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Differentiation of Parkinson's disease and progressive supranuclear palsy with magnetic resonance imaging: The first Brazilian experience

Orlando G.P. Barsottini[a,*], Henrique B. Ferraz[a], Antonio C.M. Maia Jr.[b], Carlos J. Silva[b], Antonio J. Rocha[b]

[a] *Department of Neurology, Universidade Federal de São Paulo, Rua Cabedelo, 265 São Paulo-SP, CEP 05618-010, Brazil*
[b] *Fleury Institute, MRI Unit, Sao Paulo, Brazil*

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Abstract

Background: The objective of this study is to differentiate PSP from Parkinson's disease through magnetic resonance imaging.
Methods: We included 14 consecutive patients with PD (9) or PSP (5). These measures included the third ventricle, midbrain diameter, quadrigeminal plate, brainstem volumetry, and interpeduncular angle.
Results: Patients with PSP presented enlargement of third ventricle (100% vs. 33%), lower midbrain diameter (mean 13.2 ± 1.7 mm vs. 16.5 ± 1.7 mm) and thinning of the quadrigeminal plate (mean 2.7 ± 0.3 mm vs. 3.6 ± 0.3 mm) in comparison with PD.
Conclusions: Characteristic findings on MRI may help to differentiate PD from PSP.

Keywords: MRI; Atypical parkinsonism; Parkinson's disease; Progressive supranuclear palsy

1. Introduction

The most common cause of parkinsonism is Parkinson's disease (PD). Approximately 20–24% of PD patients will eventually develop atypical parkinsonian disorders, also called atypical parkinsonism (AP) [1].

Parkinsonism is considered atypical when the condition evolves rapidly, responds poorly or transiently to levodopa therapy or has other associated features. Structural damage in this group of disorders is more extensive than in PD, and could explain the poor therapeutic response [1]. The MRIs of PD patients show signal abnormalities and progressive atrophy in the substantia nigra. The most characteristic imaging feature is hypointensity in the substantia nigra on T2-weighted images as a result of iron accumulation [2].

Progressive supranuclear palsy (PSP) is characterized by parkinsonism associated with supranuclear vertical gaze palsy, postural instability, and axial rigidity, frequently without resting tremor [3]. PSP is now classified in the tauopathy group due to the involvement of TAU protein in the pathogenesis of this disorder. PSP is a rare disease, and is difficult to distinguish from PD relying only on clinical criteria. The MRI reflects the involvement of many structures. The midbrain atrophy is particularly well demonstrated on midline sagittal images, showing reduced midbrain diameter, enlarged cerebral aqueduct and thinned quadrigeminal plate. Signal abnormalities are mild and consist of hyperintensity in the periaqueductal region on T2-weighted sequences [4].

2. Patients and methods

A cross-sectional study was carried out comprising a sample of patients seen at the Movement Disorders Outpatient Clinic of the *Universidade Federal de São Paulo*. Fourteen consecutive patients were assessed and met the diagnostic criteria for PD or PSP.

Five patients met the National Institute of Neurological Disorders and Stroke and Society for PSP (NINDS-SPSP) criteria for probable PSP [5]. There were nine patients with a clinical diagnosis of PD, defined according to the United Kingdom PD Brain Bank criteria [6]. The mean age and mean duration of disease were similar between the two groups of patients at the time MRI was performed. The study was approved by the Ethics Research Committee of the *Universidade Federal de São Paulo*; written

*Corresponding author. Tel.: +55 11 37449875; fax: +55 11 38870066.
E-mail address: orlandobarsottini@gmail.com (O.G.P. Barsottini).

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informed consent was obtained from all participants. The exclusion criteria were: stroke, leukoencephalopathies (demyelinating, metabolic, toxic, infectious), severe unrelated neurological or physical disease.

3. MRI imaging protocol

MRI-based volumetry was performed by using the method described by Luft et al. [7]. All measurements were performed on a Horizon Signa 1.5-T scanner (General Electric, Milwaukee, USA), using the standard head coil. Two MRI series were acquired. High resolution T1-contrasted images were acquired using a three-dimensional spoiled gradient recalled pulse sequence (3D-SPGR-repetition time [TR] = 23 ms; echo time [TE] = 4.3 ms; flip angle = 37°; number of excitations [NEX] = 1; slice thickness = 1.0 mm) producing 1 mm isotropic voxels.

A double-contrast spin echo (SE) was acquired twice in interleaved slice positions to obtain a gapless set of images (TR = 3200 ms; TE = 30/90 ms; 1 NEX; slice thickness = 3.0 mm; gap = 1.5 mm). Since the SE sequence included two echoes, two image sets of different contrast (TE = 30 ms; proton density contrast; TE = 90 ms: T2-weighted contrast) equal slice positions were obtained. The 3D-SPGR images were used for cerebellar and brainstem volumetry. Basal ganglia were measured using SE images.

For post-processing, data were transmitted to a graphics workstation (Silicon Graphics, Mountain View, CA).

MRI-based volumetry was performed using the method described in detail by Schulz et al. [8]. In brief, it consisted of manual, landmark-defined presegmentation followed by automated region growing-based detailed segmentation and calculation of volume as demonstrated in Fig. 1. Manual presegmentation based on predefined anatomical landmarks was followed by automatic region-growing segmentation of regions of interest. Volumes were obtained by multiplying together the number of voxels per regions of interest and the slice thickness. Interactive pre-segmentation was necessary when the boundaries between structures were not contrasted; therefore, they were not segmented by region growing. Brainstem and cerebellum were segmented first and then subtracted from the original images. The cranial border of the brainstem was defined as the axial plane through mamillary body and posterior comissure. Its caudal border was formed by a plane parallel to the latter and aligned for the posterior rim of the foramen magnum. Cerebellum was separated from the brainstem based on a coronal plane through posterior comissure and obex, shifted posteriorly to pass through the posterior edge of the inferior colliculus. The above-described methods produce data with a mean coefficient of variation of 0.72, as reported previously for structure of the inferior fossa [9]. The intraclass correlation coefficient for choosing segmentation thresholds for gray and white matter as well as for measurements of cortical structures was 0.98 ($p<0.001$). Basal ganglia were measured by using the first and second echoes of the SE dataset. Additional information from the second contrast allowed better identification of each nucleus (multispectral analysis). The volumetric analyses of the caudate nucleus and putamen were performed using the Xinapse Systems software (Jim Version 3.0).

The following were measured and analyzed: presence or not of enlargement of the third ventricle by subjective analysis; anteroposterior diameter of the midbrain through linear measuring, on the sagittal plan, of the smallest possible measure on the axis that is orthogonal to the cerebral aqueduct; quadrigeminal plate thickness by measuring the maximum thickness on the sagittal plan, in the midline, on the plan that is orthogonal to the cerebral aqueduct axis; interpeduncular angles by measuring the angles formed by straight lines that cross the middle segment of cerebral peduncles with an intersection point in the cerebral aqueduct (external angle) and by measuring the angle formed by the internal limits of cerebral peduncles (internal angle) Fig. 2; brainstem volumetry through manual delimitation of structures, slice-by-slice, based on volumetric sequences; volumetry of the caudate

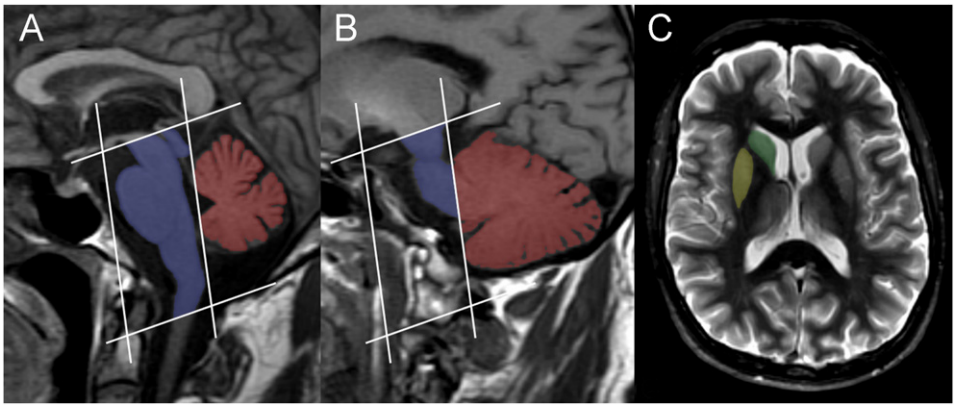

Fig. 1. Predefined anatomical landmarks were followed by automatic region-growing segmentation of regions of interest. The cranial border of the brainstem was defined as the axial plane through mamillary body and posterior comissure (A and B). Its caudal border was formed by a plane parallel to the latter and aligned for the posterior rim of the foramen magnum. Cerebellum was separated from the brainstem based on a coronal plane through posterior comissure and obex, shifted posteriorly to pass through the posterior edge of the inferior colliculus. The volumetry of the caudate nucleus and putamen were done by manual delimitation of structures, slice-by-slice, of these midbrain structures (C).