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

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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 (≤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.

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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 (±1%) following Gd-DTPA injection was relatively small. The relative change in signal to noise ratio defined as SI(NAWM)−SI(background)/SD of SI(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

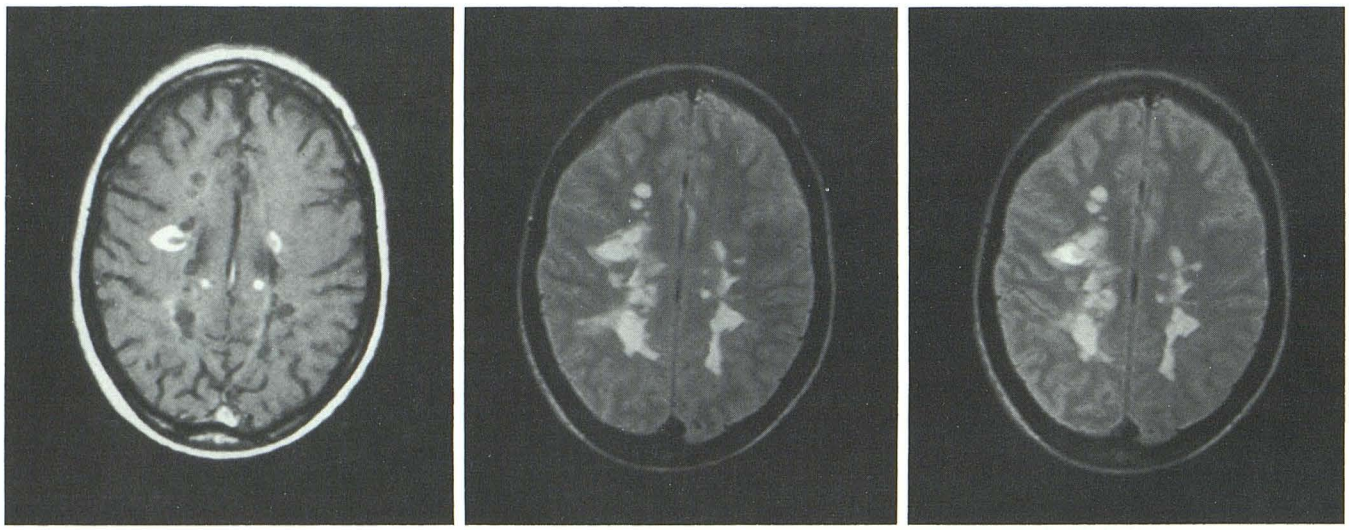

Fig. 1. *A*, Postcontrast short TR SE image, showing multiple Gd-DTPA enhancing lesions, one of which (right frontal white matter) is oval-shaped and enhances nonuniformly (mean increase in SI after contrast 1.54); this lesion was used for analysis as an "enhancing lesion."

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.

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