Reliability of ^{1}H-MRS of the Cervical Spine at 3T

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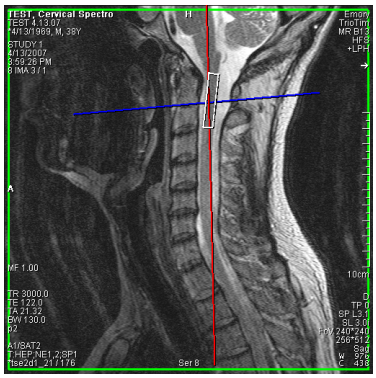
Introduction: Proton Magnetic Resonance Spectroscopy has been applied to observe the differences between spectroscopic findings in the cervical spinal cord of multiple sclerosis (MS) patients[1], spinal tumor patients[2] and healthy subjects. It has also been used to compare the concentrations of major metabolites within the spinal cord to other regions of the central nervous system (CNS)[3] and to devise an acquisition and post-processing protocol to quantify the main CNS metabolites on the cervical spinal cord[4,5]. These studies have been done on 1.5T, 2T and 3T systems. Some of these studies are qualitative; for studies quantifying the metabolite concentrations, the statistical approach focuses only on the inter-subject variability. Determining the reliability (intra-subject variability) of MRS in the cervical cord is important for determining what metabolite changes are detectable in a longitudinal study. The purpose of this study was to quantify the intra-subject variability of the spectroscopy of the cervical spinal cord at 3T. A secondary goal was to compare our MRS measurements to those reported in the literature.

Materials and methods:T2 TSE localizer images were acquired on a 3T whole-body system (TIM Trio; Siemens Medical Solutions, Malvern, PA) with head, neck and spine matrix coils, selecting the two lower elements from the head coil and the two upper elements from spine coil and all the channels from the neck coil. Spinal cord ^{1}H-MRS examinations were performed with a point-resolved spectroscopy (PRESS) spin-echo sequence, with TR = 2000 ms and TE = 35 ms. A three-pulse chemical shift-selective (CHESS) saturation sequence for water suppression and 400 repetitions were used. A rectangular VOI along the main axis of the cord with dimensions of approximately 9x7x35 mm^3, was located with the lower limit of the voxel level with the inferior aspect of the C2 vertebral body (See Figure for position). For each metabolite spectrum, 4 additional acquisitions with no water suppression were collected, yielding a total spectrum acquisition time of approximately 14 min for the cervical spine acquisition. Automated optimization of gradient shimming, transmitter pulse power, and water suppression were used. All MRS data were analyzed by means LCModel[6].



Spectroscopy measurements were made in the cervical spinal cord of 6 healthy volunteers. This study was approved by our institutional review board and informed consent was obtained from all volunteers. We performed the entire procedure three times in two volunteers to estimate the intra-subject variability. Each trial was declared as a new scan with its own localizer images and spectroscopy acquisitions. Every time we finished an exam, the subject was taken out of the scanner and off of the table, the exam was closed and a new exam was declared in the console. The subject was repositioned on the scanner, and all localizer images, automatic adjustments, voxel positions and spectroscopy measurements were redone from scratch. The pooled standard deviation was computed from the three runs on each of the two subjects. In one of the subjects who was scanned three times, 6 saturation bands were placed all around the voxel to evaluate the effect on metabolite quantification and variability.

Results and Discussion: The intra-subject variability is given in Table 1. The pooled standard deviation is an estimate of the intra-subject reliability. As expected, the intra-subject variability is uniformly less than our inter-subject variability (Table 2). Metabolite concentrations of NAA, Cr, and Cho are lower in subject 2 when sat-bands are applied. This suggests that application of sat-bands may successfully suppress signal contamination from outside of the voxel. Inter-subject mean values and standard deviations for the metabolite concentrations and the concentration ratios to creatine are given in Table 2 and are compared with those found in literature. The reported concentrations vary from one study to the next and our results appear comparable.

Table 1: Intra-subject variability from two subjects, concentration values are given in mmol/l

		[NAA]	[Cr]	[Cho]	[mI]	NAA/Cr	Cho/Cr	mI/Cr
Subject 1	Ave(SD)	4.68 (1.26)	4.04 (0.25)	1.80 (0.10)	5.77 (0.10)	1.17 (0.37)	0.45 (0.01)	1.43 (0.08)
Subject 2	Ave(SD)	3.70 (1.02)	3.80 (0.95)	1.57 (0.50)	3.87 (2.06)	0.97 (0.02)	0.42 (0.11)	0.98 (0.35)
Pooled SD		1.15	0.69	0.36	1.46	0.26	0.08	0.25
Subject 2 (Sat)	Ave(SD)	2.93 (1.04)	2.92 (0.67)	1.22 (0.06)	2.94 (0.59)	0.98 (0.14)	0.43 (0.10)	1.01 (0.06)

Table 2: Average and standard deviation of metabolite concentrations in the spinal cord in mmol/l

	Field	Subjects	[NAA]	[Cr]	[Cho]	[mI]	NAA/Cr	Cho/Cr	mI/Cr
This study	3T	6	4.23 (1.57)	3.56 (1.25)	1.51 (0.47)	3.77 (1.59)	1.25 (0.46)	0.44 (0.14)	1.019 (0.30)
Marliani (5)	3T	10	6.8 (1.6)	4.8 (0.6)	2.2 (0.4)	8.0 (1.1)	1.4 (0.3)	0.5 (0.1)	1.7 (0.2)
Gomez-Anson (4)	1.5T	6	2.93 (0.53)	2.62 (1.09)	1.05 (0.22)	3.55 (1.08)	1.28 (0.48)	0.45 (0.17)	1.52 (0.77)
Cooke (3)	2T	6	17.3 (0.5)	9.5 (0.9)	2.7 (0.5)				

Conclusion:
MRS of the cervical spinal cord in six normal controls was obtained with good quality. Our pooled standard deviation estimates of intra-subject reliability are the first to be reported in the literature. The intra-subject variability estimates will be most useful for determining the detectability of metabolite changes that are measured longitudinally within-subject. Additional repeated scans are planned to better estimate intra-subject reliability.

Acknowledgement: The authors work was supported by a Georgia Research Alliance grant and an Emory Radiology and GA Tech Biomedical Engineering seed grant.

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