Dynamic MR Imaging:
A Further Possibility for Characterizing CNS Lesions

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To improve the specificity of MR imaging, 45 patients with different lesions in the CNS were studied with gadolinium-DTPA from June to December 1985. With a dosage of 0.2 ml/kg body weight, no adverse effects were seen. Seventeen of these patients were also studied with dynamic MR imaging, using a spin-echo sequence of TR = 100 msec and TE = 30 msec and a display matrix of 128^2. Four parameters were determined and compared with histologic findings: the time to peak of signal intensity, the ascent to peak of signal intensity, the height of peak of signal intensity, and the percentage of peak of signal intensity at the end of measurement. In this small series, anteriovenous malformations had a short time to peak and a steep ascent to peak as compared with tumors. Gliomas had a slow ascent to peak and usually a longer time to peak as compared with tumors of mesodermal origin. Paragliomas according to ZÜLCH's classification had a steeper ascent to peak than gliomas. Dynamic MR with gadolinium-DTPA may lead to further information about lesions in the CNS, as the ascent to peak parameter seems helpful in discriminating among different lesions.

MR detects many lesions of the CNS with higher sensitivity than does X-ray CT. gadolinium-DTPA (Gd-DTPA) has been used as an efficient contrast agent for the evaluation of focal blood-brain barrier defects by virtue of the decrease of the T1 relaxation time [1, 2]. This effect allows discrimination between gross tumor and edema in a manner similar to CT with contrast material [3, 4]. The kinetics of Gd-DTPA within different brain lesions seem to be similar to the kinetics of conventional ionic or nonionic water-soluble X-ray contrast agents as they are used for CT [2], but the degree of enhancement is reportedly greater than that seen with CT [3]. Because of these effects it seems helpful to use contrast material in MR imaging, but we should not give away the advantages of the information we may gain by observing signal-intensity changes as related to time of measurement after Gd-DTPA injection. To increase the known information about CNS lesions, a method similar to dynamic X-ray CT scanning has been used [5]. The following gives our preliminary results in dynamic MR imaging and our opinions of this technique's usefulness in further characterizing tissue with Gd-DTPA.

Materials and Methods

From June to December 1985, 45 patients with different lesions of the CNS were studied with 0.2 ml/kg body weight of Gd-DTPA. Seventeen of these patients were also studied with dynamic MR imaging (Table 1). A 0.5 T superconducting magnet was used for the study, with slice thickness of 10 mm. In the precontrast examination we obtained T1- and T2-weighted images with different spin-echo sequences: TR = 600 msec, TE = 35 msec; TR = 1600 msec, TE1 = 35 msec, TE2 = 140 msec; and TR = 3000 msec, TE = 120 msec. For comparison with the postcontrast dynamic study, one T1-weighted image was obtained with the shortest acquisition and calculation time that could be achieved at this time: 20 sec, one excitation, TR = 100 msec, TE = 30 msec. Immediately after this measurement, 0.2 ml/kg body weight Gd-DTPA was injected every 30 sec. This relatively long injection time was due

to the regimen of the clinical study in which we were involved. After application of contrast material, serial MR was started. Within 160 sec, nine images were obtained of the same plane of interest with a matrix of 128^2 pixels (Fig. 1). One additional image was measured about 30 min after the end of dynamic MR. The signal intensity within the lesion and within a corresponding area of the normal contralateral hemisphere was determined by mean pixel value of a defined region of interest. Mean values and standard deviations were plotted against the time of data acquisition. The height of the peak of signal intensity, the time to peak of signal intensity, the ascent to peak of signal intensity, and the percentage of height of signal intensity at the end of measurement were determined and compared with histologic findings (Fig. 2).

TABLE 1: Histologic Findings in 17 Patients

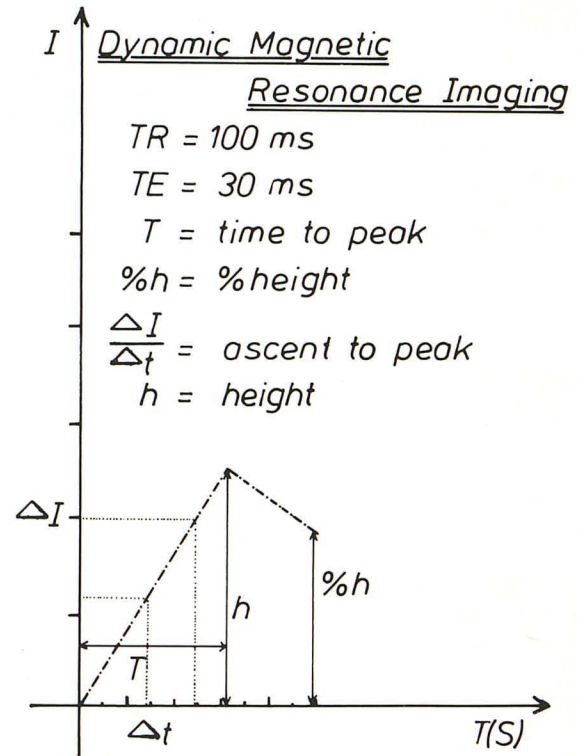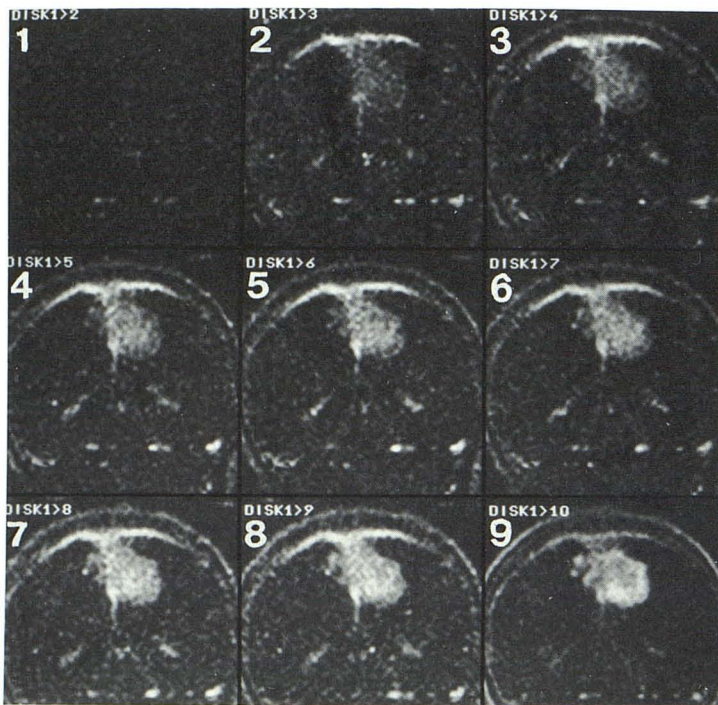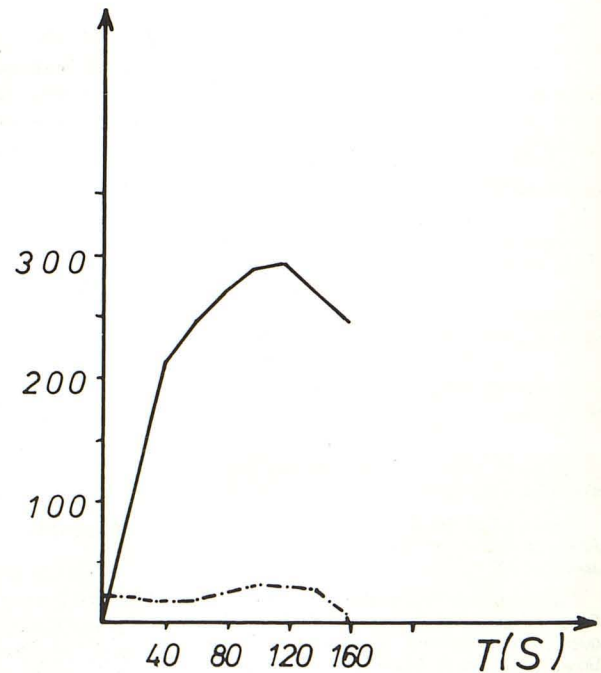| Histology	No. of Patients
Glioma	4
Meningioma	3
A-V malformation	3
Metastasis	2
Brain infarction	1
Acoustic neurinoma	1
Plexus papilloma	1
Hemangioblastoma	1
Ependymoma	1
Total	17

Fig. 2.—Definition of parameters in dynamic MR imaging.

A

B

Fig. 1.—A, SE serial images of coronal plane of interest. Images were measured every 20 sec from injection of contrast material (image 1, *top left*) to 160 sec postinjection (image 9, *bottom right*).
B, Time-signal intensity curve for same meningioma as in A. Solid curve = signal intensity in lesion; broken curve = signal intensity in normal tissue.

Preliminary Results

As a clinical example, a case of hemangioblastoma is presented. The precontrast, T1-weighted scan (Fig. 3A) reveals a zone of decreased T1 relaxation time within a zone of long T1 relaxation time in the left cerebellopontine angle, which also appeared to represent a cyst on a T2-weighted scan. On the postcontrast scan (Fig. 3B), proton relaxation enhancement occurred in the cystic area. The time-signal-intensity curve (Fig. 4) fitted that of a vascular lesion, so the lesion was suspected as being a hemangioblastoma, which was proved angiographically and removed surgically.

Table 2 summarizes the results of dynamic MR imaging in 17 cases of various intracranial lesions. In this small series, three arteriovenous malformations had a steep ascent to peak of signal intensity as compared with tumors, and a short time to peak of signal intensity. After determining the standard mean deviation, this difference was found to be significant. In four cases of glioma, the ascent to peak of signal intensity was slower than in the four cases of tumors of mesodermal origin and in the three cases of paragliomas. This difference was also significant. All other differences were not significant after determining the standard mean deviation. In the case of brain infarction the time between ictus and examination was about 5 weeks.

Considerations

The results from this small series suggest that further characterization of intracranial lesions by dynamic MR with Gd-DTPA is possible. However, dynamic MR needs a shorter data acquisition time than do results that are acquired with our present 0.5 T superconducting MR unit, since more information is needed about the wash-in period that occurs within the first minute after a more rapid bolus injection of Gd-DTPA. One also has to consider the circulation time, because the perfusion time seems to be different in different intracranial lesions. This may explain why our preliminary results are different from those obtained with dynamic CT imaging. Fast imaging methods recently developed for MR are capable of solving this problem [6]. Nevertheless, our initial experience with dynamic MR supports the hope that one may obtain further information about different brain lesions in order to discriminate among them with at least the
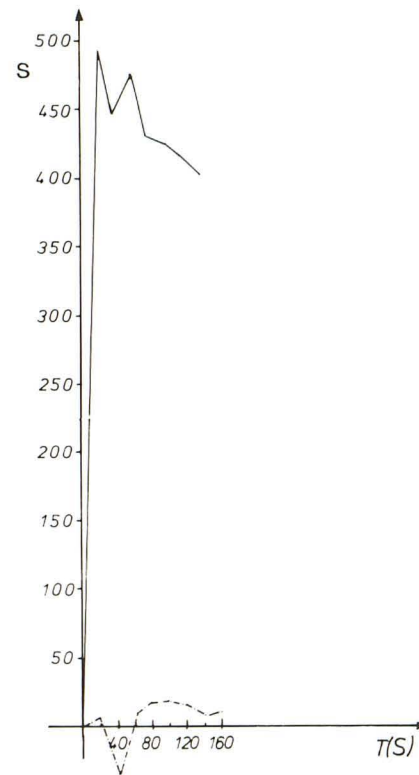

Fig. 4.—Time-signal intensity curve for angioblastoma. Solid curve = signal intensity in lesion; broken curve = signal intensity in normal tissue.
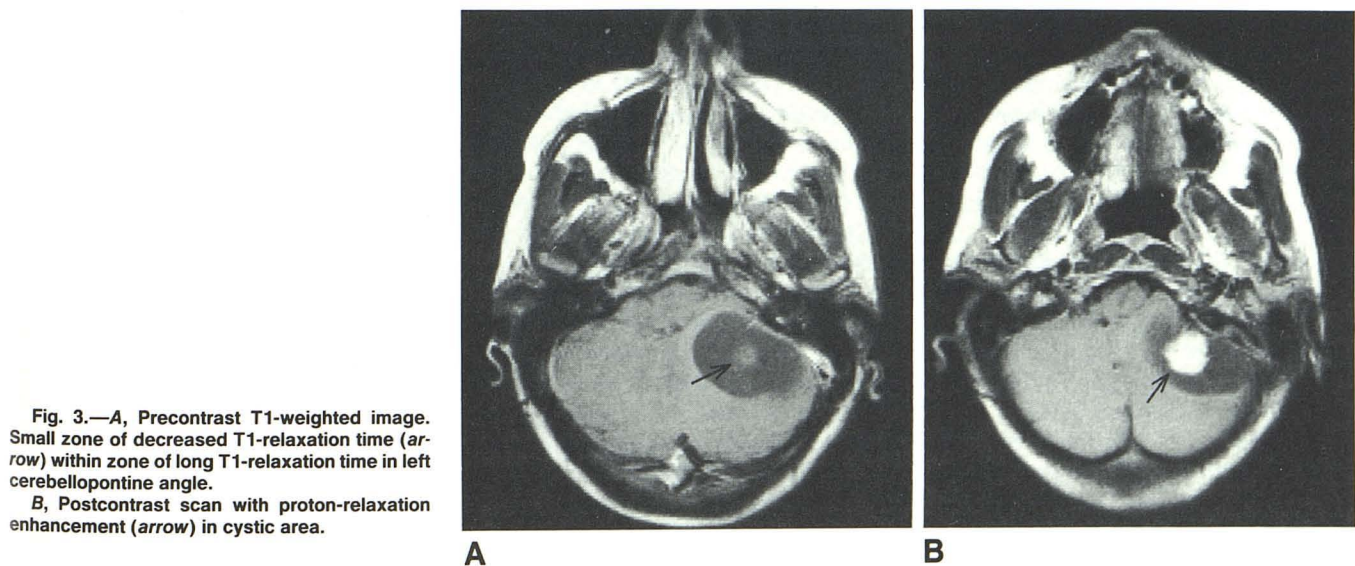

Fig. 3.—*A*, Precontrast T1-weighted image. Small zone of decreased T1-relaxation time (*arrow*) within zone of long T1-relaxation time in left cerebellopontine angle.
B, Postcontrast scan with proton-relaxation enhancement (*arrow*) in cystic area.

same accuracy as has been possible with dynamic CT. Further investigations with a greater number of cases are necessary to confirm this impression.

TABLE 2: Characterization of Lesions by Dynamic MR

Lesion	No. of Cases	Time to Peak (sec)	Height of Peak	Percentage of Height	Ascent to Peak
A-V malformation	3	36.7	118.3	40.8	4.0
Paraglioma	3	106.7	243.8	85.3	2.9
Tumor of meso-dermal origin	4	70.0	297.1	57.3	2.7
Glioma	4	105.0	143.6	82.9	1.3
Metastasis	2	150.0	115.5	93.7	0.78
Brain infarction	1	80.0	60.8	92.0	1.05

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