Reproducibility of ME-COSI in Human Brain and Phantom

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Introduction: The Multi-Echo enhanced Correlated Spectroscopic Imaging (ME-COSI) sequence, which combines two-dimensional (2D) correlated spectroscopy (COSY) (1) with 2D spatial encoding (2) has previously been introduced (3). 2D correlated spectroscopy allows the detection of "cross-peaks" due to J-coupling interactions which can be used to unambiguously resolve many metabolites with coupled spins from more dominant co-resonant metabolites. The goal of this study was to investigate the reproducibility of metabolite peak volumes observed with the ME-COSI sequence in human brain and with a brain phantom.

Materials & Methods: To test ME-COSI reproducibility *in vitro*, a gray matter phantom containing 16 metabolites at physiological concentration was scanned thirty-two times over five non-consecutive days. For *in vivo* studies, four healthy human volunteers (mean age = 29) were scanned (inter-subject), including one who was scanned five times (intra-subject). Scan parameters were as follows: 30ms TE, 1500ms TR, 80x80 mm FOV, 20mm slice for phantom or 40mm for brain, 8x8 spatial array, 2.0ml voxels, 2000Hz bandwidth, 1 avg and 256 complex points. Brain scans acquired 64 Δt_1 increments and took 25 min. each and phantom scans acquired 100 Δt_1 over 40 min.. Phantom studies had 2.0ml voxels compared to 4.0ml in the brain. All acquisitions were performed with an 8-channel head coil on the Siemens Tim-Trio 3T scanner running on the VB15 platform. Acquired data were post-processed and in a MATLAB-based program and extracted spectra were displayed and quantified using the FELIX NMR program. Data were quantified in terms of the volume of a given peak compared to the volume of the 3.0 ppm diagonal peak of creatine (S/S_{Cr})

Results & Discussion: Figure 1 shows coefficients of variation (CV) of S/S_{Cr} for various metabolites in the brain. CVs ranged from 4-11% for diagonal peaks of creatine (Cr39_d), choline (Cho_d), n-acetyl aspartate (NAA_d) and myo-inositol (mI_d). The cross peaks of NAA, glutamate/glutamine (Glx), phosphoethanolamine (PE), aspartate (Asp) and γ-aminobutyric acid (GABA) had CVs of 9-25%. Inter-subject CVs were on average 38% higher than those from the intra-subject study. Incomplete suppression of water and skull marrow lipids obscured peaks from glutathione (GSH) and lactate (Lac), respectively, so they were only measured in the phantom.

Figure 2 shows CVs for the metabolites measured the gray matter phantom and Figure 3 shows a typical voxel extracted from the phantom. CVs of higher concentrated metabolites like NAA, Cr, Cho, Asp and Glx (4) ranged from 6-15%. Cross-peaks from dilute metabolites like Lac, GSH, PE and mICh were expectedly found to have larger CVs, ranging from 18-25%. Lac, whose concentration was 400 μM, had a CV of 24.9% for its cross peak at $[F_1,F_2]$ = 1.3, 4 ppm. The cross peaks of GSH were identified at 4.5, 2.6 ppm, making it susceptible to inconsistencies in the suppression of the nearby water peak, which contributed to its CV of 22.7%.

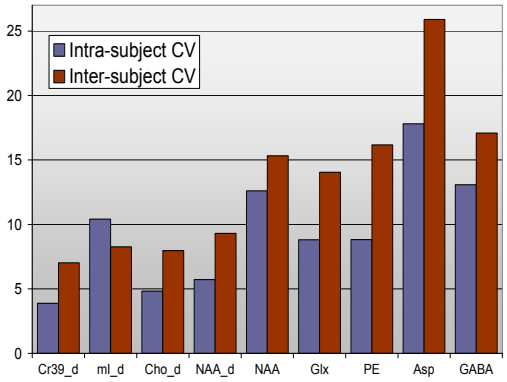

Figure 1: CVs of S/S_{Cr} (%) for several metabolites measured in human brain.

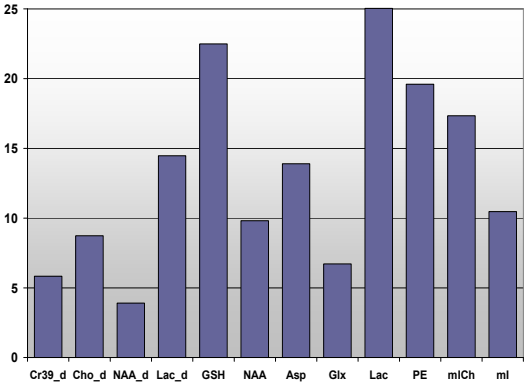

Figure 2: CVs of S/S_{Cr} (%) for metabolites in the gray matter phantom.

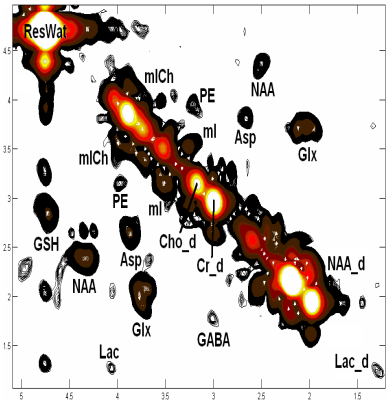

Figure 3: 2D spectra from a 2.0ml ME-COSI voxel from gray matter phantom.

Conclusion

A published reproducibility study (5) of single-voxel 2D COSY found inter-day CVs of 7-15% for brain phantom metabolites, suggesting a performance level of ME-COSI comparable to existing methods. ME-COSI improves on COSY by acquiring from a spatial array of voxels rather than a single one. Because of its larger volume of interest (VOI), ME-COSI encounters less outer-volume noise than COSY, allowing acquisition from smaller voxels (2.0ml compared to 27.0ml). Further improvements in reproducibility could be achieved by 1) exploiting parallel imaging using multi-channel receive coils, 2) increasing the voxel volume or number of averages or 2) developing peak-fitting techniques to automate peak-volume measurements and reduce operator bias.

References

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