Clinical Efficacy of Short-echo time Chemical Shift Imaging Compared to Single Voxel Spectroscopy

A. P. Lin[1], A. Widjesenke[1], D. Yang[1], F. Shic[1], C. Enriquez[1], B. D. Ross[1]

[1]Clinical MR Unit, Huntington Medical Research Institutes, Pasadena, CA, United States

Introduction: Proton magnetic resonance spectroscopy has been proven to demonstrate distinct biochemical changes across a spectrum of diseases. Single voxel techniques (SVS), perfected in the early nineties have slowly given way to mutilvoxel methods such as chemical shift imaging (CSI). The advantage of CSI is that it covers a large area of the brain from which a grid of multiple individual spectra is produced using frequency and phase encode steps. The advantage of CSI is particularly apparent when evaluating heterogeneous brain lesions where a single CSI acquisition replaces the need for several individual SVS acquisitions in order to get complete spatial information. CSI acquisitions are generally performed at echo-times of 135-144ms or 270-288ms in order to take advantage of the flat baselines at long echo. While this offers the advantage of inverting the coupled spin of lactate at TE=135ms, the choice of a longer echo-time not only reduces the overall signal-to-noise ratio but also reduces the number of metabolites that are observed due to the short T2 relaxation times of important brain chemical such as myo-inositol.

Purpose: We present a protocol in which a combines short-echo (TE=35ms) SVS and CSI in a single exam. The purpose is two fold: (i) to validate short TE CSI by comparison with an MRS technique of known efficacy and (ii) to determine the diagnostic accuracy and reproducibility of these short-echo techniques.

Methods: All exams were performed on a 1.5T clinical MR scanner (GE Medical Systems, LX 8.3 and 9.0) using the original manufacturer's sequences (PROBE-P, PROBE-SI). All subjects gave informed consent and studies were approved by the HMH IRB Board. Five neurologically-normal, healthy volunteers were examined with multiple acquisitions of SVS (PRESS, TR=1500ms, TE=35ms, voxel size=2.0x2.0x2.0cm^3) in the posterior cingulate gyrus (PCG) and left parietal white matter (WM)as well as multiple acquisitions of CSI from the posterior area of the brain (PRESS-CSI, TR=1000ms, TE=35ms, excitation area = 8.0x7.0x1.0cm^3, FOV=16x16, 24x24 frequency and phase encode steps with a voxel resolution of 0.44cc). A prospective study of 100 consecutive patients and controls was established in which a combined SVS and CSI protocol was used.

All data was processed using commercial software (AW 4.0 workstation, Functool 2) and metabolite ratios of NAA, Cho, and mI to Cr were obtained for both SVS and CSI. Data processing of the CSI data included the use of the individual as well as summed spectra in the regions from which the SVS were acquired (Figure 1). This provided a method for validating the CSI data with robust SVS results and was used for measuring the variability of each technique.

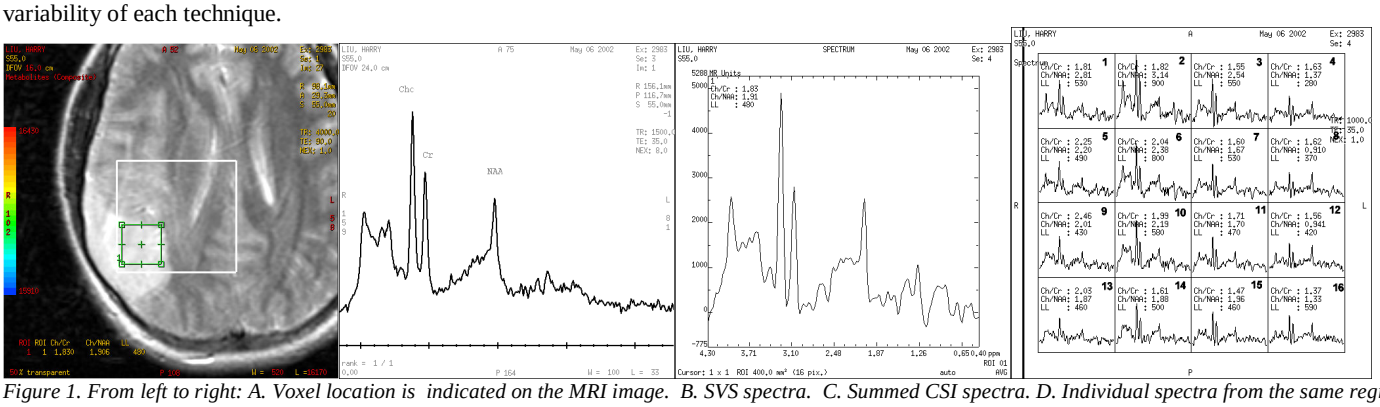

Figure 1. From left to right: A. Voxel location is indicated on the MRI image. B. SVS spectra. C. Summed CSI spectra. D. Individual spectra from the same region as the summed spectra.

Efficacy of CSI versus SVS was measured using ten cases of suspected brain tumor. Two experienced readers were blinded to the patient identification and history and asked to evaluate randomly ordered SVS and CSI results in two separate trials. A diagnosis was made based on SVS and on CSI and then compared to biopsy-proven results.

Results: Reproducibility of CSI, both summed voxel and individual voxels, and SVS is summarized in Table 1. CSI demonstrates far greater variability than SVS using both the summed and individual spectra. Summed spectra appear to reduce the variability slightly as compared to the individual spectra. Much of the variability of the individual CSI spectra was due to phasing differences between spectra. In the blinded study, two of the CSI exams gave a false positive and a false negative, therefore an accuracy of 80%. Due to sampling error, the SVS results gave a false negative in a single case in which CSI was accurate. The combined SVS/CSI exam would therefore have given 100% accuracy.

	PCG			White Matter		
Metabolite	SVS	CSI Summed	CSI Individual	SVS	CSI Summed	CSI Individual
NAA/Cr	5%	13%	11%	10%	16%	17%
Cho/Cr	9%	15%	19%	12%	16%	17%
mI/Cr	11%	12%	22%	12%	23%	20%

Table 1. Reproducibility Measurements of SVS, Summed CSI, and Individual CSI in PCG and WM.

Conclusion: (1) Reproducibility of CSI is such that detectable changes must be greater than one standard deviation from the mean of the measurement whereas SVS is highly accurate and can be used for subtle metabolitc changes. (2) In brain tumor cases, the accuracy of CSI suffers from the same issues that plague its reproducibility and therefore the most efficacious exam would include both CSI and SVS to confirm results.