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Optimal detection of infratentorial lesions with a combined dual-echo MRI sequence: “PT2”

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Abstract

Background—The infratentorial compartment is cardinal for multiple sclerosis diagnosis. T2-weighted (T2) and proton density (PD) MRI can visualize infratentorial lesions, but only suboptimally.

Objective—To combine PD and T2 for better lesion assessment.

Methods—T2 and PD from 35 cases were averaged to form “PT2” images. Two raters counted infratentorial lesions and qualitatively assessed their conspicuity.

Results—PT2 showed 244 infratentorial lesions, of which 94% and 74% were seen in PD and T2. PT2 received higher grades for image quality and lesion conspicuity ($p < 0.001$ for all comparisons).

Conclusion—PT2 could improve our ability to diagnose and monitor multiple sclerosis.

Keywords

Multiple Sclerosis; MRI; Infratentorial Brain; T2 lesions

Introduction

Cerebral multiple sclerosis (MS) lesions are typically distributed in the periventricular, juxtacortical, and infratentorial white matter of the brain. T2-FLAIR MRI uses an inversion

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Disclosure

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pulse to suppress cerebrospinal fluid (CSF) signal and distinguish supratentorial white matter lesions (WML) from CSF, leading to better detection of periventricular and juxtacortical WML. FLAIR is less sensitive to infratentorial lesions (1), although some improvement can be achieved at higher field strengths (2).

Dual-echo T2-weighted fast spin echo MRI allows rapid acquisition of proton density-weighted (PD) and T2-weighted (T2) images in the same scan. T2 and PD contrasts more sensitively detect infratentorial WML than conventional FLAIR (1, 3); however, image quality and conspicuity of lesions are still suboptimal. Missed infratentorial lesions may have a substantial impact on the MRI-based classification and diagnosis of patients with clinically isolated syndromes (CIS), with adverse consequences for prognostic classification and therapeutic decision-making (4).

Here, we combine the two contrasts, PD and T2, which are obtained simultaneously with the dual-echo sequence, to generate a new image called “PT2.” We hypothesized that PT2 would improve image quality and lesion conspicuity in the infratentorial compartment relative to the PD and T2.

Methods

Participants

Following ethical approval, we scanned 35 consecutive MS cases (5) over a 6-month period. Scans without infratentorial lesions detected on PD or T2 were excluded. Experienced clinicians determined disability according to the Expanded Disability Status Scale (EDSS) (6).

MRI

MRI was performed on a 3-tesla (T) scanner (Signa Excite HDxt; General Electric, Waukesha, WI) using an 8-channel receive coil. We acquired whole-brain, dual-echo fast-spin-echo images (in-plane resolution, 0.5×1mm, slice thickness, 3mm; acquisition time, 1min 57sec; repetition time, 5320msec; echo time 1, 23msec; echo time 2, 116msec).

Image postprocessing

We analyzed data using MIPAV (<http://mipav.cit.nih.gov>). The two contrasts obtained in the dual echo sequence (T2 and PD) were averaged, resulting in a new image: “PT2.”

Data analysis

Two trained raters, a neurologist (MIG, 11 years of experience) and a neuroradiologist (PY, 21 years of experience), separately evaluated the 3 sequences. Qualitative assessment was performed for image quality (defined as the overall visual quality of the image with regard to noise level, contrast, and artifacts) and lesion conspicuity (defined as the ease of visibility of lesions). To evaluate these two criteria, an ordinal grading system was used: 0, poor; 1, acceptable; 2, good; 3, excellent. Infratentorial lesions were counted by consensus of the two raters.

Statistical analysis

The inter-rater agreement was estimated by using a weighted κ test (7). Grades given by both of the raters were used to compare PT2 images against the other two contrasts by the non-parametric Friedman test with post-hoc multiple comparisons.

Results

Participants

We studied MRI scans from 35 MS cases. 33 had relapsing-remitting MS and 2 had secondary progressive MS. 19 were women; mean (standard deviation) age was 45 (11) years; disease duration was 8 (5) years; and EDSS range was 0–7.

Qualitative analysis

There was moderate agreement for infratentorial lesion conspicuity ($\kappa=0.42$) and infratentorial image quality ($\kappa=0.40$) and fair agreement for supratentorial lesion conspicuity ($\kappa=0.35$) and image quality ($\kappa=0.31$). PT2 received higher grades than T2 for infratentorial (Figure, panels C,F,I) and supratentorial (Panels L,O) lesion conspicuity ($p<0.001$). PT2 also received higher grades than PD for infratentorial and supratentorial lesion conspicuity ($p<0.001$). PT2 received higher grades for infratentorial and supratentorial image quality than both T2 and PD ($p<0.001$). Data for the two raters are summarized in Table 1.

Infratentorial lesion counts

A total of 244 lesions were detected with PT2, of which 230 (94%) were seen in PD and 180 (74%) in T2. Six lesions were only detected in PT2 (2.5%).

Discussion

Our results show that PT2 has a higher rate of infratentorial lesion detection, and provides better image quality and higher lesion conspicuity, than PD and T2 alone. The combined image had fewer artifacts, less noise, and better contrast, and it detected more lesions.

Conventional fast-spin-echo PD and T2-weighted sequences are included in standard MS protocols because they have high sensitivity for detecting focal MS lesions in the brain (3). The pulse sequence efficiently provides both contrasts, simultaneously, in <2 minutes. As the two echoes are collected <100msec apart, the images are naturally coregistered. PT2 images were generated using MIPAV, which is cross-platform. For the scanner used in this study, technologists could also generate PT2 on the MRI console by using the manufacturer's "functool" program, after which the images may then be sent to the local Picture Archiving and Communication System for radiological interpretation.

MRI at high field strength has a substantial influence on the classification of patients with CIS. Based on MRI findings, patients may be diagnosed with MS immediately, or their risk level of future MS conversion may be defined (4). This is critical for patient management because it affects prognostic classification and therapeutic decision-making. The presence of infratentorial lesions portends more substantial disability in people with initial findings

suggestive of MS (8, 9), which is not surprising given that the brainstem and cerebellum are clinically “eloquent” locations that subserve critical functions (10). In this sense, better lesion detection in this region using PT2 may improve our ability to diagnose and monitor MS, hopefully with the effect of reducing long-term disability.

Interestingly, PT2 was also better than PD and T2 for supratentorial lesion detection and image quality. Because FLAIR is more sensitive than PD and T2 for supratentorial lesion detection (1), future studies should compare PT2 to FLAIR directly. This was not the goal of our study. Volumetric 3D FLAIR scans were also obtained, and parameters were optimized for detection of supratentorial lesions. Lesion conspicuity in the posterior fossa was relatively poor, and as such we did not perform a quantitative comparison with P2T.

Conclusion

As the infratentorial brain is a cardinal compartment for MS diagnosis, PT2 imaging, which requires no additional acquisition time, could improve our ability to diagnose and monitor the disease. As post-processing is simple, acquiring the images is feasible in the clinical setting, making a strong argument for its incorporation in radiologist and MS neurologist readings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

A, D, G: Infratentorial T2 images. B, E, H: Infratentorial PD images. C, F, I: Infratentorial P2T images. Note the better image quality and lesion conspicuity in C, F, and I in comparison to the other images. Arrows in C, F and I point to lesions not well defined in other sequences. J, M: Supratentorial T2 images. K, N: Supratentorial PD images. L, O: Supratentorial P2T images. Note the better image quality and lesion conspicuity in L and O. Arrows in L and O point to leukocortical lesions.

Table 1

Mean ranks and Friedman test to compare effect in the 4 analyzed variables.

Variable	PT2	PD	T2	Chi-square	p-value
Image quality IT	2.81	1.87	1.32	102.4	<0.001
Rater 1	2.86	1.74	1.40	.	<0.001
Rater 2	2.76	2.00	1.24	.	<0.001
Image quality ST	2.75	1.74	1.51	93.5	<0.001
Rater 1	2.93	1.56	1.51	.	<0.001
Rater 2	2.57	1.91	1.51	.	<0.001
Lesion conspicuity IT	2.79	1.94	1.26	105.9	<0.001
Rater 1	2.79	1.90	1.31	.	<0.001
Rater 2	2.80	1.99	1.21	.	<0.001
Lesion conspicuity ST	2.71	1.78	1.51	88.9	<0.001
Rater 1	2.90	1.57	1.53	.	<0.001
Rater 2	2.51	1.99	1.50	.	<0.001

IT, infratentorial, ST, supratentorial.