

Are your **MRI contrast agents** cost-effective?

Learn more about generic **Gadolinium-Based Contrast Agents**.



FRESENIUS
KABI

caring for life

AJNR

Gadopentetate dimeglumine enhancement of multiple sclerosis lesions on long TR spin-echo images at 0.6 T.

F Barkhof, J Valk, O R Hommes, P Scheltens and J J Nauta

AJNR Am J Neuroradiol 1992, 13 (4) 1257-1259

<http://www.ajnr.org/content/13/4/1257>

This information is current as of May 11, 2024.

Gadopentetate Dimeglumine Enhancement of Multiple Sclerosis Lesions on Long TR Spin-Echo Images at 0.6 T

Frederik Barkhof,^{1,5} Jacob Valk,¹ Otto R. Hommes,² Philip Scheltens,³ and Jos J.P. Nauta⁴

Summary: the authors sought to determine if Gd-DTPA enhancement of multiple sclerosis (MS) hampers lesion detection on long TR spin-echo images (TE 60 msec) at 0.6 T. They measured the signal intensity (SI) of 41 lesions (10 patients) and normal-appearing gray (NAGM) and white matter (NAWM) before and after administration of contrast. The change in SI of nonenhancing lesions and NAGM and NAWM was small ($\leq 1.5\%$), and of enhancing lesions (5.3%) moderate. The contrast of nonenhancing lesions to NAGM and NAWM changed insignificantly, but the contrast of enhancing lesions to NAGM and NAWM increased significantly. The authors conclude that long TR images can be obtained after Gd-DTPA without hampering lesion conspicuity in research MR protocols in multiple sclerosis.

Index terms: Sclerosis, multiple; Contrast media, paramagnetic

Multiple sclerosis (MS) is a demyelinating disease of the central nervous system, accompanied by inflammation and disruption of the blood-brain barrier (BBB), which can be demonstrated by means of Gd-DTPA, leading to enhancement of T1-relaxation and an increase in signal intensity (SI) on short TR spin echo (SE) images. Gd-DTPA enhancement is one of the most important radiologic markers of disease activity in MS (1).

Gd-DTPA enhancement is an early finding and even one that may precede (2) the evolution of most MS-lesions in patients with a relapsing-remitting or secondary progressive disease course (1). Gd-DTPA enhancement is dependent on the permeability of the BBB, which changes as the lesions become older (3, 4). As MS-lesions evolve the permeability of the BBB gradually diminishes, leading to a gradual delay/decrease in Gd-DTPA enhancement. Therefore, a postinjection interval is often employed to improve lesion detection (1, 5, 6).

The purpose of the present study is to see whether Gd-DTPA injection has any influence on the SI of MS lesions on long TR SE sequences or influences lesion conspicuity.

Patients and Methods

Ten patients (eight women and two men, with an age ranging from 27–44 years) with clinically definite MS (7) who were experiencing a relapse, were scanned before treatment on a superconducting system (Teslacon II, Technicare) with a standard head coil and a resonance frequency of 25.6 MHz (0.6 T). Throughout the scanning procedure the section thickness was 5 mm (gap 1.25 mm), with an inplane resolution (pixel-size) of 1.0×1.3 mm. Long TR SE sequences 2755/60 (reduced bandwidth)/2 (TR/TE/excitations) were obtained precontrast.

Gd-DTPA (Magnevist, Schering AG, Berlin, Germany) (0.2 mmol/kg) was injected intravenously, followed by normal saline (10 mL), with the patient remaining in the same position in the head coil. Postcontrast series (planned as the precontrast series) consisted of long TR (2755/60(reduced bandwidth)/2) sequences (19 sections) obtained directly after contrast and subsequent (ie, starting 12 minutes after contrast injection) short TR (400/28/4) sequences (2 series of 9 sections).

Gd-DTPA enhancement was present on 9/10 scans, from which we selected 24 enhancing and 18 nonenhancing lesions (at least one nonenhancing lesion per patient) (Fig. 1). The average level of the background noise on the long TR images was 119 (average SD 60). The SI of both enhancing and nonenhancing lesions (LE) and normal appearing gray (NAGM) and normal appearing white matter (NAWM) on the same section was measured on pre- and postcontrast long TR and postcontrast short TR images at exactly the same location. The significance in changes (averaged per patient) in SI and contrast was tested by referring the standard score z to the Standard Gaussian distribution.

Received September 3, 1991; accepted and revision requested October 10; revision received December 6.

Department of ¹ Diagnostic Radiology, ³ Department of Neurology, and ⁴ Department of Theory of Medicine, Epidemiology, and Biostatistics, Free University Hospital, P. O. Box 7057, 1007 MB Amsterdam, The Netherlands.

² Institute of Neurology, University Hospital Nijmegen, P. O. Box 9101, 6500 HB Nijmegen, The Netherlands.

⁵ Address reprint requests to F. Barkhof, Department of Diagnostic Radiology, Free University Hospital, P. O. Box 7057, 1007 MB Amsterdam, The Netherlands.

Results

After contrast the mean SI of nonenhancing lesions changed from 9942 (± 3754) to 9931 (± 3919) ($P = .88$), while the NAWM on the same sections changed from 6449 (± 2480) to 6352 (± 2380) ($P = .0574$) and the NAGM from 7895 (± 2952) to 7862 (± 2897) ($P = .45$). The enhancing lesions increased in SI from 8744 (± 3927) to 9205 (± 3971) ($P = .562$). The corresponding NAWM changed from 6122 (± 2497) to 6044 (± 2434) ($P = .0768$) and the NAGM from 7436 (± 2804) to 7365 (± 2801) ($P = .24$). For enhancing lesions the contrasts increased significantly after Gd-DTPA (LE/NAGM: 1.41 (± 0.14) to 1.52 (± 0.16), $P = .01$, and LE/NAWM 1.15 (± 0.09) to 1.24 (± 0.12), $P = .04$), while the contrast of NAWM/NAGM (0.82, ± 0.04) did not change ($P = .99$). For nonenhancing lesions the contrast changed insignificantly ($\leq 1\%$, $P \geq .59$).

Discussion

Gd-DTPA is widely used for its relaxation effect in ^1H imaging. In vitro there is a linear correlation between Gd-DTPA concentration in water and both T1 and T2 relaxation at 20 MHz (8). Increase

of Gd-DTPA concentration enhances proton relaxation in water. In vivo Gd-DTPA has a strong enhancing effect on T1 relaxation, but only a weak enhancing effect on T2 relaxation (4, 9–12).

A widely used SE pulse sequence in MS studies employs a TR of approximately 2500 msec and an TE between 40 and 60 msec (1, 5, 6, 13–15). Such images are commonly referred to as “mildly T2-weighted” images and are normally obtained before Gd-DTPA injection. The rationale for doing so probably is to avoid an enhancing effect of Gd-DTPA on T2 relaxation, with subsequent loss of signal from Gd-DTPA-enhancing lesions on “T2-weighted” images, thus diminishing lesion conspicuity (16).

The decrease in SI of the NAWM (± 1.5) and NAGM ($\pm 1\%$) following Gd-DTPA injection was relatively small. The relative change in signal to noise ratio defined as $\text{SI}(\text{NAWM}) - \text{SI}(\text{background}) / \text{SD of SI}(\text{background})$ did not exceed 3%, which is clinically not significant. There was a moderate increase of the mean SI of Gd-DTPA-enhancing lesions (5.3%), which was not statistically significant due to the large variation of the observed values. This can be explained by the

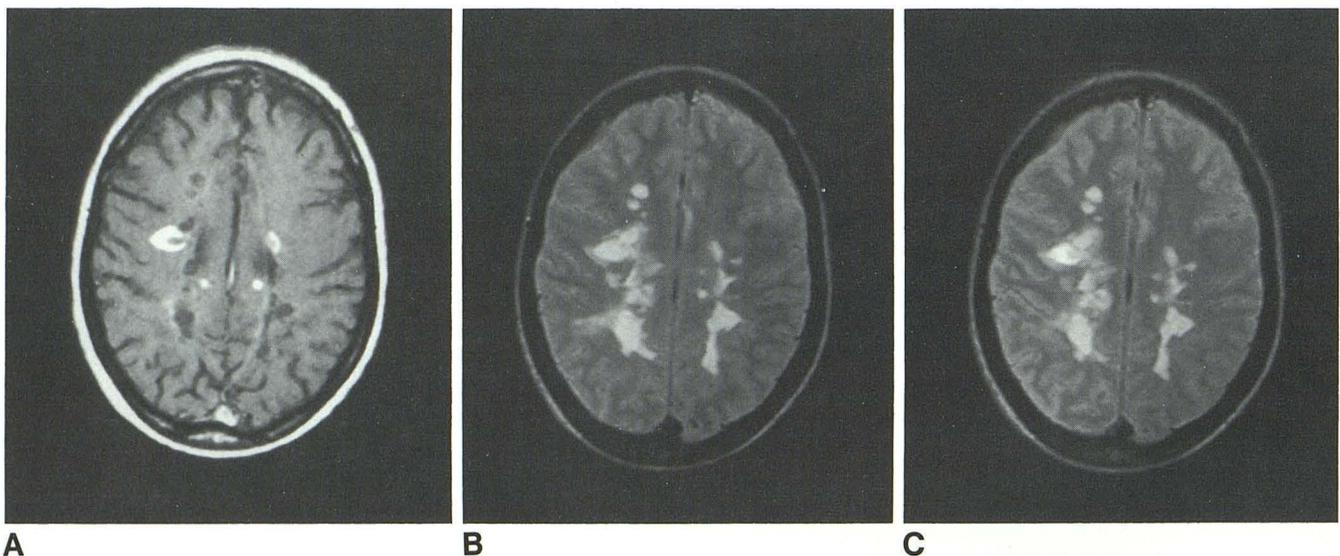


Fig. 1. A, Postcontrast short TR SE image, showing multiple Gd-DTPA enhancing lesions, one of which (right frontal white matter) is oval-shaped and enhances nonuniformly (mean increase in SI after contrast 1.54); this lesion was used for analysis as an “enhancing lesion.”

B, Precontrast long TR SE image at the same level as A, showing multiple lesions in the white matter with increased SI. In addition to the right frontal oval-shaped lesion (SI = 17042), the most posterior right parietal lesion was used for analysis as a “nonenhancing” lesion (SI = 18608). The SI of the normal appearing white matter (NAWM) was 9889, while the SI of the normal appearing gray matter (NAGM) was 12039.

C, Postcontrast long TR image at the same level as A, showing slight enhancement of the right frontal oval-shaped lesion (SI = 19086), without any change in SI of the nonenhancing lesion posteriorly in the right parietal white matter (SI = 18440) or NAGM (SI = 12056) and a slight decrease in the SI of NAWM (SI = 9718).

fact that not all lesions enhance uniformly (sometimes in a ring or crescent like form; see Fig. 1). Consequently, there is a larger spread in the averaged difference in SI measured over enhancing lesions as compared to nonenhancing lesions (SD 725 vs 220).

The contrast of Gd-DTPA-enhancing lesions to NAWM/NAGM on long TR increased statistically significant after Gd (27% and 53%, respectively). The observed increase in SI can only be an effect of enhanced T1 relaxation, which is still appreciated with TR 2755 at 25.6 MHz, so enhancing lesions will have a larger initial magnetization vector at the time of the next excitation pulse. Apparently this effect outweighs the effect (if any) of T2 shortening. There were no significant changes in contrast of nonenhancing lesions. This means that Gd-DTPA up-take improves lesion conspicuity of Gd-DTPA-enhancing lesions on long TR SE images, without hampering detection of lesions who do not take up Gd-DTPA. Based on the results of our study, we propose the following imaging protocol for research MR imaging studies in MS: 1) Gd-DTPA injection, 2) Scout images for repositioning, 3) short TR series, and 4) long TR series.

The use of this scanning protocol has two major advantages. Repositioning errors introduced by removing the patient from the magnet bore for contrast injection are prevented. Both short TR and long TR images will be perfectly well-comparable in position. Long TR and short TR sequences can be obtained consecutively, which makes an often employed postcontrast interval (5–10 minutes) to improve lesion conspicuity on the short TR sequence superfluous.

Acknowledgments

This work was supported by grants from the Praeventiefonds (28-1453), and the Nolet Foundation. Ton Schweigmann is acknowledged for excellent technical support.

References

1. Miller DH, Barkhof F, Berry I, Kappos L, Scotti G, Thompson AJ. Magnetic resonance imaging in monitoring the treatment of multiple sclerosis: concerted action guidelines. *J Neurol Neurosurg Psychiatry* 1991;54:683–688
2. Kermode AG, Thompson AJ, Tofts P, et al. Breakdown of the blood-brain barrier precedes symptoms and other MRI signs of new lesions in multiple sclerosis. *Brain* 1990;113:1477–1489
3. Kermode AG, Tofts PS, Thompson AJ, et al. Heterogeneity of blood-brain barrier changes in multiple sclerosis: an MRI study with gadolinium-DTPA enhancement. *Neurology* 1990;40:229–235
4. Larsson HBW, Stubgaard M, Frederiksen JL, Jensen M, Henriksen O, Paulson OB. Quantitation of blood-brain barrier defect by magnetic resonance imaging and gadolinium-DTPA in patients with multiple sclerosis and brain tumors. *Magn Reson Med* 1990;16:117–131
5. Barkhof F, Hommes OR, Scheltens Ph, Valk J. Quantitative MR changes in Gadolinium-DTPA enhancement after high dose intravenous methylprednisolone in multiple sclerosis. *Neurology* 1991;41:1219–1222
6. Barkhof F, Frequin STFM, Hommes OR, et al. A correlative triad of gadolinium-DTPA MRI, EDSS and CSF-MBP in relapsing multiple sclerosis patients treated with high dose intravenous methylprednisolone. *Neurology* 1992;42:63–67
7. Poser CM, Paty DW, Scheinberg L, et al. New diagnostic criteria for multiple sclerosis: guidelines for research protocols. *Ann Neurol* 1983;13:227–231
8. Gadian DG, Payne JA, Bryant DJ, Young IR, Carr DH, Bydder GM. Gadolinium-DTPA as a contrast agent in MR imaging: theoretical projections and practical observations. *J Comput Assist Tomogr* 1985;9:242–251
9. Watabe T, Azuma T. T1 and T2 measurements of meningiomas and neuromas before and after Gd-DTPA. *AJNR* 1989;10:463–470
10. Barnhart JL, Kuhnert N, Bakan DA, Berk RN. Biodistribution of GdCl₃ and Gd-DTPA and their influences on proton magnetic relaxation in rat tissues. *Magn Reson Imaging* 1987;221–231
11. Wessbacher FW, Maravilla KR, Dalley RW. Gadolinium enhancement of intracranial lesions on spin density and T2 weighted images. *Magn Reson Imaging* 1990;8(s):45
12. Sander B, Schörner W, Felix R. Effects of gadolinium-DTPA on relaxation times of intracranial tumors in magnetic resonance imaging. *AJNR* 1989;10:879–880
13. Miller DH, Rudge P, Johnson G, et al. Serial gadolinium enhanced magnetic resonance imaging in multiple sclerosis. *Brain* 1988;111:927–939
14. Grossman RI, Braffman BH, Brorson JR, Goldberg HI, Silberberg DH, Gonzalez-Scarano F. Multiple sclerosis: serial study of gadolinium-enhanced MR imaging. *Radiology* 1988;169:117–122
15. Paty DW, Oger JF, Kastrukoff LF, et al. MRI in the diagnosis of MS: a prospective study with comparison of clinical evaluation, evoked potentials, oligoclonal banding, and CT. *Neurology* 1988;38:180–185
16. McNamara MT. Paramagnetic contrast media for magnetic resonance imaging of the central nervous system. In: Brant-Zawadzki M, Norman D, eds. *Magnetic resonance imaging of the central nervous system*. New York: Raven, 1987:101