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Gd-DTPA: An Alternative Contrast Medium for CT

Aidan D. Quinn, Neil J. O'Hare, Fintan J. Wallis, and Graham F. Wilson

Objective: The purpose of this study was to demonstrate that gadolinium-diethylenetriamine pentaacetic acid (Gd-DTPA) could be used as a contrast medium in CT as an alternative to iodine-based compounds.

Materials and Methods: Solutions of different concentrations of Gd-DTPA and iopromide were scanned in a tissue equivalent phantom and it was shown that Gd-DTPA caused 2.5 times the attenuation of an equimolar solution of iopromide. From these in vitro studies an in vivo dose of 0.5 mmol/kg Gd-DTPA was calculated to be equivalent to 50 ml iopromide 300.

Results: Pre- and postenhancement CT was performed in a volunteer using Gd-DTPA intravenously, and adequate enhancement occurred in intracranial vessels.

Conclusion: Gd-DTPA can be used to provide enhancement during CT and might be of value in iodine-sensitive patients.

Index Terms: Contrast media—Gadolinium—Computed tomography.

Gadolinium-diethylenetriamine pentaacetic acid (Gd-DTPA) has been shown to be a safe contrast medium in MRI (1,2). Dimeglumine pentetate (Magnevist, Schering, Berlin, Germany) has been shown to cause opacification of the renal tract on CT performed subsequent to its use in MRI (3,4). Recently it has been shown to be a safe angiographic contrast medium (5).

Gadolinium has a k-edge of 52 keV and iodine has a k-edge of 33 keV. Therefore, greater attenuation would be expected using gadolinium in CT, where the peak in intensity of the X-ray spectrum occurs at ~50 keV. Theoretically, it has been shown that when using CT, gadolinium has increased detectability over iodine (6).

We report the use of Gd-DTPA as a contrast medium in cranial CT having first calculated the required dose using phantom studies.

MATERIALS AND METHODS

In Vitro

A tissue equivalent phantom into which solutions of contrast medium could be placed was scanned using a third generation CT scanner (Shimadzu SCT-3000TX). Constant scanning parameters were used for all scans: slice thickness 10 mm, 120 kV, 150 mA, scan time 2 s.

Serial dilutions of a low-osmolar iodine-based contrast medium iopromide 370 (Ultravist, Schering) and of Gd-DTPA (500 mmol/L Magnevist, Schering) were scanned and the attenuation of each recorded as mean Hounsfield units using region of interest analysis.

In Vivo

Ninety milliliters of Gd-DTPA (Magnevist) was injected slowly intravenously into a 90 kg volunteer and limited CT was performed through the circle of Willis using the following parameters: 120 kV, 250 mA, 4.5 s exposure time using 5 mm contiguous slices.

TABLE 1. *Gd-DTPA attenuation values for different concentrations in vitro*

Concentration (mmol/L)	Attenuation (HU)
50	330 ± 5
12.5	79 ± 0.5
6.25	40 ± 0.5
5.0	31 ± 0.5
3.5	22 ± 0.5
2.6	18 ± 0.5

From the Diagnostic Imaging Department, St. James's Hospital, James's Street, Dublin 8, Ireland. Address correspondence and reprint requests to Dr. A. D. Quinn.

TABLE 2. *Iopromide attenuation values for different concentrations in vitro*

Concentration (mmol/L)	Attenuation (HU)
145	356 ± 5
36	92 ± 0.5
18	45 ± 0.5
9	24 ± 0.5
6.8	18 ± 0.5
5.1	14 ± 0.5

RESULTS

In Vitro

Tables 1 and 2, the graph of Fig. 1, and Fig. 2 demonstrate the greater attenuation by Gd-DTPA solutions compared with iodine compounds. At equimolar concentrations, Gd-DTPA caused 2.5 times the attenuation of a solution of iopromide. Using this multiplier, it was calculated that 90 ml Magnevist (47 mmol Gd-DTPA) would give similar attenuation to our usual dose of 50 ml iopromide 300 (117 mmol iodine) in cranial CT.

In Vivo

The CT scan of Fig. 3 demonstrates the adequate vascular enhancement in the circle of Willis following an intravenous bolus of 90 ml Gd-DTPA. No side effects such as sensation of warmth, flushing, nausea were experienced.

DISCUSSION

We have shown that Gd-DTPA causes satisfactory vascular enhancement in cranial CT at a dose of 0.5 mmol/kg which would compare to a dose of 1.3 mmol/kg for iodinated contrast media. We recognize that this large dose exceeds the manufacturer's recommended dose (6) and would be too costly

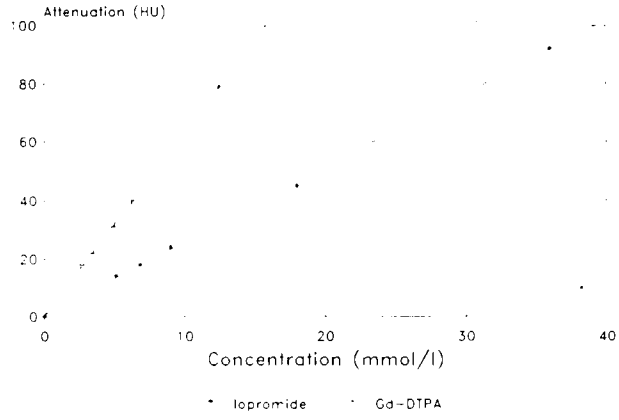

FIG. 1. Attenuation values for different concentrations of Gd-DTPA and iopromide in vitro.

for routine use. However, it might find a role in patients with a definite history of iodine allergy as has recently been shown for angiography (5).

A recent double-blind control trial has shown no difference in tolerance between 0.1 mmol/kg of Gd-DTPA and 0.3 mmol/kg of Gd-DTPA (8). In other clinical studies of Gd-DOTA (gadoterate meglumine) at a dose of 0.4 mmol/kg in MRI of acute myocardial infarction (9) and Gd-HP-DO3A (gadoteriol) at a dose of 0.3 mmol/kg in cranial MR (10) have been used.

From our knowledge of the use of [^{99m}Tc]DTPA in nuclear medicine imaging, we can predict that Gd-DTPA might be of value as a contrast medium in CT cisternography, intracerebral lesions, renal lesions, etc.

In addition, the advent of gadolinium-based compounds for MRI of specific organ systems such as the hepatobiliary system may allow concurrent evaluation by CT (11).

There is the potential for the use of Gd-DTPA as a contrast medium in intravenous urography/angiography in patients with proven iodine allergy, provided the mean energy of the X-ray beam is increased to 52 keV to maximize the attenuation advantage of gadolinium. This would be advantageous

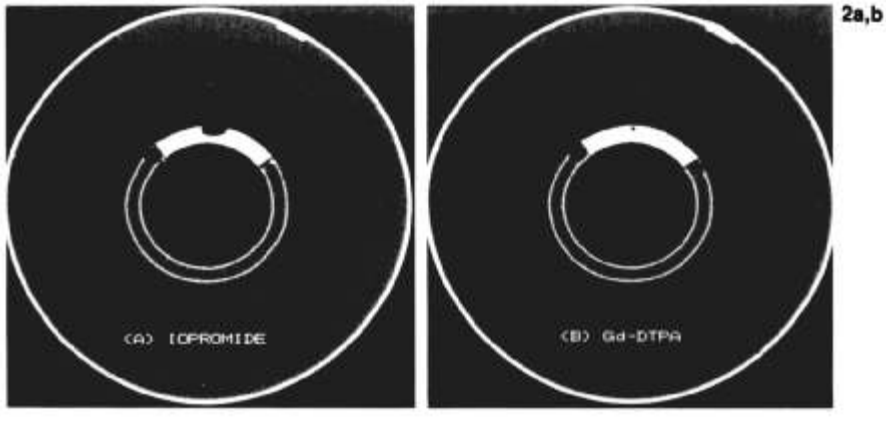

FIG. 2. CT scans of phantom containing solutions of **(a)** iopromide 36 mmol/L and **(b)** Gd-DTPA 12.5 mmol/L.

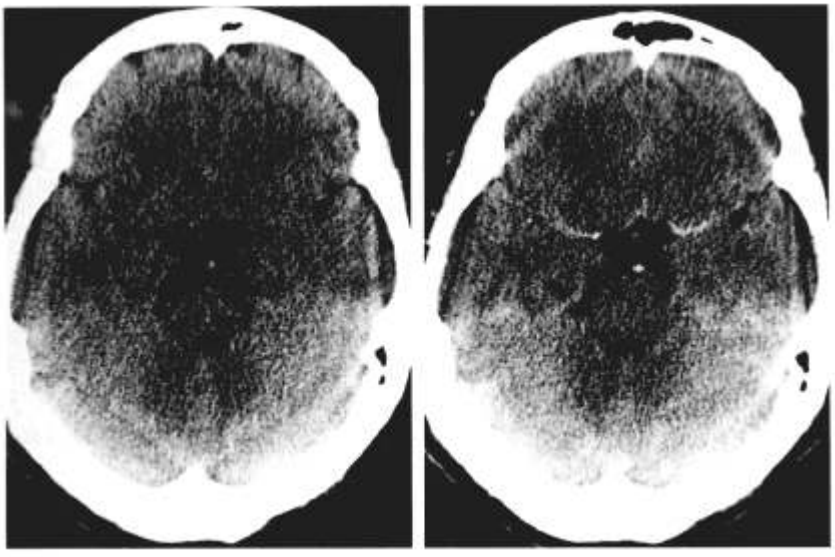

FIG. 3. CT scans **(a)** before and **(b)** after intravenous Gd-DTPA.

in reducing the radiation dose to the patient. In conclusion, we postulate that Gd-DTPA is of value as an alternative contrast medium in CT at a dose of 0.5 mmol/kg in certain situations.

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