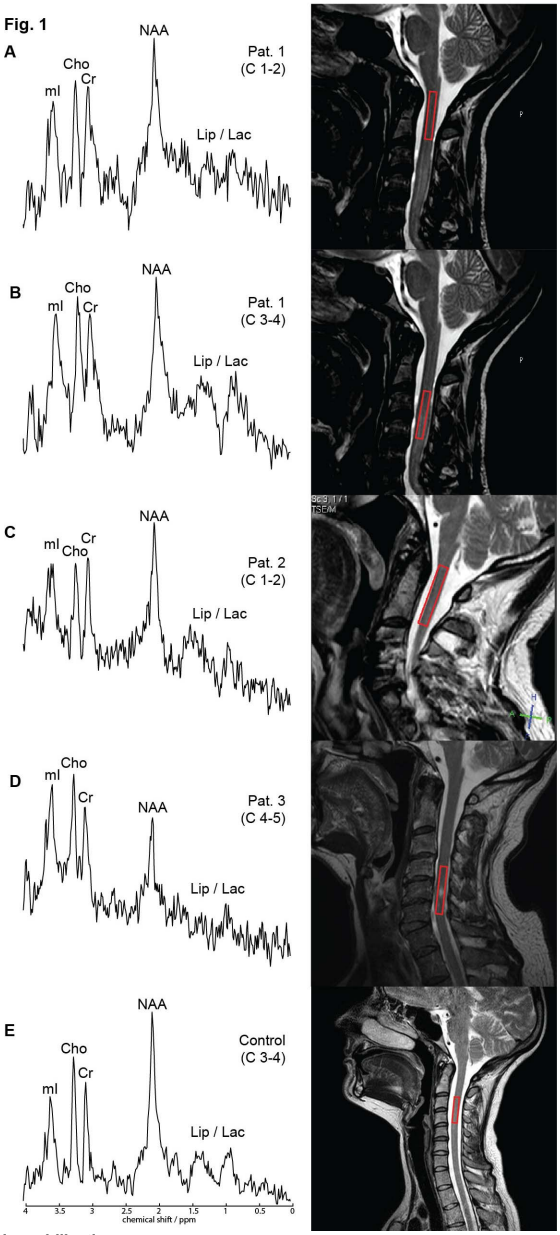


***Table 1: Patient details and quantification results. Note: ‡ decompression, ■ stabilization, ▲ CSF-drainage, ◊ Immobilisation***

| Patient No. | Age, sex | ASIA classification | Syringomyelia | Injury location | treatment | NAA/Cr (mean ± SD, mean CRLB) | Cho/Cr (mean ± SD, mean CRLB) | mI/Cr (mean ± SD, mean CRLB) | SNR (mean ± SD), FWHM (mean ± SD) |
|---|---|---|---|---|---|---|---|---|---|
| 1 (C 1-2) | 25 Y, m | B (sub C 2) | yes | Th 3-4 | ‡, ■, ▲ | 1.1 ± -, 16% | 0.4 ± -, 10% | 3.0 ± -, 10% | 3 ± -, 12 ± - Hz |
| 1 (C 3-4) | 25 Y, m | B (sub C 2) | yes | Th 3-4 | ‡, ■, ▲ | 0.9 ± -, 18% | 0.5 ± -, 14% | 4.2 ± -, 8% | 4 ± -, 10 ± - Hz |
| 2 (C 1-2) | 52 Y, m | A (sub C 2) | yes | Th 2-3 | ‡, ■, ▲ | 1.2 ± -, 10% | 0.4 ± -, 9% | 2.7 ± -, 9% | 4 ± -, 12 ± - Hz |
| 3 (C 4-5) | 64 Y, m | C (sub C 6) | no | C 5 | ◊ | 1.0 ± -, 15% | 0.5 ± -, 9% | 3.6 ± -, 8% | 4 ± -, 10 ± - Hz |
| Controls (C 3-4), n=16 | 21-46 Y,- | - | - | - | - | 1.7 ± 0.4, 7% | 0.4 ± 0.07, 8% | 2.9 ± 0.5, 7% | 7 ± 1.1, 8.6 ± 2 Hz |