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The Role of MR Imaging in Evaluating Metastatic Spinal Disease

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Fifty-eight patients with suspected epidural metastases were evaluated with MR imaging. Six patients were examined on two separate occasions. MR was judged to be diagnostic in 60 of the 64 examinations. Twenty-two patients also underwent myelography. MR was as diagnostic as myelography in all cases of epidural metastases. In addition, MR offered several advantages over myelography in the evaluation of metastatic spinal disease, including demonstration of paravertebral tumor extension, identification of additional osseous metastatic lesions, and visualization of areas of spinal cord compression occurring between areas of myelographic blocks.

We conclude that MR imaging is the examination of choice for evaluating suspected metastatic spinal disease.

Before MR, myelography was considered the procedure of choice for the diagnosis of spinal metastases and associated spinal cord compression [1]. In addition to the well-known side effects of water-soluble contrast media and to the risk of exposing the patient to ionizing radiation, myelography carries other potential risks, including rapid neurologic deterioration after lumbar puncture [2], nerve root avulsion [3], and puncture-site hematomas that occasionally lead to death [4–10]. Moreover, evaluation of the entire spinal canal with water-soluble contrast material may not be possible in a very ill patient with diffuse metastatic spinal disease. Other limitations of myelography include its inability to detect spinal metastases that have not yet encroached upon the subarachnoid space and its inability to demonstrate paravertebral tumor extension. Difficulty is also encountered when there are two areas of myelographic block. It may not be possible to demonstrate the extent of either lesion, and, if the areas of block are widely separated, there is a possibility that a significant, undetectable intervening lesion is present. The use of CT after conventional myelography (CT myelography) may eliminate some of these limitations. However, since only the areas of abnormality demonstrated on myelography and not the entire spine are usually imaged, CT myelography may also miss multiple, separated areas of metastatic disease.

MR imaging has proven to be an excellent technique for visualizing the spinal cord. It is considered the procedure of choice for the diagnosis of syringohydromyelia and the Chiari malformation [11–17], and has proven valuable in the diagnosis of multiple sclerosis involving the spinal cord [18–20], spinal canal stenosis [21–23], tumors of the spinal cord and spinal canal [19, 21, 22, 24–26], spinal dysraphism [24, 27], and vertebral osteomyelitis [28]. Some authors consider MR to be equal or superior to CT or myelography for the diagnosis of disk herniation [29–31], although others do not share this view [32, 33]. There have been a few scattered cases of metastatic disease, with and without associated spinal cord compression, included in general articles on spinal MR imaging [11, 18, 21–25, 34]. However, no reports specifically addressing the role of MR in the evaluation of patients with cord or root compression from metastatic disease have been published.
The present retrospective study was undertaken to assess the efficacy of MR compared with other imaging techniques as a screening examination in the evaluation of patients with suspected spinal cord compression secondary to metastatic disease. We also sought to identify any additional information that MR might provide.

Materials and Methods

Information for this study was gathered by a retrospective review of the medical records and radiographic studies of 58 patients who had undergone MR examination as part of their evaluation for suspected metastatic spinal disease. MR was performed 64 times in 58 patients ranging in age from 5 to 91 years old. MR images were obtained on a 0.5-T superconductive scanner (Picker International) using a standard body coil. Surface coils were not used. Both T1- and T2-weighted sagittal MR scans were routinely obtained. Coronal and/or axial scans were additionally obtained in instances in which orthogonal views were required to completely define or exclude an abnormality.

Information recorded during the medical record review included the clinical indication for obtaining the MR scan (asymptomatic, back pain only without neurologic deficit, myelopathy, or radiculopathy). In our review of the radiographic files, pertinent studies were reviewed and results recorded, including plain radiographs, conventional myelograms, radioisotope bone scans, CT, and MR examinations.

The diagnoses were grouped in the following manner: (1) no evidence of metastatic disease; (2) osseous metastatic disease only (single or diffuse foci); (3) subarachnoid space compromise without evidence of spinal cord compression; and (4) spinal cord compression.

Results

We found excellent correlation between the myelographic and MR studies in the 22 patients who underwent both examinations (Fig. 1). MR examinations were considered diagnostic in 60 of the 64 studies. Three of the four cases in which MR was considered inaccurate included one false-negative study in which MR failed to demonstrate a small, 3-mm intradural drop metastatic lesion identified on myelography and CT myelography; one false-positive study in which MR suggested intradural lesions secondary to phase-encoding error (Fig. 2) but myelography and CT myelography proved normal; and one study that was uninterpretable due to motion artifact in which the degree of subarachnoid space compression could not be determined. In the fourth instance, an epidural lesion was undetected by MR and myelography but was demonstrated by contrast-enhanced CT 1 month later.

Table 1 compares the diagnoses made on the basis of the MR examinations with the symptoms that prompted the studies. As expected, most of the patients presenting with a myelopathy had spinal cord compression, or at least subarachnoid space compression, demonstrated by MR. Five of the 22 patients presenting with back pain only, in the absence of neurologic deficits, also had some degree of cord compression demonstrated on MR.

![Fig. 1.—Correlation between myelography and MR. A and B, Lateral metrizamide myelograms. C and D, Sagittal T2-weighted MR images (TR/TE = 1700/120). Ventral extradural defects are identified on both studies at L2, T10, T8, and T7. No significant cord compression is present.](image-url)
Fig. 2.—Phase-encoding artifact (false-positive MR).
A, T1-weighted mid-sagittal MR scan shows normal cervical-thoracic spinal cord without compression or abnormal signal intensity (TR/TE = 800/40).
B, T2-weighted MR study reveals diffuse inhomogeneity of spinal cord. The examination was erroneously phase-encoded in the horizontal rather than the vertical axis (TR/TE = 1700/120). Complete myelography and CT myelography were normal.

**TABLE 1: Comparison of MR Findings with Presenting Symptoms**

<table>
<thead>
<tr>
<th>MR Findings</th>
<th>Back Pain</th>
<th>Myelopathy</th>
<th>Radiculopathy</th>
<th>Asymptomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>No metastases</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Osseous metastases</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Subarachnoid space compression</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Spinal cord compression (Intradural disease)</td>
<td>5</td>
<td>16</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1 (false positive)</td>
<td>1 (false negative)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>27</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

Conventional myelography followed by CT was performed in 22 patients. Myelography was considered diagnostic in 16 of 22 examinations. In four of the six nondiagnostic cases, a myelographic block was identified after lumbar instillation of contrast. Rather than proceeding to C1–C2 puncture to demonstrate the upper extent of the block, either the clinician or the radiologist elected to perform MR or CT (Fig. 3). If these four cases are exempted, myelography was accurate 89% of the time. When the accuracy of MR is compared with myelography, MR provided the same diagnoses as myelography in 19 of 22 studies. The three discrepant studies are described above. Most importantly, in no case did myelography or CT myelography provide more information about a clinically significant epidural lesion than did a technically satisfactory MR examination.

MR provided additional information not appreciated at myelography in 13 of the 22 patients. In four patients, MR demonstrated both the upper and lower extent of the lesion where myelography demonstrated only one (described in the preceding paragraph). In three patients, MR demonstrated paraspinal muscle involvement not appreciated at myelography. In one of these patients, both MR and myelography demonstrated a normal spinal cord and subarachnoid space but only MR revealed paraspinal tumor that accounted for the patient’s radicular symptoms (Fig. 4). MR revealed additional areas of cord compression in two patients. In one of these patients, contrast was blocked from below in the lumbar region and was blocked from a C1–C2 tap in the upper thoracic region. The myelogram was, therefore, unable to demonstrate intervening areas of disease in the thoracic region (Fig. 5). In the other patient, contrast was blocked from below and the patient was unable to undergo a C1–C2 approach because of marked cervical instability due to metastases. The second area of cord compression was therefore not demonstrated. In the remaining four cases, MR revealed additional areas of osseous spinal metastatic disease.
Fig. 3.—36-year-old man with malignant melanoma presented with lower extremity weakness and a T5 sensory level.

A and B, Metrizamide myelograms from a lumbar approach show a complete block to the cephalad flow of contrast at T5 level in an extradural configuration (80° head-down position).

C, CT myelogram at mid-T5 level reveals displacement of spinal cord (c) anteriorly and to left. A faint amount of contrast is visible.

D, CT myelogram at T4 level reveals no metrizamide, making the distinction between spinal cord and tumor impossible. No contrast was present on higher sectioning and extent of patient's block was not able to be seen.

E, Mid-sagittal MR scan shows a large posterior lesion at T5 (arrows) that markedly compresses the spinal cord (c) TR/TE = 550/40).
Fig. 4.—56-year-old man with lymphoma presented with left L4 radicular symptoms. Myelography was normal. CT was not performed. A and B, Coronal MR images show diffuse signal alteration, enlargement, and fat plane disruption of left psoas and paraspinal muscles when compared with the normal right (TR/TI = 2100/600).

Fig. 5.—Demonstration of pathology between two areas of myelographic block. A, Pantopaque instilled via lumbar tap is blocked at L2 level. B, Metrizamide introduced via lateral C1-C2 puncture is blocked at T4 level. C, Mid-sagittal MR scan shows marked collapse of T8 with associated ventral spinal cord compression. In addition, compression of at least the subarachnoid space is present at T8, T9, T10, and L1 with possible cord compression at T10 level (TR/TE = 2000/120).
Six patients underwent repeat MR to evaluate new or increasing symptoms. Progression of disease was identified in all six patients (Fig. 6).

Discussion

MR has several, general, well-recognized advantages over other imaging methods, including superior soft-tissue discrimination, ability to directly image in the sagittal and coronal planes, and the lack of exposure to ionizing radiation. More specifically, in relation to imaging the spinal cord, MR has been shown to image a variety of pathologic conditions effectively, without the need for intrathecal injection of contrast material. This is a significant advantage, considering patient discomfort, technical time required of the radiologist, and the host of reported, typically transient, neurologic complications associated with the use of intrathecal contrast. In view of the recent report by Hollis et al. [2] claiming a 16–24% incidence of rapid neurologic deterioration requiring surgery after lumbar puncture in the presence of complete subarachnoid block, the ability to screen for metastatic spinal disease in a noninvasive manner becomes especially appealing.

We found MR to be as reliable as myelography, even when followed by CT, for the demonstration of subarachnoid space or spinal cord compression from epidural metastatic disease. The T1-weighted images were best for demonstration of spinal cord compression, while the T2-weighted images best showed subarachnoid space impingement in the absence of cord compression. We believe that routine screening for cord compression from epidural metastatic disease can be accomplished with a sagittal T1-weighted examination. If pathology is not identified and the patient has localizing symptoms, additional T1-weighted images in orthogonal planes and/or T2-weighted images are obtained to identify any subtle subarachnoid space or paravertebral disease that might be responsible for the patient’s symptoms. In this series, MR spine examinations usually required between 60 and 90 min of scanner time compared with 2 hr needed to perform myelography and CT myelography. Occasionally, the combination of myelography and CT myelography required up to 3 hr when the patients were in very poor condition or when a myelo-

Fig. 6.—36-year-old woman with breast carcinoma presented with a myelopathy. Contrast introduced from a lumbar approach was blocked at T3–T4 level while contrast instilled via lateral C1–C2 approach was blocked at T2–T3 level.

A, MR scan shows collapse of T3 vertebral body, an associated ventral epidural mass (arrowheads), and spinal cord compression. Air introduced during lumbar myelography is trapped within ventral subarachnoid space at T4 and T5 levels (dots) (TR/TE = 2000/80). The patient underwent radiation and chemotherapy but presented with increasing symptoms 3 months later.

B, Repeat MR scan reveals involvement of T2 in addition to T3, producing increased focal kyphosis and bow-string compression of spinal cord (TR/TE = 1000/40). The patient then underwent anterior decompression and ventral rod­ding.
graphic block was encountered from a lumbar approach and a second C1–C2 tap was required. At most institutions the cost of an MR examination is approximately the same or lower than the cost of a complete myelogram followed by CT. MR, therefore, can be performed in less time without an increase in cost to the patient and with a definite decrease in discomfort.

We have shown that MR has several additional advantages over other imaging methods for the evaluation of epidural metastatic disease. First is its ability to detect widely separated metastatic lesions that may not be detected myelographically or by CT myelography because they are either strictly osseous and produce no subarachnoid space compression or, more importantly, because they are located between two areas of myelographic block. Black [1] reports that close to 20% of patients with spinal metastatic disease have at least two sites of involvement at some time during the course of their disease. The identification of multiple areas of involvement, especially if widely separated, becomes extremely important when deciding between surgery or radiotherapy or in appropriate mapping of radiation ports.

Another advantage of MR over other imaging methods is its ability to demonstrate paravertebral tumor that may go undetected myelographically. Although CT would also be expected to demonstrate paravertebral tumor, it may not be performed in the presence of a normal myelogram, and the lesion would therefore go undetected. This was the case in one of our lymphoma patients who presented with a radiculopathy. The myelogram was entirely normal and CT was not performed. MR, however, revealed tumor involvement of the nerve roots in the paraspinal region that was responsible for the patient's symptoms (see Fig. 4).

In our six patients who underwent two MR examinations, we found the repeat MR scans were especially useful to assess progression of disease since a preceding baseline scan was available for comparison.

We found the main limitations to the use of MR as a screening examination for the evaluation of epidural metastatic disease were primarily technical and related to motion artifact during sequences requiring long acquisition times, as well as to phase-encoding artifacts. Two of our non-diagnostic studies involved intradural lesions (one false-positive and one false-negative). Our false-negative case, although not surgically or pathologically proven, had multiple intradural defects at myelography and positive CSF examination. At the present time we do not consider MR, at 0.5 T using a standard body coil, a reliable screening method for investigation of small intradural drop metastases. Perhaps with higher field strengths and the use of surface coils, intradural disease will be as reliably demonstrated by MR as is epidural disease. This, however, requires additional investigation.

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