Diffusion weighted imaging differentiates corticobasal degeneration from progressive supranuclear palsy and Parkinson's disease

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Introduction

Corticobasal degeneration (CBD) and progressive supranuclear palsy (PSP) are two neurodegenerative disorders within the category of tauopathies. The similar pathogenesis may be reflected in a similar clinical phenotype. Certain characteristics help to guide the clinician to a likely diagnosis of CBD or PSP, but differential diagnosis remains difficult. DWI studies have shown increased apparent diffusion coefficient (ADC) values in basal ganglia of MSA (1) and PSP patients (2) compared with Parkinson's disease (PD) patients and increased ADC values in middle cerebellar peduncles (MCP) of MSA patients compared with PD and PSP patients (3). No DWI study has been performed in CBD patients.

The aim of our study was to analyze ADC maps from CBD, PSP and PD patients in order to identify objective markers to discriminate between these groups.

Methods

We studied thirteen PD patients (age 62±10 years, mean±SD), nine PSP patients (62±7), five CBD patients (72±10) and nine healthy volunteers (63±4). Diagnosis was made according to the Brain Bank criteria for PD, the Litvan criteria for PSP and the Lang and Kumar criteria for CBD.

Subjects were studied in a 1.5T General Electrics Medical Systems (Milwaukee, Wisconsin) Signa Horizon LX whole-body scanner. Axial DW images were obtained (thickness = 5 mm, inter-slice gap = 1 mm) using a single-shot EPI sequence (matrix size = 192 x 192 mm). Orthogonal x, y, and z diffusion encoding gradients were applied with gradient strengths corresponding to b-values of 300, 600 and 900 mm^2/s. In addition, images without diffusion weighting were acquired corresponding to b = 0 s/mm^2 and exhibiting T_2-contrast. The ADC of each direction was determined pixel-wise using a least-squares fit, assuming a signal attenuation depending mono-exponentially on the b-value. By calculating the mean of the three directions, the ADC trace map was generated.

ROIs were defined to include corpus callosum and left and right thalamus, caudate, putamen, pallidus and frontal white matter. Histograms of ADC were generated for all voxels in left and right cerebral hemispheres separately. The skew of the ADC distribution was assessed by finding the 50th percentile values along with the mean. We calculated the ratio of the smaller to the larger 50th percentile value (median) for left and right hemispheres, to give an index of symmetry (1 = perfect symmetry).

Statistical significance, determined by the Kruskal-Wallis test and posthoc Mann-Whitney U test, was taken as $p<0.05$.

Table 1. ADC values and symmetry index in studied subjects.

ROIs	ADC ($x10^{-3}$ mm^2/s)				*P (Kruskal-Wallis test)*
	NC	PD	PSP	CBD	
Caudate	0,76 ± 0,05	0,76 ± 0,03	0,75 ± 0,03	0,79 ± 0,02	0,12
Putamen	0,71 ± 0,02	0,72 ± 0,02	0,75 ± 0,02	0,78 ± 0,02	*0,0002*[A]
Pallidus	0,75 ± 0,08	0,74 ± 0,03	0,76 ± 0,05	0,79 ± 0,04	0,14
Thalamus	0,77 ± 0,05	0,79 ± 0,05	0,77 ± 0,03	0,82 ± 0,05	0,21
Frontal WM	0,80 ± 0,04	0,77 ± 0,02	0,79 ± 0,03	0,79 ± 0,03	0,25
Corpus callosum	0,84 ± 0,04	0,82 ± 0,06	0,81 ± 0,07	0,79 ± 0,03	0,4
Cerebral hemispheres histograms					
median left	0,90 ± 0,04	0,89 ± 0,04	0,87 ± 0,02	0,97 ± 0,03	*0,005*[B]
median right	0,90 ± 0,04	0,89 ± 0,04	0,87 ± 0,02	0,94 ± 0,04	*0,03*[C]
Symmetry index	0,99 ± 0,004	0,99 ± 0,004	0,99 ± 0,004	0,96 ± 0,01	*0,002*[D]

[A]Mann-Whitney test: CBD vs PD/Nrl P=0,002; PSP vs Nrl P=0,003; PSP vs PD P=0,01.
[B]Mann-Whitney test: CBD vs PSP P=0,003; CBD vs PD P=0,005; CBD vs Nrl P=0,009 .
[C]Mann-Whitney test: CBD vs PSP P=0,004
[D]Mann-Whitney test: CBD vs PSP/Nrl P=0,003; CBD vs PD P=0,001

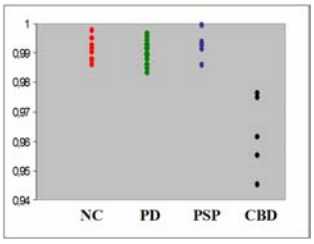

Figure 1. Scatterplot of symmetry index from PD, PSP, CBD patient and normal control (NC).

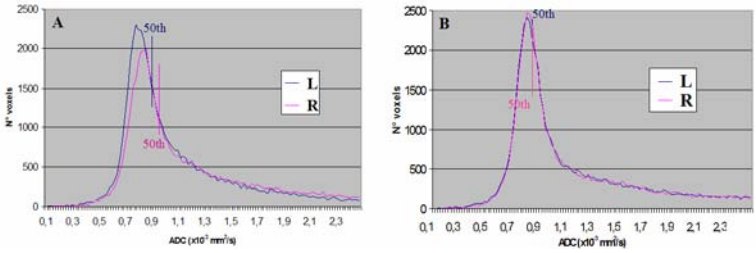

Figure 2. Cerebral hemispheres histograms in a (A) CBD and in a (B) PSP patient.

Results

For all groups and in every ROI selected ADC values were not statistically different between right and left side and are reported as mean value. Comparing groups a difference was detected in the putamen and posthoc analysis showed that ADC values in CBD and PSP were significantly greater than in PD and controls (Table 1). Putaminal ADC values did not distinguish CBD from PSP. A significant difference was found in the medians of cerebral hemispheres histograms, as in CBD patients the values were significantly greater, prevalently in the left side (Figure 2), while a difference in symmetry index was found to be due to a reduction in CBD compared to PSP, PD and healthy controls (Figure 1).

Discussion

Our results are in agreement with previous findings that the majority of PSP patients have increased ADC values in the putamen (2-3). However, we did not detect significant differences in caudate, pallidus or thalamus. The CBD patient group has not previously been studied. As with other atypical parkinsonisms, CBD patients showed an increased putaminal diffusivity. We were able to discriminate CBD from PSP patients using cerebral hemispheres histograms and an index of inter-hemispheric symmetry of global ADC. Asymmetry in CBD was significantly greater than in other groups, with no overlap between CBD and PSP (Figure 1). Abnormal histograms are explicable by the substantial cortical involvement in CBD. Evidence of asymmetric diffusivity is consistent with typically asymmetric signs and symptoms, with data from PET (4) and SPECT (5) studies revealing asymmetric patterns, and with voxel-based morphometry that indicated asymmetric atrophy in CBD (6). Lack of significant differences between left and right side in putamen and other ROIs of CBD patients can be interpreted by more evident asymmetry in the cortex than in basal ganglia. These preliminary results strongly suggest that DWI is useful for differentiating CBD from PSP and PD.

References

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