

This is the final article in a 4-part series that discusses the use of macrocyclic GBCAs in MRI.

CE credits available

This quarterly supplement to *Applied Radiology* confers 1.0 ARRT Category A Continuing Education credit, which will be awarded upon completion of an online post test. The entire text of this supplement and the post test are available at www.appliedradiology.org/aici.

This supplement and the ensuing post test are designed to be completed within 60 minutes. The goal is to provide an overview of key considerations when evaluating the efficacy and safety of a contrast agent, and to provide a review of key studies related to the evaluation and use of specific contrast agents.

Release date: 11/01/2016

Expiration date: 10/31/2018

Use of ProHance® (Gadoteridol): A Safe, Effective, and Versatile Contrast Agent for MR Imaging

A question-and-answer session with Matthew J. Kuhn, MD, Clinical Professor at the University of Illinois College Of Medicine at Peoria, Illinois.

Gadolinium-based contrast agents (GBCAs) have been in use since the late 1980s. The first to be approved by the U.S. Food and Drug Administration (FDA), in 1988, was the linear agent Magnevist® (gadopentetate dimeglumine), and the second, in 1992, was the macrocyclic agent ProHance® (gadoteridol). Both Magnevist® (gadopentetate dimeglumine) and ProHance® (gadoteridol) are non-tissue-specific, extracellular fluid (ECF) agents that were initially approved for imaging the central nervous system (CNS). Since then, an additional 7 GBCAs have been approved, 4 of which are also ECF agents (Table 1). The remaining 3 include MultiHance® (gadobenate dimeglumine), a dual ECF-liver GBCA, Eovist® (gadoxetate disodium), a liver imaging agent, and Ablavar® (gadofosveset trisodium), a blood pool agent (no longer being manufactured). Among other properties, the 7 ECF agents (including MultiHance® [gadobenate dimeglumine]) vary in their chemical structure (macrocyclic or linear), concentration (0.5 or 1M), and stability, as well as their approved indications and doses (Table 1). Here we discuss with Dr. Matthew J. Kuhn, an early pioneer of contrast-enhanced MRI, his personal experience with each of the currently available GBCAs, as well as his preference for ProHance® (gadoteridol) for MR neuro and cardiac imaging applications.

Applied Radiology (AR): Welcome, Dr. Kuhn. Can you please describe your imaging facility?

Dr. Matthew J. Kuhn (MJK): I currently practice at 4 hospitals: UnityPoint Health-Methodist Hospital (500 beds), UnityPoint Health-Proctor Hospital (289 beds), Pekin Hospital (107 beds), and Galesburg Cottage Hospital (173 beds). Among these 4 sites, we have 10 scanners in total, most of which are GE and most of which are 1.5 or 3T, but we also have others.

AR: Can you tell us about your experience with the various GBCAs currently in use for contrast-enhanced MRI?

MJK: I first used contrast in 1987, as co-principal investigator on a compassionate-use study of Magnevist® (gadopentetate dimeglumine) in patients with brain tumors. This was prior to its subsequent approval in 1988. We continued to use Magnevist® (gadopentetate dimeglumine) post-approval, and I have administered this agent to many patients over the years; however, since it is known to be associated with nephrogenic systemic fibrosis (NSF), we didn't see any benefit in continuing its use.

In the early 1990s, I was involved in clinical research with ProHance® (gadoteridol), including Phase 3 studies in both adults and children.¹⁻⁴ A major focus at that time was the potential use of the macrocyclic ProHance® (gadoteridol) for high-dose applications. In 1994, we published results of one of the first clinical trials evaluating high-dose ProHance® (gadoteridol) for detection of brain metastases.² In this intraindividual study, 4 patients with "solitary" brain metastases demonstrated on contrast-enhanced computed tomography (CT) were administered both single dose (0.1 mmol/kg) Magnevist® (gadopentetate dimeglumine) and triple dose (0.3 mmol/kg) ProHance® (gadoteridol) in 2 separate MR exams 2 to 6 days apart. Compared to the 4 lesions seen on CT, 18 metastases were detected on MR – 7 on unenhanced MR images, 9 with Magnevist® (gadopentetate dimeglumine), and all 18 with ProHance® (gadoteridol). This finding of additional lesions with ProHance® (gadoteridol) was significant because it changed the therapeutic planning in these patients from surgery to radiation. We also found the use of triple dose ProHance® (gadoteridol) allowed for reduced costs and shorter hospital stays.^{2,5} ProHance® (gadoteridol) is the only agent approved for use at triple dose (0.3 mmol/kg).⁶

MultiHance® (gadobenate dimeglumine) is a high-relaxivity agent that was approved for use in CNS MRI in the United States in 2004 (Table 1). In 2006, we published a large, multicenter, intraindividual crossover study comparing equivalent doses of MultiHance® (gadobenate dimeglumine) and Magnevist® (gadopentetate dimeglumine) for MRI of CNS lesions, and showed that the higher relaxivity of MultiHance® (gadobenate dimeglumine) provided significantly better enhancement and diagnostic information for MRI of the CNS.⁶ We performed a follow-up study focused on patient outcomes in which we found that the better enhancement and diagnostic information obtained with MultiHance® (gadobenate dimeglumine) potentially allowed for better surgical planning and follow-up, as well as improved disease management.⁸

So we have found that MultiHance® (gadobenate dimeglumine) is a great complement to ProHance® (gadoteridol) due to its higher relaxivity. I use only ProHance® (gadoteridol) and MultiHance® (gadobenate dimeglumine). However, MultiHance® (gadobenate dimeglumine) is linear, and some radiologists may want the extra security of a macrocyclic agent

Supported by an unrestricted
educational grant from



Table 1. Currently-Available ECF GBCAs^{6,31-38}

Trade Name Generic Name	Magnevist® Gadopentetate dimeglumine	ProHance® Gadoteridol	Omniscan™ Gadodiamide	OptiMARK™ Gadoverseta- mide	MultiHance® Gadobenate dimeglumine	Gadavist® Gadobutrol	Dotarem® Gadoterate meglumine
Year FDA- approved	1988	1992	1993	1999	2004	2011	2013
Chemical Structure	Linear	Macrocyclic	Linear	Linear	Linear	Macrocyclic	Macrocyclic
Ionicity	Ionic	Nonionic	Nonionic	Nonionic	Ionic	Nonionic	Ionic
Concentration (M)	0.5	0.5	0.5	0.5	0.5	1	0.5
Approved Indications*	CNS (A,P); head & neck; body (A,P)	CNS (A,P); head & neck (A)	CNS (A,P); body (A,P)	CNS (A); liver (A)	CNS (A,P), aorto-iliac/femoral occlusive vascular disease	CNS (A,P); breast disease; supra-aortic/ renal disease (A,P)	CNS (A,P)
Approved dose (mmol/kg)*	0.1	0.1 + 2nd dose of 0.2 up to 30 min after 1st dose if needed (A); 0.1 (P)	0.1	0.1	0.1	0.1	0.1
Conditional Stability (pH7.4)	18.4	17.1	14.9	15.0	18.4	15.3	19.3
Kinetic Stability	Low	High	Low	Low	Medium	High	High
Excess Chelate (mg/mL)	0.4	0.23	12	28.4	0	0.5	0

*A=adult; P=pediatric
CNS=central nervous system; ECF=extracellular fluid; GBCAs=gadolinium-based contrast agents; MRA=magnetic resonance angiography.

in patients with low glomerular filtration rate (GFR). In some of our practices, in patients with a GFR <40, they will only use ProHance® (gadoteridol), while others are comfortable using MultiHance® (gadobenate dimeglumine) in these patients; it just depends on their policy. Note that there are no unconfounded NSF cases with either agent. In fact, very recently, we published a prospective, multicenter study to determine the incidence of NSF in patients with chronic kidney disease (CKD) exposed only to ProHance® (gadoteridol; n=171) or MultiHance® (gadobenate dimeglumine; n=363), and no cases of NSF were seen with either agent.⁹ These findings are consistent with the classification of these 2 agents as low-risk GBCAs.

AR: Do you have personal experience with Omniscan™ (gadodiamide) or OptiMARK™ (gadoversetamide)?

MJK: I did use the GBCA OptiMARK™ (gadoversetamide) early on, primarily for research, and I have used Omniscan™ (gadodiamide) only as a comparator, not for clinical use. Both of these agents are relatively unstable and considered higher risk for NSF (Table 1).¹⁰ In addition, we know that they are both formulated with excess chelate, and I don't want my patients exposed to either unnecessary chelate or free gadolinium, both of which are more likely to be present with these agents. Biochemically, everything is in equilibrium – no agent has 100% gadolinium bound tight to the chelate – however, certainly, the unbound fraction is greater with Omniscan™ (gadodiamide) and OptiMARK™ (gadoversetamide) compared to other agents.

AR: What about the most recently approved agents, such as Gadavist® (gadobutrol) and Dotarem® (gadoterate meglumine)?

MJK: The newest agent on the market, Dotarem® (gadoterate meglumine), was actually the second agent approved in the world after Magnevist® (gadopentetate dimeglumine), but was only available in Europe for a very long time. I have no personal experience with this agent. Gadavist® (gadobutrol) is another relatively new agent and this agent has twice the concentration of gadolinium (1M) vs the other agents (0.5M). I have used it, but I have limited experience with this agent. We often use half dose in patients with renal dysfunction, and for most agents, this translates to half volume. When it comes to Gadavist® (gadobutrol), this would mean quarter volume, and we did have a tech give half volume Gadavist® (gadobutrol) to a patient, which is essentially overdosing a patient with CKD. So I find this difference in concentration adds an unnecessary layer of complexity.

AR: Can you describe in more detail the attributes that you think are most important in selecting a GBCA?

MJK: Absolutely. I like to consider 3 things: safety, efficacy, and versatility. You always want to use the safest agent for your patient – for reduction of adverse events (AEs), side effects, and NSF. In a large study of over 28,000 patients, AEs associated with administration of ProHance® (gadoteridol) have been demonstrated to be exceedingly low.¹¹ In addition, in terms of NSF, ProHance® (gadoteridol) is in the safest class of agents (Class II).¹⁰ Importantly, ProHance® (gadoteridol) has demonstrated efficacy and safety in

children,^{4,12} and has a pediatric indication.⁶ In children, the greater stability of a macrocyclic agent is potentially even more important, as they have longer lives ahead of them.

Second, you want the agent to be effective in order to get the best-quality images. Early Phase 2 and Phase 3 dosing studies comparing up to triple-dose ProHance® (gadoteridol) with single dose Magnevist® (gadopentetate dimeglumine) showed that at equivalent doses, the performance of these agents was comparable, while higher doses of ProHance® (gadoteridol) were safe and more effective at detecting and delineating CNS lesions.^{2,13} Since then, a number of double-blind, intraindividual, crossover studies comparing ProHance® (gadoteridol) with other GBCAs have been published. In a Phase 3 trial from 2001, Greco and colleagues showed that equivalent 0.1 mmol/kg doses of ProHance® (gadoteridol) and Magnevist® (gadopentetate dimeglumine) were equally effective for MRI of intracranial lesions in 92 patients.¹⁴ Most recently, equivalent single doses of ProHance® (gadoteridol) and the 1M agent Gadavist® (gadobutrol) were compared in a large, multicenter, crossover study in 229 patients with brain tumors (the TRUTH study). The authors found that the agents provided similar information for visualization and diagnosis of brain lesions and concluded that the 2-fold higher concentration of Gadavist® (gadobutrol) conferred no benefit for routine morphologic imaging.¹⁵ In addition, the clinical studies included as part of the Gadavist® (gadobutrol) clinical development program clearly state that the performance of 0.5M ProHance® (gadoteridol) is similar to that of 1.0M Gadavist® (gadobutrol).³⁰

Finally, an important quality in a GBCA is versatility – the ability to use the agent in a variety of clinical settings. So, for example, the triple-dose approval of ProHance® (gadoteridol) has been a huge advantage in the past, and still remains so. We have a gamma knife center, and our surgeons insist on double and triple dose studies, and they are comfortable with using ProHance® (gadoteridol) at these higher doses in their patients. ProHance® (gadoteridol) is approved for triple dose and, since it has such an excellent safety profile and is macrocyclic, they feel comfortable doing that. No other GBCA has that triple-dose approval. There are many studies showing triple dose is better not only for metastatic disease,² but also for imaging of multiple sclerosis lesions.¹⁶ For cardiac MR, we typically use a higher dose (30 mL), so it is also important to use a safe agent for this application. Finally, we use ProHance® (gadoteridol) in the setting of intraoperative MRI. This technique requires dynamic, real-time images to be acquired during the surgical procedure. This places greater demands on the contrast – it may be necessary to give multiple doses as the operation proceeds – and ProHance® (gadoteridol) is not just approved for high doses, but for repeat doses.⁶

AR: *Lately, there has been much discussion among radiologists and the public regarding gadolinium deposition in the brain. What is your thinking on this topic?*

MJK: Well, we know from older studies that following GBCA administration, gadolinium can be found in the bones of patients. White and colleagues showed that gadolinium was retained in human bone following hip replacement surgery, and that approximately 4 times more gadolinium was left behind following administration of the less stable linear agent Omniscan™ (gadodiamide) compared to the macrocyclic agent ProHance® (gadoteridol).¹⁷ We also know gadolinium can be found in the skin of patients with NSF.¹⁸

Recently, a number of groups have reported detecting T1 hyperintensity in the brain following unenhanced scans, and this signal has been attributed to residual gadolinium from prior GBCA administration.¹⁹⁻²³ The precise form and concentration of the gadolinium have yet to be elucidated, and no associated clinical sequelae have been demonstrated. At first, gadolinium deposition was thought to occur more frequently with linear than with macrocyclic agents.²⁴⁻²⁶ However, most recently, it was demonstrated that exposure to any agent can potentially result in gadolinium deposition.²⁷ Very recently, a study showed gadolinium deposition in the liver of pediatric patients, even with a macrocyclic agent, in this case Dotarem® (gadoterate meglumine).²⁸ Presently, the FDA has indicated that the use of GBCAs should be limited to clinical circumstances in which the additional information provided by the contrast is necessary, and that the necessity for repetitive GBCA MRIs should be reassessed; however, at this time, they are not recommending any changes to the labels of GBCA products.²⁹ Importantly, studies published recently support the lack of clinical consequences of gadolinium deposition in the brain: Welk et al showed

no association between Parkinsonism symptoms and ≥ 1 GBCA exposure in almost 100,000 patients.³⁰

References

- Kuhn MJ, Youssef HT, Swenson LC, Gleason TJ. Comparison of triple dose gadoteridol with standard dose gadopentetate dimeglumine in the evaluation of intracranial lesions. *J Magn Reson Imaging*. 1993;3(P):100.
- Kuhn MJ, Hammer GM, Swenson LC, Youssef HT, Gleason TJ. MRI evaluation of "solitary" brain metastases with triple-dose gadoteridol: comparison with contrast-enhanced CT and conventional-dose gadopentetate dimeglumine MRI studies in the same patients. *Comput Med Imaging Graph*. 1994;18:391-399.
- Youssef H, Kuhn M, Hammer G, Meis L, Burk T, Pencsek T. Phase III multicenter evaluation of high-dose gadoteridol in neurologic pathology: comparison of 0.1 mmol/kg gadopentetate dimeglumine and 0.3 mmol/kg gadoteridol in patients with lesions of the CNS. *Neuroradiology*. 1995;37:558-559.
- Kuhn MJ, Swenson LC, Youssef HT, Hammer GM, Gleason TJ, Binstadt DH. Safety and sensitivity of high dose gadoteridol in children. *Proceedings from the Thirty-sixth annual meeting of the Society for Pediatric Radiology*. 1993;95.
- Mayr NA, Yuh WTC, Muhonen MG, et al. Cost/benefit analysis of high-dose MR contrast studies in the evaluation of brain metastases (abstr). In: *American Society of Neuroradiology Book of Abstracts*. 1993;193-194.
- ProHance® (Gadoteridol) Injection, [prescribing information]. Princeton, NJ: Bracco Diagnostics Inc.; November 2013.
- Maravilla KR, Maldjian JA, Schmalfluss IM, et al. Contrast enhancement of central nervous system lesions: multicenter intraindividual crossover comparative study of two MR contrast agents. *Radiology*. 2006;240:389-400.
- Kuhn MJ, Picozzi P, Maldjian JA, et al. Evaluation of intraaxial enhancing brain tumors on magnetic resonance imaging: intraindividual crossover comparison of gadobenate dimeglumine and gadopentetate dimeglumine for visualization and assessment, and implications for surgical intervention. *J Neurosurg*. 2007;106:557-566.
- Souleiz G, Bloomgarden DC, Rofsky NM, et al. Prospective Cohort Study of Nephrogenic Systemic Fibrosis in Patients with Stage 3-5 Chronic Kidney Disease Undergoing MRI with Injected Gadobenate Dimeglumine or Gadoteridol. *Am J Roentgenol*. 2015;205:469-478.
- American College of Radiology (ACR) Committee on Drugs and Contrast Media. ACR Manual on Contrast Media, Version 10.2. 2016. Available at <http://www.acr.org/~media/ACR/Documents/PDF/QualitySafety/Resources/Contrast%20Manual/FullManual.pdf>. Accessed July 23, 2016.
- Morgan DE, Spann JS, Lockhart ME, Wingham B, Bolus DN. Assessment of adverse reaction rates during gadoteridol-enhanced MR imaging in 28,078 patients. *Radiology*. 2011;259:109-116.
- Debatin JF, Nadel SN, Gray L, et al. Phase III clinical evaluation of gadoteridol injection: experience in pediatric neuro-oncologic MR imaging. *Pediatr Radiol*. 1992;22:93-98.
- Yuh WT, Fisher DJ, Engelken JD, et al. MR evaluation of CNS tumors: dose comparison study with gadopentetate dimeglumine and gadoteridol. *Radiology*. 1991;180:485-491.
- Greco A, Parker JR, Ratcliffe CG, Kirchin MA, McNamara MT. Phase III, randomized, double-blind, cross-over comparison of gadoteridol and gadopentetate dimeglumine in magnetic resonance imaging of patients with intracranial lesions. *Australas Radiol*. 2001;45:457-463.
- Maravilla KR, Smith MP, Vymazal J, et al. Are there differences between macrocyclic gadolinium contrast agents for brain tumor imaging? Results of a multicenter intraindividual crossover comparison of gadobutrol with gadoteridol (the TRUTH study). *Am J Neuroradiol*. 2015;36:14-23.
- Wolansky LJ, Finden SG, Chang R, et al. Gadoteridol in multiple sclerosis patients. A comparison of single and triple dose with immediate vs. delayed imaging. *Clin Imaging*. 1998;22:385-392.
- White GW, Gibby WA, Tweedle MF. Comparison of Gd (DTPA-BMA) (Omniscan™) versus Gd (HP-DO3A) (ProHance®) relative to gadolinium retention in human bone tissue by inductively coupled plasma mass spectroscopy. *Invest Radiol*. 2006;41:272-278.
- High WA, Ayers RA, Chandler J, Zito G, Cowper SE. Gadolinium is detectable within the tissue of patients with nephrogenic systemic fibrosis. *J Am Acad Dermatol*. 2007;56:21-26.
- Kanda T, Ishii K, Kawaguchi H, Kitajima K, Takenaka D. High signal intensity in the dentate nucleus and globus pallidus on unenhanced T1-weighted MR images: relationship with increasing cumulative dose of a gadolinium-based contrast material. *Radiology*. 2014;270:834-841.
- McDonald RJ, McDonald JS, Kallmes DF, et al. Intracranial Gadolinium Deposition after Contrast-enhanced MR Imaging. *Radiology*. 2015;275:772-782.
- Errante Y, Cirimele V, Mallio CA, Di Lazzaro V, Zobel BB, Quattrocchi CC. Progressive increase of T1 signal intensity of the dentate nucleus on unenhanced magnetic resonance images is associated with cumulative doses of intravenously administered gadodiamide in patients with normal renal function, suggesting dechelation. *Invest Radiol*. 2014;49:685-690.
- Quattrocchi CC, Mallio CA, Errante Y, Cirimele V, Carideo L, Ax A, Zobel BB. Gadodiamide and Dentate Nucleus T1 Hyperintensity in Patients with Meningioma Evaluated by Multiple Follow-Up Contrast-Enhanced Magnetic Resonance Examinations with No Systemic Interval Therapy. *Invest Radiol*. 2015;50:470-472.
- Ramalho J, Castillo M, AIObaidy M, Nunes RH, Ramalho M, Dale BM, Semelka RC. High Signal Intensity in Globus Pallidus and Dentate Nucleus on Unenhanced T1-weighted MR Images: Evaluation of Two Linear Gadolinium-based Contrast Agents. *Radiology*. 2015;276:836-844.
- Robert P, Lehericy S, Grand S, et al. T1-Weighted Hyperintensity in the Deep Cerebellar Nuclei After Repeated Administrations of Gadolinium-Based Contrast Agents in Healthy Rats: Difference Between Linear and Macrocyclic Agents. *Invest Radiol*. 2015;50:473-480.
- Radbruch A, Weberling LD, Kieslich PJ, et al. High-signal intensity in the dentate nucleus and globus pallidus on unenhanced T1-weighted images: evaluation of the macrocyclic gadolinium-based contrast agent gadobutrol. *Invest Radiol*. 2015;50:805-810.
- Robert P, Violas X, Grand S, et al. Linear Gadolinium-Based Contrast Agents Are Associated With Brain Gadolinium Retention in Healthy Rats. *Invest Radiol*. 2016;51:73-82.
- Murata N, Gonzalez-Cuyar LF, Murata K, et al. Macrocyclic and Other Non-Group 1 Gadolinium Contrast Agents Deposit Low Levels of Gadolinium in Brain and Bone Tissue: Preliminary Results From 9 Patients With Normal Renal Function. *Invest Radiol*. 2016;51:447-453.
- Maximova N, Gregori M, Zennaro F, Sonzogni A, Simeone R, Zanon D. Hepatic Gadolinium Deposition and Reversibility after Contrast Agent-enhanced MR Imaging of Pediatric Hematopoietic Stem Cell Transplant Recipients. *Radiology*. 2016. [Epub ahead of print]
- US Food and Drug Administration (FDA). Gadolinium-based contrast agents for magnetic resonance imaging (MRI): Drug Safety Communication - FDA evaluating the risk of brain deposits with repeated use. July 27, 2015. <http://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm456012.htm>. Accessed August 6, 2015.
- Welk B, McArthur E, Morrow SA, MacDonald P, Hayward J, Leung A, Lum A. Association Between Gadolinium Contrast Exposure and the Risk of Parkinsonism. *JAMA*. 2016;316:96-98.
- Dotarem® (gadoteric acid) [product information]. Roissy CdG Cedex, France: Guerbet; March 2014.
- Gadavist® (gadobutrol) injection [prescribing information]. Wayne, NJ: Bayer HealthCare Pharmaceuticals; April 2016.
- Magnevist® (brand of gadopentetate dimeglumine) injection [prescribing information]. Wayne, NJ: Bayer HealthCare Pharmaceuticals; June 2014.
- MultiHance® (gadobenate dimeglumine) injection [prescribing information]. Princeton, NJ: Bracco Diagnostics Inc.; July 2013.
- Omniscan™ (gadodiamide) injection [prescribing information]. Princeton, NJ: GE Healthcare; August 2013.
- OptiMARK™ (gadoversetamide) injection [prescribing information]. St. Louis, MO: Covidien Medical; October 2014.
- Idee JM, Port M, Robic C, Medina C, Sabatou M, Corot C. Role of thermodynamic and kinetic parameters in gadolinium chelate stability. *J Magn Reson Imaging*. 2009;30:1249-1258.
- Shen Y, Goerner FL, Snyder C, et al. T1 relaxivities of gadolinium-based magnetic resonance contrast agents in human whole blood at 1.5, 3, and 7 T. *Invest Radiol*. 2015;50:330-338.

Case Study

MRI of 75-year-old female with confusion, weakness, speech problems, and visual deficit

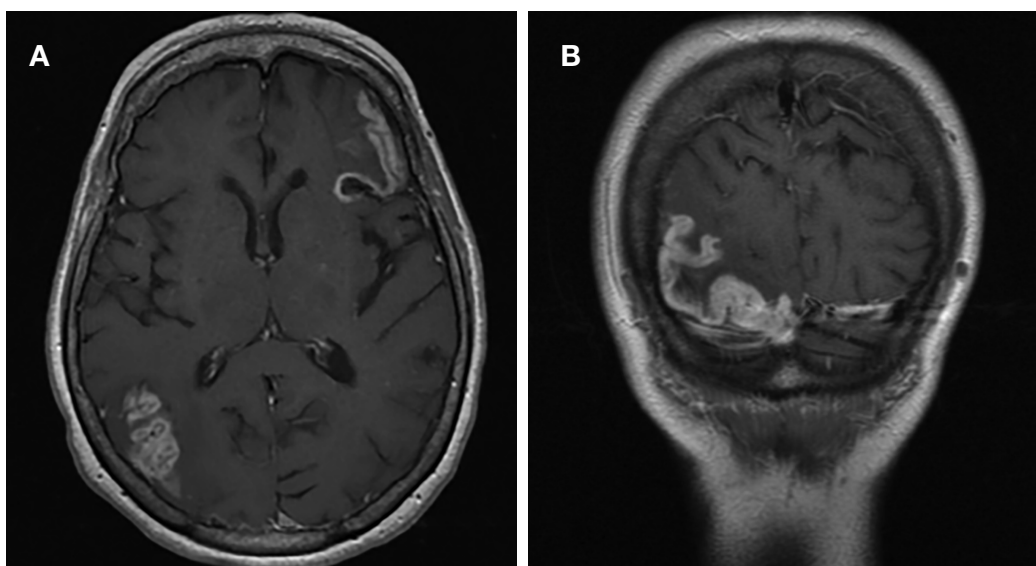


FIGURE 1. Post-enhanced axial (A) and coronal (B) T1-weighted images of the head.

Case Summary

A 75-year-old woman presented with sudden onset confusion, weakness, expressive speech problems, and visual deficit following cardiac catheterization 3 weeks earlier. She also had a history of breast cancer with radiation therapy. An MRI of the head was performed on a 3T GE scanner. The patient received 14 mL of ProHance® (gadoteridol) administered intravenously without complication. Post-enhanced axial and coronal T1-weighted images are shown.

Imaging Findings

There is thick, curvilinear enhancement within the cortex of the left frontal lobe and right parietal-occipital lobes involving only the cerebral cortex. This produces a “gyriform” pattern of enhancement along the surface of the brain. There is minimal surrounding cytotoxic edema and mass effect.

Diagnosis

Subacute cerebral infarction

Conclusion

Blood brain barrier breakdown results in cortical contrast enhancement during the subacute phase of cerebral infarction. Contrast enhancement limited to the cerebral cortex produces a gyriform pattern of enhancement. In addition to subacute cerebral infarction (as seen above), the differential diagnosis includes encephalitis, cerebritis, the post-ictal state, hypertensive encephalopathy, and contrast material overdose.

REFERENCE

1. Kuhn MJ, Burk TJ, Powell FC. Unilateral cerebral cortical and basal ganglia enhancement following overdosage of nonionic contrast media. *Comput Med Imaging Graph.* 1995;19:307-311.