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# Detection of Cerebrospinal Fluid Metastasis: CT Myelography or MR?

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**PURPOSE:** To determine the sensitivity of contrast MR versus myelography followed by CT in the detection of cerebrospinal fluid metastases in children with primary central nervous system tumors. **METHODS:** Thirty-three patients who had primary central nervous system malignancies had spinal MR with gadolinium within 2 weeks of a myelogram followed by CT. MR technique included T1-weighted image sequences of the entire spine with and without gadolinium. CT scans were routinely performed at T-12 to L-2, L-4 to S-1, and foramen magnum to C-2. All studies were reviewed blindly; the number, character, and location of all metastases was recorded and the results of the two studies compared. Cerebrospinal fluid cytologic findings were recorded for each patient, and compared with the results of the imaging studies. **RESULTS:** Seven of the 33 patients had metastases detected; metastases were seen on both MR and myelography followed by CT. However, MR showed 24 lesions and myelography followed by CT showed only 15. When a lesion was seen on both MR and myelography followed by CT, the MR was usually more convincing. Superficial lesions seen on MR sometimes would be missed on myelography followed by CT. Both MR and myelography followed by CT were quite sensitive in the detection of small lesions (2 to 3 mm) when present on spinal nerve roots. Whereas MR showed multiple lesions not seen on myelography followed by CT, CT failed to show any metastases not seen on MR. Imaging studies showed metastases in 3 patients who had normal cytologic findings. **CONCLUSIONS:** MR shows significantly more cerebrospinal fluid metastases than myelography followed by CT.

**Index terms:** Spine, neoplasms; Magnetic resonance, comparative studies; Myelography, comparative studies; Children, neoplasms

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Disseminated cerebrospinal fluid (CSF) metastases following central nervous system (CNS) malignant tumors are well known. Four percent to 32% of children with CNS tumors will have CSF metastases when diagnosed primarily or at the time of recurrence (1). Patients frequently are asymptomatic and are healthy on clinical examination until the CSF metastases are quite large. Finally, detection of these secondary lesions, with appropriate treatment, is vital if these patients are to survive (2, 3). Both myelography followed by computed tomogra-

phy (CT) and magnetic resonance (MR) imaging with gadopentetate dimeglumine have been used for the detection of the CSF metastases secondary to CNS primary tumors (4, 5). When gadopentetate dimeglumine became available as an MR contrast material (6), MR for the detection of CSF metastases appeared intuitively to be a more sensitive study. A prospective study (November 11, 1989 to December 31, 1992) is the subject of this report. The goal of the study was to determine which of the two studies was superior, in the hope that the other study could be omitted in the future.

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## Materials and Methods

Forty-four patients with primary CNS tumors were studied between November 1989 and December 1992. All of them had primary brain tumors. When an imaging study was proposed, both MR studies with gadolinium and myelography followed by CT were performed wherever possible. Thirty-three of the original 44 patients had spine MR within 2 weeks of their myelography followed by CT. The

Table 1: Number of lesions shown on MR and CT myelography

Patient	MR			Myelography followed by CT			Number of Lesions on MR: on myelography followed by CT	CSF Cytology
	Lumbar	Thoracic	Cervical	Lumbar	Thoracic	Cervical		
1		2 CN			1 CN		2:1	+
2		5 CN	2 CN		1 CN	2 CN	7:3	-
3	5 NR	3 CN		1 C, 2 RN	2 CN		8:5	+
4	1 SC, 2 RN	1 CN		1 RN	2 CN		4:3	+
5			1 CN			1 CN	1:1	+
6	1 CN			1 CN			1:1	-
7	1 RN			1 RN			1:1	-
<b>Total</b>		<b>24</b>			<b>15</b>			

Note.—S indicates superficial; R, root (pial); N, nodular; C, cord (pial); -, negative for metastatic disease; and +, positive for metastatic disease.

age of the patients ranged from 1 to 34 years (mean, 9 years); 20 were male and 13 female. The tumors all were histologically confirmed and included medulloblastoma (n=14), ependymoma (n=7), glioblastoma (n=3), neuroblastoma (n=2), pinealoblastoma (n=2), glioma (n=1), malignant teratoma (n=1), and germinoma (n=1).

The 1.5-T MR technique consisted of T1-weighted images made in the sagittal plane, using 3-mm-thick sections, skip 1.5 mm. These were done with and without gadopentetate dimeglumine (0.1 mmol/kg; 1 mL/10 lbs.) Axial T1-weighted images were 5 mm thick, skip 2.5 mm. All patients had thoracic and lumbar spine exams with a surface coil; axial scans were performed through the entire length of the cord. The cervical region was examined in almost every patient.

The myelogram followed by CT studies included a total myelogram, followed by 5-mm scans from the foramen magnum to C-2, T-12 to L-2, and L-4 to S-1 in the search for CSF metastases. Nonionic contrast (iopamidol), 200 or 300 mg iodine/mL, was used in all cases. The volume was determined by the child's weight. Lumbar puncture was performed with a 22-gauge needle. CSF was obtained in all children at the time of myelography. When a possible lesion was detected with myelography, additional CT axial sections measuring 5 mm thick were made over that area of interest.

The number and type of lesions detected by one neuroradiologist (E. R. H.) for each technique was recorded. Finally, the results of the CSF cytology studies were recorded.

## Results

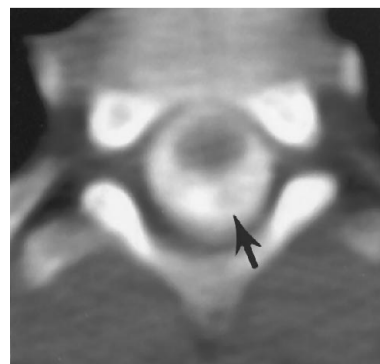
### MR with Gadolinium

Seven (21.2%) of the 33 patients had MR scans with gadolinium positive for metastatic disease. Most of these patients had multiple sites of disease. Three had lumbar metastases (Table 1), 4 had thoracic metastases, and 2 had cervical deposits. Nodular enhancing deposits were the most common lesions (Figs 1-3). Six

patients had cord lesions, 5 of which were nodular; 1 patient had a superficial lesion. Three patients had root lesions (Fig 4) that were uniformly nodular. Malignant cells were present in the CSF in 4 of the 7 patients with positive imaging studies.



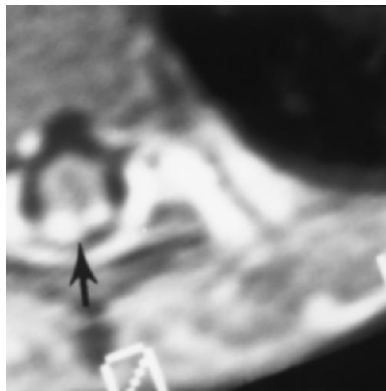
A



B

Fig 1. Patient 1. A, 7-year-old boy with one small exophytic nodule at T-2 seen on MR (600/200/1 [repetition time/echo time/excitations]).

B, On myelography followed by CT, the exophytic nodule, while faintly seen (arrow), was located on CT because the MR had been done previously. It would not have been detected on the myelogram without the prior MR.



A

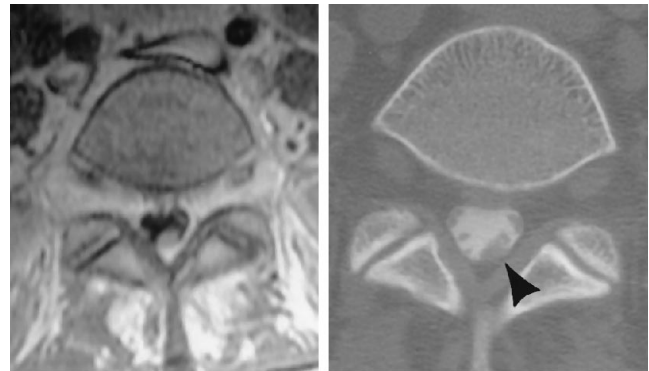


B

Fig 2. Patient 2, 7-year-old girl.

A, Enhancing nodules lower thoracic cord on MR (600/200).

B, Myelography followed by CT shows one confluent exophytic lesion at a comparable level. The conspicuity and specificity is much greater with contrast-enhanced MR.



A

B

Fig 4. Patient 7, 13-year-old boy. A, A small nodule on one of the lumbosacral roots at L-5 on MR (600/20/1).

B, On myelography followed by CT, one can see a similar but more ovoid soft tissue nodule.

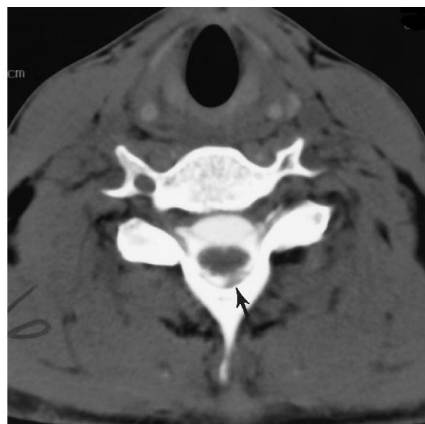
*Myelograms followed by CT*

Seven (21.2%) of the 33 patients had myelography followed by CT findings positive for metastases. As with MR, most of the patients had multiple lesions. Three had lumbar metastases, 4 had thoracic, and 2 had cervical lesions. The pattern of the disease was similar to that seen in MR; all but 1 of the 6 had nodular lesions of the cord. Three patients had nodular root lesions. The CSF cytologic findings were positive for tumor in 4 of the 7.

When the MR examination was compared with myelography followed by CT, MR showed more lesions (24:15), and the MR lesions were more conspicuous, particularly when significantly enhanced with gadopentetate dimeglumine. When the same lesion was viewed by MR and then by myelography followed by CT, the MR usually was the more convincing. Superfi-



A



B

Fig 3. Patient 5, 8-year-old girl.

A, MR (600/20/1) shows gadolinium-enhanced nodule on dorsal aspect of cord at C-7 (arrow).

B, Axial myelography followed by CT shows the nodular exophytic dorsal metastasis (arrow).

cial pial lesions seen by MR would sometimes be missed on myelography followed by CT. Both MR and myelography followed by CT were quite sensitive to detection of small pial lesions 2 to 3 mm in diameter when located on spinal nerve roots (Fig 4).

One of the patients had positive MR findings that were recorded as positive on myelography followed by CT (Fig 1). This lesion might not have been detected if the MR had not been performed first. In no instance did myelography followed by CT detect a positive lesion not seen on MR exam. When multiple lesions were present, MR almost routinely showed a greater number of lesions than myelography followed by CT (Table 1). In our series at risk for CSF metastases, MR plus gadolinium detected 24 lesions in 7 patients, and myelography with CT detected 15 lesions in the same 7 patients. The imaging studies showed CSF metastases in 21% of the 33 patients. Cytologic findings were positive in 57% of patients with positive imaging studies, and were positive in 30% of patients who had negative imaging studies. As the study progressed, MR was noted to show all the lesions seen on myelography followed by CT, plus others that were not seen on myelography followed by CT. At this point, the study was stopped because performing a second study (myelography followed by CT) was thought to be unethical, because general anesthesia was usually required. We no longer perform routine myelography followed by CT in the evaluation of possible spinal metastases.

## Discussion

The sensitivity of MR for the detection of CSF metastases has increased tremendously with the advent of gadolinium enhancement (6). Gadopentetate dimeglumine at doses of 0.1 mmol/kg has greatly improved sensitivity over previous studies with noncontrast scans. With increased emphasis on health care cost-containment programs, it is increasingly important to develop and use efficacy studies that will lead to more precise imaging algorithms for CSF metastases as well as other imaging studies. Our data show that MR pulse gadolinium enhancement using a sagittal scan survey over a large part of the spine and supplemented by axial scans is more sensitive than myelography followed by CT. In myelography, although the entire spine may be imaged the lesions often are

Table 2: CSF metastases in 33 paired patients, 1989 to 1992

	MR	Myelography followed by CT
Patients with positive exam	7	7*
Number of metastases	24	15
CSF cytology positive in patients with positive images	4 of 7	57%
CSF cytology positive with negative images	8 of 26	30%

\*Patient #1: A CSF metastasis was seen on MR before myelography followed by CT. This information guided myelogram and specific CT levels.

not very conspicuous. The lesion must be detected on this total myelogram before it can be scanned by CT for detail at appropriate selected levels. Therefore, much depends on detection of the lesion on the myelogram. Certainly small filling defects on myelography are less conspicuous than gadolinium-enhanced lesions with high signal against a gray-black background on T1-weighted sequences.

The number of lesions shown is much greater on MR (Tables 1 and 2) in this study as well as in another study by Kramer (7). This is not unexpected because metastatic deposits do not always expand the cord significantly. A myelography survey examination may well be not sufficiently sensitive to detect these lesions, so that they can be imaged by CT scanning. The fact that our MR protocol routinely included consecutive axial scans over the entire spinal cord translates into a higher detection rate, because CT scans are confined to relatively shorter segments of the spine in this study. Sagittal MR scans after gadolinium enhancement alone would have shown all lesions except one of the five lumbar root lesions in patient 3.

The number of patients with positive imaging studies in this investigation is small. Most patients having myelography as a second study had to be given general anesthesia. After conducting a prospective study for 38 months that appeared to show that MR showed all lesions seen on myelography, plus lesions that were not seen on myelograms, it was no longer justifiable to continue the study comparing the two imaging techniques.

When cytologic findings on the CSF are compared with imaging studies, the sensitivity of MR is high. Cytology is not routinely positive in patients who have metastases on imaging. In

our group of 7 patients with positive MR scans, 3 had negative cytology. In those patients who had negative imaging studies, cytology was positive in 8 (30%) of 26. Although three CSF cytology exams are necessary to determine whether the patient has truly "positive cytology," the two additional lumbar punctures were not routinely performed in our patients.

Are cytologic findings more likely to be positive when imaging demonstrates large or multiple lesions, and correspondingly less positive when lesions are fewer in number or absent? In our series, cytologic findings were positive in patient 1 with two small nodules, in patient 3 with eight small and medium-size nodules, in patient 4 with two small and two medium-size lesions, and in patient 5 with one small to medium-size nodule. Cytologic findings were negative in patient 2, who had seven small and medium-size nodules, and in patients 6 and 7, each of whom had only one small lesion. Although the number of patients studied is limited, one would suspect that when the number of metastases is very limited (1 each in patients 6 and 7), cytology more likely will be negative. This hypothesis is, however, somewhat at odds with the finding that our patients with negative imaging studies had positive cytologic findings in 30% of the cases. Obviously, the proper study in the search for CSF metastases is to perform the enhanced MR of the spine and to perform a lumbar puncture for cytology at approximately the same time. If an enhanced MR of the head has not been done, it should be performed to detect cerebral recurrence. If both of these studies are negative, and two additional CSF studies for cytology are also negative, the patient may be assumed to be free of tumor.

In summary, we compared contrast MR with myelography followed by CT in 33 patients with paired imaging examinations. In 7 of the patients, metastases were detected. MR detected 24 lesions; myelography followed by CT detected 15. Despite these small numbers, we conclude that MR shows significantly more lesions, the lesions have greater conspicuity on MR, and, because metastases usually show contrast enhancement on MR, MR is more specific than myelography followed by CT. If the MR findings are positive, myelography followed by CT usually need not be performed and cytologic examination of the CSF may be unnecessary. Based on this study, myelography followed by CT is unlikely to show a lesion not detectable with MR.

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