

5D Echo-planar J-resolved spectroscopic imaging of cerebral metabolites in HIV-infected youth: a preliminary study

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Target Audience: Basic scientists interested in compressed sensing (CS) reconstruction of 3D-localized J-resolved spectroscopic imaging in human brain; clinical researchers interested in quantitative MRSI of perinatally HIV-infected youths.

Purpose: Perinatally HIV-infected youths have abnormal cerebral metabolite concentrations, but this has not been well studied. By incorporating a varying TE, 2D J-resolved spectroscopy reduces spectral crowding by pushing multiplet splittings into a second spectral dimension¹. Multivoxel MR Spectroscopic Imaging (MRSI) can be used to obtain spectra throughout the brain, providing better coverage than single voxel techniques². An echo planar readout allows the interleaved acquisition of 1 spatial and 1 spectral dimension, greatly accelerating scan time³. Nonuniform sampling (NUS) can be used on the incrementally acquired dimensions k_y , k_z , and t_1 to further accelerate scan time^{4,5}. Previous studies have been limited mostly to single voxel 1D or 2D MRS acquisitions and are therefore limited in their spatial coverage^{6,7}. A goal of this study was to evaluate a recently implemented 5D NUS echo-planar J-resolved Spectroscopic Imaging (EP-JRESI)⁵ in HIV Youth and age-matched healthy children and also, to investigate the reproducibility of metabolite quantitation using adult healthy volunteers.

Methods: Five healthy children (mean age 19.4 years) and 6 HIV-infected children (mean age 18.7 years) were scanned using the 5D EP-JRESI with the following scan parameters: TE/TR = 30/1200 ms, FOV = 24x24x12 cm³, 1.5x1.5x1.5 cm³ resolution, spectral BW = 1190/1000 Hz, 64 t_1 increments, 8x NUS for a scan time ~20 min. A 8-channel head “receive” array in combination with a body “transmit” was used. One spatial encoding was accomplished using 32 oversampled points along the bipolar read-out and the remaining spatial dimensions were sampled using 16 points each. The 5D EP-JRESI data was processed using a modified split Bregman algorithm for L1 minimization of the data in the image/spectral domains; outside the spectral region of interest (1-4.3 ppm), data was masked to increase self sparsity and decrease dynamic range for the reconstruction^{5,8}. Metabolite ratios were calculated using peak integration after ~1 pixel/ppm data shifting to take into account chemical shift displacement artifacts between the different resonances. Prior to evaluating the children, nine healthy adults (mean age 24.3) were also scanned.

	FW	FG	OW	OG	BG
NAA/Cr	1.77 ± 0.48	1.47 ± 0.45	1.73 ± 0.44	1.69 ± 0.40	1.67 ± 0.41
Cho/Cr	0.36 ± 0.14	0.46 ± 0.12	0.43 ± 0.04	0.40 ± 0.04	0.41 ± 0.05
ml/Cr	1.09 ± 0.63	1.24 ± 0.43	0.75 ± 0.26	0.84 ± 0.27	1.14 ± 0.16
NAA/Cho	5.49 ± 2.04	3.28 ± 1.26	4.02 ± 1.15	4.25 ± 1.31	4.17 ± 1.06
ml/Cho	2.94 ± 0.61	2.66 ± 0.47	1.72 ± 0.48	2.06 ± 0.56	2.80 ± 0.17
Cr/Cho	3.06 ± 0.82	2.27 ± 0.50	2.32 ± 0.22	2.50 ± 0.25	2.50 ± 0.29

Table 1. Metabolite ratios in healthy youths.

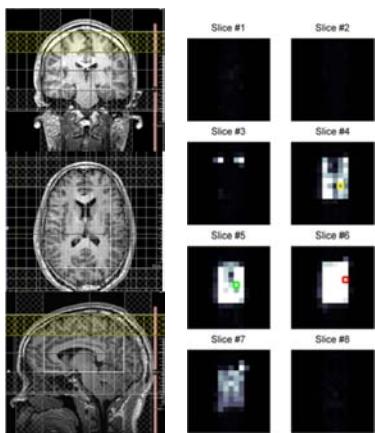


Figure 1. MRI localization and 3D NAA metabolite map of an HIV-infected youth

	FW	FG	OW	OG	BG
NAA/Cr	1.66 ± 0.38	1.18 ± 0.55	2.68 ± 0.70*	2.34 ± 0.50*	1.84 ± 0.25
Cho/Cr	0.32 ± 0.06	0.42 ± 0.07	0.46 ± 0.04	0.37 ± 0.06	0.44 ± 0.07
ml/Cr	0.58 ± 0.31	0.73 ± 0.28*	0.80 ± 0.19	0.67 ± 0.27	1.00 ± 0.36
NAA/Cho	5.26 ± 1.29	2.77 ± 1.04	5.82 ± 1.31*	6.50 ± 2.12	4.27 ± 0.79
ml/Cho	1.72 ± 0.62*	1.74 ± 0.72*	1.77 ± 0.49	1.79 ± 0.56	2.24 ± 0.57
Cr/Cho	3.20 ± 0.54	2.43 ± 0.44	2.20 ± 0.17	2.74 ± 0.49	2.32 ± 0.38

Table 2. Metabolite ratios in HIV-infected youths. * p<.05 significance from healthy youths.

Results: Table 1 shows the metabolite ratios of NAA, total choline (Cho), myo-inositol (ml) to creatine (Cr) in healthy youths in frontal white (FW), frontal gray (FG), occipital white (OW), occipital gray (OG), and basal ganglia (BG) from the left side of the brain. Table 2 shows the same information for HIV-infected youths and indicates those regions that are statistically different from healthy. Similar results were obtained from locations in the right hemisphere. Figure 1 shows 3D localization MRI image and the NAA metabolite map of an infected youth. Figure 2 shows the extracted spectra from the highlighted voxels in Fig 1 in three adjacent slices. Healthy adults showed similar CVs along with decreased NAA relative to healthy children.

Discussion: The data suggest an increase in the NAA in the occipital lobe and ml in the frontal lobe between HIV-infected and healthy children. Previous reports have focused on single voxel spectroscopy in the frontal lobe and basal ganglia. More patients need to be scanned to confirm these results in the occipital lobe as well as other brain regions.

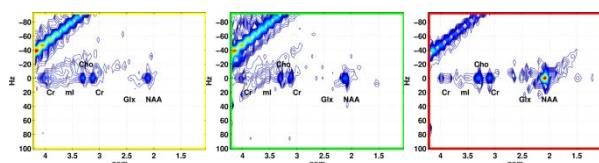


Figure 2. Extracted 2D spectra from the voxels highlighted in Fig 1.

Conclusion: This is a first pilot validation of the novel 5D EP-JRESI sequence (3D spatial+ 2D spectral) in children with HIV and healthy controls. We have demonstrated that 5D echo planar J-resolved spectroscopy can be reliably performed in adults and children, giving spectral information over the entire brain volume.

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