Gd-DTPA as a Contrast Agent in CT[1]

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An evaluation was done of the effect of gadolinium diethylenetriaminepentaacetic acid (DTPA) on computed tomographic (CT) studies performed after magnetic resonance (MR) imaging. CT scans of two solutions of Gd-DTPA demonstrated substantial attenuation. In two patients who underwent CT after Gd-DTPA-enhanced MR imaging, the high attenuation of concentrated Gd-DTPA was seen in the urinary bladder and renal collecting system. However, in the concentration presently used in MR imaging, Gd-DTPA results in only minor enhancement of renal cortex.

Index terms: Computed tomography (CT), contrast media, 80.1211, 80.1214 • Contrast media, complications • Gadolinium • Magnetic resonance (MR), contrast media

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THE rare-earth element gadolinium chelated with diethylenetriaminepentaacetic acid (DTPA) has been used for several years as a contrast agent in magnetic resonance (MR) imaging in controlled experiments. It has proved to be a safe, well-tolerated, and effective contrast agent (1–5). In many patients who are referred for diagnostic radiology, combinations of imaging studies are performed. The combination of computed tomography (CT) and MR imaging is frequently performed, especially in correlative studies for efficacy assessment. The purpose of this study was to determine if a Gd-DTPA-enhanced MR study performed prior to a CT examination changes the information in the CT images.

Materials and Methods

CT scans of several solutions were obtained for comparison. Solutions of Gd-DTPA manufactured by Schering (Berlin, Federal Republic of Germany) for intravenous administration (Magnevist; concentration of gadopentetate, 0.469 g/mL) and oral administration (SH L 452 F; concentration of gadopentetate, 0.009 g/mL) were scanned and compared with CT scans of ioxithalamate (Telebrix 35; Guerbet, Paris), with a concentration of 350 mg iodine per milliliter, and tap water. The test tubes were scanned with a Philips scanner (Shelton, Conn) to determine the attenuation of the various solutions. A 6-mm-thick section was obtained with 120 kV, 200 mA, and an exposure time of 2.4 msec. Subsequently a region of interest was selected with a cursor. The volume meaured 1 cm^3.

In addition to the test tube studies, two patients who had first been examined with MR imaging were also examined with CT after intravenous administration of Gd-DTPA. Informed consent had been obtained. The first patient, who had multiple exostoses, was examined with CT 1 hour after intravenous injection of Gd-DTPA. In the second patient, images were obtained before and 30 seconds, 2 minutes, 3 minutes, and 9 minutes after administration of Gd-DTPA; images were obtained of the liver, kidneys, and urinary bladder to evaluate the temporal distribution of Gd-DTPA as demonstrated by CT.

Results

In the test tube studies, the Gd-DTPA solution with the highest concentration—that is, Gd-DTPA for intravenous use—had the highest attenuation (Fig 1): 2,809 HU ± 43 (standard deviation). The attenuation of Gd-DTPA for oral use was only 77 HU ± 7, the attenuation of tap water was 11 HU ± 5, and the attenuation of ioxithalamate was 3,495 HU ± 0.

The Gd-DTPA-enhanced MR examination of the patient with multiple exostoses demonstrated the previously described peripheral enhancement pattern of cartilaginous tumors (6). The CT scan obtained 1 hour after injection of Gd-DTPA did not show increased attenuation in the region that enhanced at MR imaging; however, increased attenuation was observed in the urinary bladder and the pelvis of the kidneys (Fig 2).

In the second patient, sequential CT images were made before and after injection of Gd-DTPA. The attenuation of the renal cortex measured before injection was 37 HU ± 5; 30 seconds after injection, 46 HU ± 5; 2 minutes after injection, 46 HU ± 5; 3 minutes after injection, 48 HU ± 6; and 9 minutes after injection, 43 HU ± 8. The attenuation of the liver parenchyma before injection was 63 HU ± 5; 30 seconds after injection, 67 HU ± 5; 2 minutes after injection, 65 HU ± 8; 3 minutes after injection, 66 HU ± 5; and 9 minutes after injection, 63 HU ± 5.

Thirty seconds after injection of Gd-DTPA, an increase in attenuation of only 9 HU was found in the renal cortex, whereas no enhancement was observed in the liver parenchyma. Although the increase in attenuation of renal cortex is small and was measured in only one patient, the increased corticomedullary differentiation constitutes reliable evidence that real enhancement takes place (Fig 3). Delayed im-

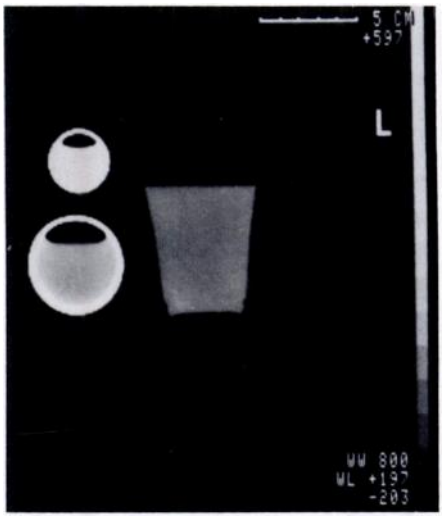

Figure 1. A 6-mm-thick CT section of three solutions: Gd-DTPA for intravenous use (upper left), Gd-DTPA for oral use (lower left), and tap water in a plastic cup (right). The two Gd-DTPA solutions were scanned in their original containers of glass.

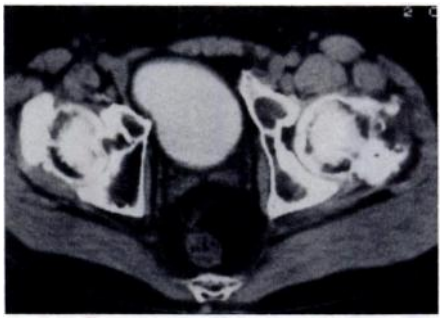

Figure 2. CT scan at the level of the urinary bladder 1 hour after injection of Gd-DTPA. The bladder, because of renal excretion, is filled with concentrated Gd-DTPA. This results in a high attenuation of the bladder lumen. No iodinated contrast agent was used. Note the multiple exostoses.

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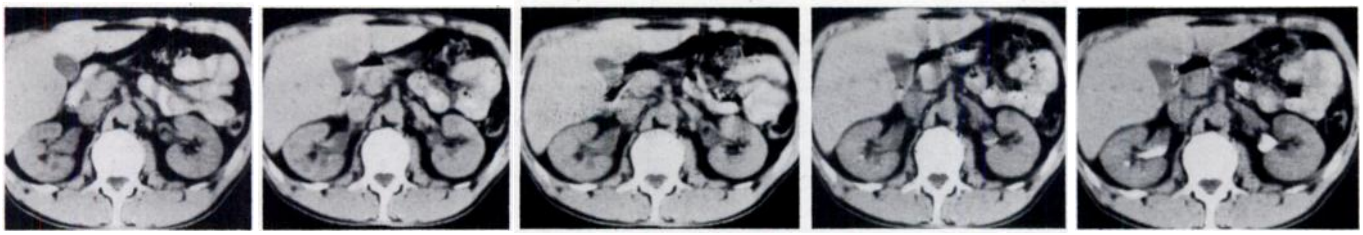

a. b. c. d. e.

Figure 3. Sequential CT images made at one level before **(a)** and 30 seconds to 9 minutes **(b-e)** after injection of Gd-DTPA (0.1 mg/kg body weight). **(a)** CT scan at the level of the liver and kidneys obtained before Gd-DTPA injection. **(b)** Minor enhancement, demonstrated as an increased corticomedullary differentiation, is observed 30 seconds after injection of Gd-DTPA. **(c)** The corticomedullary differentiation is less pronounced on this image taken 2 minutes after injection, probably because of enhancement of the renal medulla. There is no enhancement of the collecting system. **(d)** After 3 minutes, increased attenuation of Gd-DTPA is depicted in the renal collecting system. **(e)** At 9 minutes, an increase in attenuation in both renal collecting systems is observed. No enhancement of liver parenchyma is seen.

ages showed high-attenuation contrast in the collecting system of both kidneys and in the urinary bladder, identical to the images of the first patient. A renal cell carcinoma, which was suspected at ultrasound, was not found with CT or MR imaging.

Discussion

Because of the paramagnetic properties of gadolinium-64, Gd-DTPA is an effective contrast agent in MR imaging (1,2). The complex is well tolerated by humans, and no serious side effects have been reported (3-5).

Gadolinium is characterized by a high atomic number of 64, which compares favorably with that of the x-ray contrast agent iodine (iodine-53). The anticipated high attenuation by concentrated Gd-DTPA at CT was confirmed in the in vitro images (Fig 1). The pharmacokinetics of intravenously administered Gd-DTPA are similar to those of the iodine contrast agents (7-9). The CT examination performed in the two patients after intravenous administration of Gd-DTPA therefore showed an increased attenuation in the urinary bladder and collecting system of both kidneys (Figs 2, 3). Only minor enhancement of the renal cortex was demonstrated, and no enhancement of the liver was demonstrated. This is probably caused by the low concentration of Gd-DTPA in the parenchyma of kidney and liver (Fig 3).

This study demonstrates that the appearance of the urinary collecting system at Gd-DTPA-enhanced CT imaging is similar to that on iodine-enhanced CT images. This may be important when reading CT scans that were made directly after performance of Gd-DTPA-enhanced MR studies. Furthermore, Gd-DTPA may be an alternative to iodinated contrast agents in CT of the urinary collecting system. When Gd-DTPA is administered in the concentration used in MR imaging, minor enhancement of the renal cortex can be observed at CT. This observation may warrant further research into the potential of Gd-DTPA as a CT contrast agent. ■

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