Metabolite differences in small brain regions between Mild Cognitive Impairment and Alzheimer Disease Patients by 3D Chemical Shift Imaging

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Purpose: To support the clinical diagnosis between patients with mild cognitive impairment (MCI) and Alzheimer's disease (AD) by metabolic profiles of small brain volumes obtained using proton three-dimensional spectroscopic imaging (3D CSI) of brain.

Subjects and Methods: 54 MCI patients (26 male and 28 female, 74 ± 8 mean age), 11 AD patients (4 male and 7 female, 74 ± 6 mean age) and 9 control subjects (5 male and 4 female, 76 ± 5 mean age) were examined using a 3 T magnetic resonance imaging system. 3D CSI with TR 1700 ms, TE 30 ms, FOV 160x160x60 mm, matrix of 16x16 and 8 slices was measured in 11'46''. Voxel size was 10x10x7.5 mm. The CSI in axial plane was positioned parallel to the hippocampus, covering parietal gray matter (Figure 1). In the analysis of 3D CSI eight voxels representatives of parietal gray matter (Figure 1: A and B) were selected in two slices, four on the lower slice and four in upper slice. LCModel combined with Culich program was used to quantitative analyses of spectra. Ratios among peak areas of NAA, Cr, Cho, mI, Glu and Gln levels were compared among groups in each region. SPSS 17.0 program was used for statistical analysis.

Results: The average of the metabolites ratios of the eight spectra of parietal gray matter showed statistical differences. AD patients had significantly lower NAA/Cr ratio when compared with MCI patients (NAA/Cr_{AD}=1.50 ± 0.09, NAA/Cr_{MCI}=1.61 ± 0.13; Bonferroni p=0.023). MCI patients showed statistical lower values of Cho/Cr ratio than control subjects (Cho/Cr_{MCI}=0.21 ± 0.02, $Cho/Cr_{Control}$=0.23 ± 0.02; Bonferroni p=0.013).
The spectra analysis of each individual small voxel also showed NAA/Cr and Cho/Cr ratios values with statistical differences between groups (Table 1). Patients with AD had lower value of NAA/Cr than DCL patients and control group. Moreover, NAA/Cr ratios of lower slice showed lower values than those of the upper slice. Finally, no statistical differences had been observed in mI/Cr and GluGln/Cr ratios.

Discussion/Conclusion: The use of 3D CSI provides the possibility of a more detailed metabolic study of some interesting small brain anatomical regions than in the standard SV approach. Moreover, 3D CSI allows including in the study several anatomical regions of interest in a relatively reduced time of acquisition. Therefore, further connectivity correlation studies among metabolic alterations in different brain locations can be conducted. In this study metabolic differences within different small regions of the parietal gray matter region have been observed. Alteration in metabolism of parietal gray matter has been previously related with early sign of AD [1, 2]. Not statistical differences have been found in metabolite composition between right and left parts of the parietal gray matter. A clear statistical decrease in neuronal marker (NAA) and membrane turnover (Cho compounds) has been found between MCI and AD patients in the eight regions of the parietal gray matter studied (Table 1). However, no statistical differences have been detected in mI and Glu Gln metabolites. The possibility of a metabolic study of small regions in a large brain volume can provide additional information that can be useful for supporting the diagnosis and prognosis of MCI and AD patients.

References

[1] Martínez-Bisbal MC, et al. Eur J Neurol. 2004 Mar;11(3):187-93; [2] Arana E, et al. ,Br J Radiol. 2009 Feb;82(974):172

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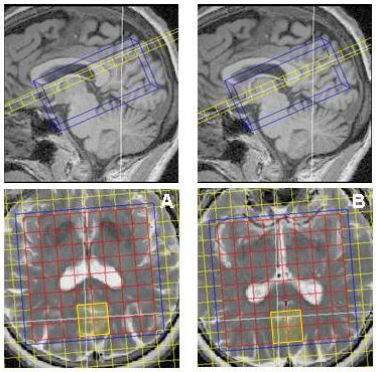

Figure 1. Example of 3D CSI location on sagittal and tranverse MRI slice. Upper (A) and lower slice (B) selected including parietal gray matter.

Table 1. Metabolic comparison among controls, MCI and AD patients in the parietal gray matter by NAA/Cr and Cho/Cr.

		NAA/Cr			Cho/Cr		
		Control	MCI	AD	Control	MCI	AD
lower	r.f.	1.54 ± 0.17	1.52 ± 0.13	1.37 ± 0.10	0.24 ± 0.02	0.22 ± 0.03	0.23 ± 0.02
	ANOVA		**0.002**			0.072	
	r.b.	1.50 ± 0.15	1.52 ± 0.14	1.43 ± 0.08	0,22 ± 0,02	0.20 ± 0.02	0.21 ± 0.02
	ANOVA		0.115			**0,031**	
	l.f.	1.56 ± 0.19	1.54 ± 0.14	1.39 ± 0.11	0.24 ± 0,02	0.22 ± 0.02	0.23 ± 0.02
	ANOVA		**0.006**			0.210	
	l.b.	1.47 ± 0.14	1.52 ±0.13	1.40 ± 0.12	0.21 ±0.02	0.20 ± 0.02	0.21 ± 0.02
	ANOVA		**0.016**			**0.047**	
upper	r.f.	1.80 ± 0.25	1.73 ± 0.18	1.56 ± 0.15	0.25 ± 0.04	0.22 ± 0.03	0.22 ± 0.02
	ANOVA		**0.007**			**0.016**	
	r.b.	1.62 ± 0.04	1.71 ±0.19	1.54 ± 0.18	0.22 ± 0.04	0.20 ± 0.03	0.20 ± 0.02
	ANOVA		**0.020**			**0.036**	
	l.f.	1.79 ± 0.24	1.72 ± 0.18	1.58 ± 0.13	0.25 ± 0.03	0.22 ± 0.02	0.22 ± 0.02
	ANOVA		**0.023**			**0,008**	
	l.b.	1.63 ± 0.14	1.70 ± 0.18	1.54 ± 0.13	0.22 ± 0.03	0.20 ± 0.02	0.20 ± 0.02
	ANOVA		**0,018**			**0,040**	

Mean ± standard deviation

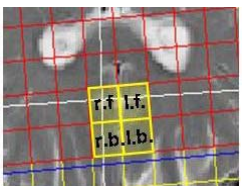

Figure 2. Voxels nomenclature. r.f.: right front, r.b.: right back, l.f.: left front, l.b.: left back.