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MR Imaging in Chronic Partial Epilepsy: Role of Contrast Enhancement

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Gadopentetate dimeglumine was administered prospectively to 150 consecutive patients who had had partial epilepsy for longer than 1 year to determine whether it is routinely indicated for the diagnosis of this disorder. MR abnormalities correlating with clinical or electroencephalographically documented seizure foci were detected in 69 cases (46%). Contrast enhancement was seen in 33 of these lesions, but the presence of enhancement altered the original radiologic diagnosis in only 17 (11%) of 150 cases. In only two cases (1%) did contrast administration reveal lesions that were not definitely apparent on the unenhanced images. The utility of contrast administration could not be predicted on the basis of seizure type (simple or complex) or the presence of secondary generalization.

Gadopentetate dimeglumine does not appear to be routinely required in the MR workup of patients with chronic partial epilepsy. It should be used selectively to clarify or better define the nature of abnormalities encountered on unenhanced images.

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The importance of MR imaging in evaluating patients with partial seizures has been demonstrated convincingly [1–19]. Even when unenhanced MR has been compared with contrast-enhanced CT, the superiority of MR has been well established [1–7, 18]. MR has been shown to be of particular value in epilepsies of temporal lobe origin, since lesions in the inferior temporal lobes may be inapparent on CT because of beam-hardening artifacts.

Recently, the accuracy of cranial MR diagnosis has been improved by the introduction of a paramagnetic contrast agent, gadopentetate dimeglumine [20–29]. The routine use of this agent has been proved to increase the detection rate of certain intracranial lesions, especially those of a vascular nature and those involving the meninges [20, 21, 24]. Moreover, gadopentetate dimeglumine may significantly improve radiologic specificity, particularly with regard to defining the extent or nature of certain neoplasms and the differentiation of aggressive processes from benign ones [20, 25, 28]. Although gadopentetate dimeglumine may be useful for delineating or characterizing a large number of intracranial diseases, its utility for the evaluation of seizure patients remains largely uninvestigated. Therefore, we designed a prospective study to determine the efficacy of routine administration of gadopentetate dimeglumine in a large population of patients with partial seizures referred for routine cranial MR imaging.

Subjects and Methods

The subjects comprised a group of consecutive patients with partial epilepsy of longer than 1 year in duration who were referred for cranial MR imaging over a 17-month period. The mean age of the subjects was 27.6 years (range, 2–76 years). Forty pediatric patients (under age 18) were studied with Institutional Review Board approval after informed consent was obtained from a parent or guardian. Eight patients who could not complete the exami-

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TABLE 1: Classification of Partial Epileptic Seizures in Study Population

Seizure Type	No.
Simple partial seizures, focal or localized, without impairment of consciousness	10
Complex partial seizures, focal, but with impairment of consciousness	79
Combined complex and simple partial seizures	12
Partial seizures evolving to secondarily generalized seizures	49

Note.—Descriptions derived from the international classification of epileptic seizures [30].

nation owing to illness or inadequate sedation were excluded from the study. Because of motion or technical artifacts, the images of nine other patients were judged to be inadequate. These subjects were also excluded from the series until 150 patients with technically satisfactory MR examinations were enrolled.

Before imaging, all patients were evaluated by an experienced epileptologist. All patients also underwent electroencephalographic (EEG) monitoring to document their seizure focus. The specific subtype of partial seizure disorder for each patient was then classified on the basis of criteria [30] developed by the International League Against Epilepsy (Table 1).

MR imaging was performed exclusively at a field strength of 1.5 T (Vista MR unit, Picker, Highland Heights, OH). Unenhanced spin-density and T2-weighted coronal images and T1-weighted sagittal or axial images were obtained routinely. Gadopentetate dimeglumine (Magnevist, Berlex Laboratories, Wayne, NJ) was administered by IV infusion at a dose of 0.1 mmol/kg. T1-weighted coronal and axial images were obtained beginning approximately 5 min after infusion.

Specific imaging parameters varied somewhat with the plane of imaging. T1-weighted sequences obtained before and after contrast administration were exclusively spin-echo, 600/20/2 (TR/TE/excitations). Other imaging parameters included a slice thickness of 5–6 mm, field of view of 20–25 cm, and image acquisition matrix of 256 × 256. Spin-density- and T2-weighted sequences, 2000–2500/20,80/1 (TR/TE/excitations), were used in all patients, with other parameters similar to those of the T1-weighted images. A gradient moment nulling technique (MAST, Picker) was used on all T2-weighted sequences, since it has been shown to be highly effective for reducing phase-shift artifacts intracranially, particularly over the temporal lobes [31, 32].

The unenhanced images alone were first interpreted by an experienced neuroradiologist who was blinded to knowledge of seizure subtype and EEG focus. After his initial principal radiologic diagnosis was recorded, the reader was shown the enhanced images and asked to assess whether contrast enhancement (or lack thereof) altered the principal unenhanced diagnosis. These data were later correlated with surgical pathology (when available) as well as neurologic and EEG assessment.

Results

Of the 150 cases studied, 69 (46%) demonstrated MR abnormalities that by clinical or EEG assessment were thought to correlate with the patient's seizure focus. The final radiologic diagnoses in the 150 patients are recorded in Table 2. Radiologic rather than pathologic diagnoses are recorded, since most of the 150 patients had either normal scans or clinically benign lesions and were medically manageable. In the 17 patients who underwent surgery, no significant discrepancies were encountered between the radiologic and pathologic diagnoses (Table 3).

The imaging findings with regard to contrast enhancement are presented in Table 4. Contrast enhancement was seen in 33 (48%) of the 69 detected lesions. All but two of these lesions, however, could be definitely seen on the unenhanced study. The two lesions representing false-negative unenhanced diagnoses are shown in Figures 1 and 2.

In 17 cases (11% of the study population), the presence of contrast enhancement was believed to modify in some way the initial unenhanced radiologic diagnosis (Table 5). In seven of these lesions the role of contrast enhancement was to better define the size or nature of suspected neoplasms. In two cases contrast-enhanced images only demonstrated inflammatory foci within areas of edema (Fig. 3). In four cases the presence of contrast enhancement radically changed the unenhanced diagnosis from a nonneoplastic to tumor category (Figs. 4 and 5).

Because relatively few patients derived significant benefit from contrast administration, no good predictors could be established of when gadopentetate dimeglumine would prove useful. The 17 cases in which contrast enhancement proved useful spanned the complete gamut of clinical presentation, seizure subtype, and duration of symptoms. Accordingly,

TABLE 2: Primary Radiologic Diagnosis in Patients with Partial Seizures

Seizure Origin	No.
Normal/no causative abnormality	81
Neoplasm	19
Trauma/postoperative	14
Vascular malformation	12
Congenital/developmental	9
Mesial temporal sclerosis	7
Stroke/infarct	5
Other	3

TABLE 3: Abnormalities Found in Operated Patients

Diagnosis	No. (n = 17)		
	Total	Seen Before Enhancement	No. Enhancing
Astrocytoma	6	6	3
Oligodendroglioma	1	1	1
Oligoastrocytoma	1	1	1
Ganglioglioma	1	1	1
Cavernous angioma	5	5	5
Sclerosis/gliosis	2	2	0
Abscess	1	1	1

TABLE 4: Imaging Findings in Patients with Chronic Partial Epilepsy

Enhancement of Lesion	Finding Before Enhancement	
	Normal	Abnormal
Yes	2	31
No	81	36
Total	83	67

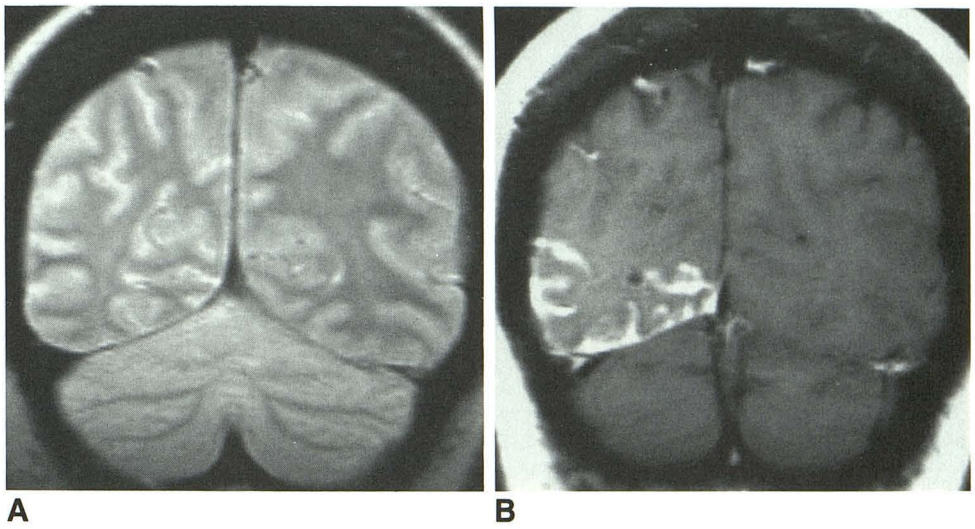

Fig. 1.—37-year-old woman with port-wine nevus on right side of face and 24-year history of complex partial seizures.

***A,* Unenhanced T2-weighted MR image is normal.**

***B,* Enhanced T1-weighted image shows extensive leptomeningeal abnormality confirming intracranial component of Sturge-Weber syndrome.**

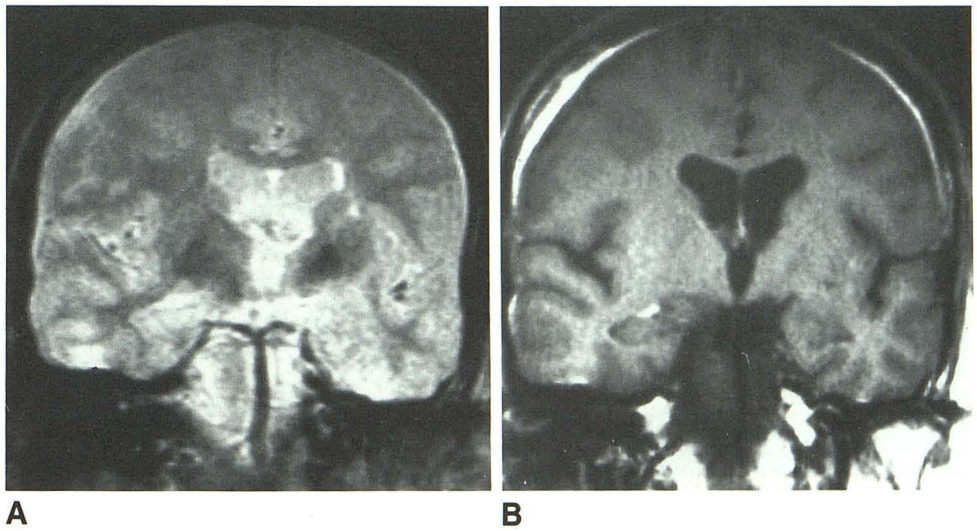

Fig. 2.—29-year-old man with 1-year history of partial seizures with secondary generalization.

***A,* Unenhanced T2-weighted image is essentially normal, degraded somewhat by motion artifact. In retrospect, there may be a subtle abnormality in right calvaria.**

***B,* Enhanced T1-weighted image shows definitely abnormal foci in right parietal and left temporal bones with associated dural thickening. Pathologic diagnosis was metastatic cancer from a mediastinal germ cell neoplasm.**

TABLE 5: How Contrast Enhancement Altered the Radiologic Diagnoses in Patients with Partial Epilepsy

Type of Assistance	No. (n = 150)
Better definition of margins, extent, grade, or nature of suspected neoplasm	7
Better delineated extent of vascular anomaly	3
Confirmation of recurrent tumor in operative bed	2
Delineation of infection or abscess	2
Other/miscellaneous	3

neither the subtype of seizure (Table 1), the presence of definitive EEG focus, nor the length of time the patient had experienced seizures was helpful for deciding whether to use contrast material.

Discussion

A number of articles have now documented the superiority of MR imaging over CT for the evaluation of patients with partial epilepsy [1–19]. In 1985, Laster et al. [1] reviewed 34 patients with epilepsy of longer than 5 years in duration who had normal contrast-enhanced CT scans. In four patients, lesions of potential surgical significance were seen only on MR. Two of these underwent surgical resection, revealing a glioma and thrombosed vascular malformation.

In another early study, Ormson et al. [6] compared the sensitivities of contrast-enhanced CT with unenhanced MR in 25 patients with refractory partial epilepsy. MR was found to be superior to CT for the detection of low-grade gliomas in these patients, but neither technique effectively identified most cases of surgically proved hippocampal sclerosis.

Latack et al. [3] first compared CT, MR, and positron emission tomographic (PET) findings in patients with 50 partial seizures. Again, the superiority of MR over CT was demonstrated convincingly. Additionally, the potential contribution of PET scanning in this disorder was first established.

Since these early studies, numerous other articles have appeared that support the general superiority of MR over CT

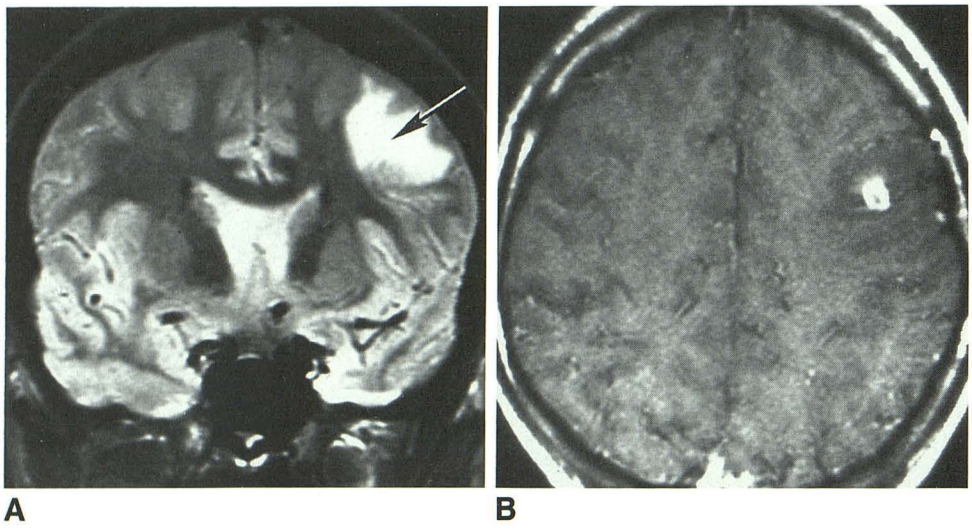

Fig. 3.—23-year-old farm worker with simple partial seizures for 3 years, now increasing in severity.

A, Unenhanced T2-weighted image reveals vasogenic edema in left posterior frontal lobe (*arrow*).

B, Enhanced image reveals tiny, round, enhancing nodule. A second smaller nodule (*not shown*) was also found in occipital lobe. Pathologic diagnosis: neurocysticercosis.

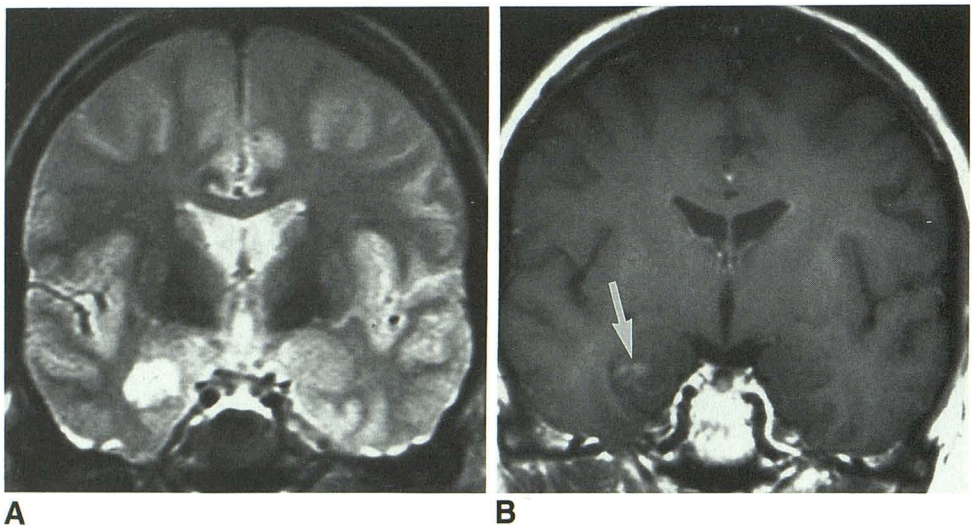

Fig. 4.—37-year-old man with complex partial seizures.

A, T2-weighted image shows high-signal lesion in medial right temporal pole. Speculative diagnosis was hippocampal sclerosis.

B, Enhanced T1-weighted image reveals subtle enhancement (*arrow*) of lesion, consistent with a low-grade glioma rather than mesial temporal sclerosis.

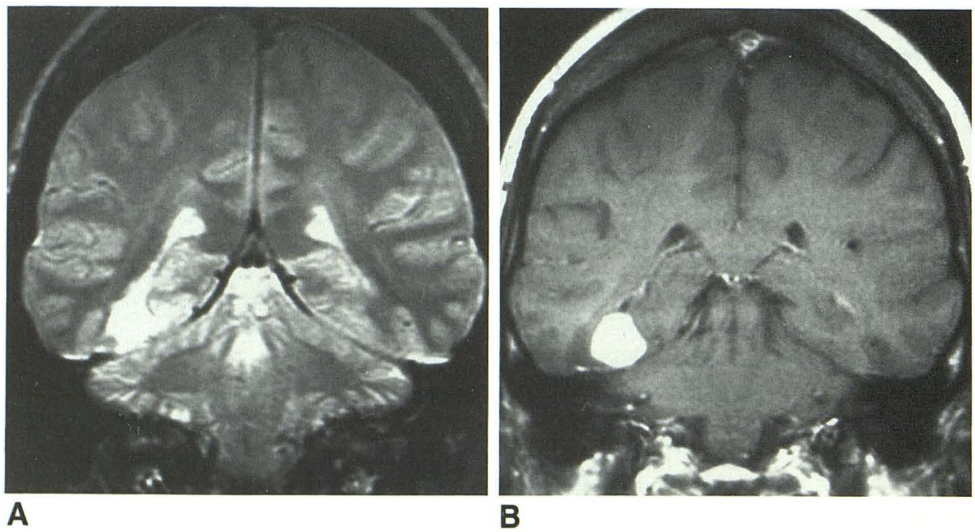

Fig. 5.—18-year-old woman with 3-year history of simple partial seizures with secondary generalization.

A, T2-weighted MR image shows peripheral wedge-shaped high-signal abnormality in right occipital lobe. Unenhanced diagnosis: old infarct or scar; neoplasm also to be considered.

B, Intense enhancement on T1-weighted image changes radiologic diagnosis strongly in support of a neoplasm. Pathology: ganglioglioma.

for evaluating patients with partial epilepsy. Depending on the series chosen, the increased diagnostic yield of MR over CT varies from about 8% to 20% [2–5, 7–19]. The advantage of MR over CT in these studies stems largely from increased detection of lesions in the temporal lobes and at the vertex. These areas are often visualized poorly on axial CT scans because of partial-volume effects or beam-hardening artifacts. Over the last 3 years, the use of paramagnetic contrast agents has significantly affected cranial MR diagnosis. A number of studies have now documented both an increase in sensitivity [20, 21, 24] and specificity [20, 25, 28] resulting from the adjunctive use of gadopentetate dimeglumine in the MR imaging of a variety of intracranial diseases. Until recently, however, the role of gadopentetate dimeglumine in the evaluation of seizure patients has remained largely uninvestigated.

This topic was first addressed as a side issue in the large prospective series reported by Elster et al. [20], where the utility and cost-effectiveness of routine gadopentetate dimeglumine administration was first analyzed. These investigators administered gadopentetate dimeglumine prospectively to 500 consecutive patients with a variety of neurologic problems, including seizures. A multifactorial analysis of their data revealed the clinical indication of "seizures" to be a relatively poor predictor for when gadopentetate dimeglumine would prove radiologically useful. However, Elster et al. did not analyze their patients with regard to seizure subtype, duration of symptoms, or clinical presentation.

While our large prospective study was underway, Cascino et al. [19] published a preliminary report describing their experience with contrast-enhanced MR imaging in 23 seizure patients. Their study population comprised a select group of surgical candidates with intractable epilepsy. In their series, 26% of patients had enhancing lesions, but contrast enhancement was not reported to increase specificity or diagnostic accuracy in any case.

Conversely, our prospective series was designed to encompass a wide range of seizure patients: both those with intractable seizures slated for surgery and those with seizures that could be managed medically. While surgical proof of diagnosis was obtained in relatively few of our patients, we believe our prospective study better represents the more typical neurology-based population of seizure patients, that is, those with mostly benign disease who can be successfully managed medically.

In this group of patients, the routine administration of gadopentetate dimeglumine is probably not indicated. In only two of 150 patients (Figs. 1 and 2) would significant lesions potentially have been missed without the use of contrast material. Review of appropriate medical history in these two patients would have revealed suspected Sturge-Weber syndrome in one and prior extracranial neoplasm in the other. Both clinical scenarios are now recognized to represent relatively high-yield indications for the routine administration of MR contrast agents [20, 33–35]. Thus, if proper medical history is obtained, the risk of missing a significant intracranial lesion in a patient with chronic partial seizures seems low.

Conversely, when a lesion is identified before enhancement, administration of gadopentetate dimeglumine may provide additional diagnostic benefits. Such benefits include increased diagnostic confidence, improved delineation of lesion margins, and improved ability to differentiate between indolent and aggressive lesions. Representative examples of this utility have been shown in Figures 3–5, and have been amply illustrated previously in works by Elster et al. [20, 29], Runge et al. [28], and others [25, 27, 35].

It should be stressed, however, that the alteration of radiologic diagnoses through the use of MR contrast agents does not necessarily translate into a change in clinical management. Frequently, patient management decisions hinge only indirectly around the results of imaging studies at all, and are difficult to study in an unbiased manner. For example, some aggressive surgeons may biopsy or resect all accessible tumors regardless of their imaging characteristics; others may elect to observe nonenhancing or benign-appearing lesions. If stereotaxic biopsy is considered, contrast enhancement of a focus within the lesion provides a relatively high-yield biopsy site. This information may not be needed if an open biopsy is planned, however. In summary, therefore, the utility of gadopentetate dimeglumine for radiologic diagnosis always exceeds its ultimate clinical impact, and this impact will vary further depending on the sophistication and philosophy of the referring physician.

As a final caveat, it should also be emphasized that the conclusions of our report cannot necessarily be extended to patients with all forms of epilepsy. Our findings relate only to patients with partial seizures of relatively long duration (greater than 1 year). Patients with primary generalized epilepsies and patients with partial seizures of recent onset may benefit more or less from the administration of gadopentetate dimeglumine.

In conclusion, the use of gadopentetate dimeglumine in patients with chronic partial epilepsy does not seem to be warranted routinely. Unenhanced images will affect the initial radiologic diagnosis in only 11% of cases, and the likelihood of missing an important abnormality by performing unenhanced imaging alone is small. Gadopentetate dimeglumine should thus continue to be used selectively in patients with chronic partial epilepsy to clarify or better define the nature of abnormalities encountered on unenhanced scans.

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