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Spinal Epidural Abscess: Evaluation with Contrast-Enhanced MR Imaging

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Seven patients with spinal epidural abscess were evaluated with MR imaging. T1-weighted images were obtained before and after administration of gadopentetate dimeglumine, and contrast-enhanced images were compared with available T2-weighted images and unenhanced T1-weighted images. In all seven cases, the epidural infection was iso- to hypointense compared with the spinal cord on unenhanced T1-weighted images, and increased in intensity on proton-density- and T2-weighted images. Three patterns of enhancement were observed after contrast administration. In three patients, the infection enhanced homogeneously, likely representing thickened, inflamed tissue with microabscesses and granulomatous material. In one patient, peripheral enhancement surrounded a central focus of low signal intensity, representing necrotic abscess. In two patients, a combination of both patterns was observed. One abscess infiltrated the posterior thoracic epidural fat, producing decreased signal within the high-signal fat on T1-weighted images. Enhanced T1-weighted images were equivalent to unenhanced T2-weighted images in detecting the extent of epidural involvement in three cases. In two cases, enhanced T1-weighted images were superior to T2-weighted images in differentiating the infectious component from surrounding CSF. In one case, contrast administration produced no discernible enhancement. Enhanced images also provided important information regarding the composition of the abscess (liquid versus solid).

Contrast-enhanced MR images are valuable in the characterization of spinal epidural abscesses.

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Spinal epidural abscess is a relatively uncommon disease accounting for approximately one case per 10,000 admissions in large tertiary care hospitals [1]. *Staphylococcus aureus* is the most common cause of localized epidural infection, although numerous other bacterial, mycobacterial, and fungal organisms can produce epidural infection [1, 2]. Epidural abscess commonly results from hematogenous dissemination of the infectious agent. The risk of spinal epidural abscess is increased in patients with chronic illness, underlying immunosuppression, or a history of IV drug abuse. Fever and localized tenderness over the spine are common early symptoms, but oftentimes the symptoms are nonspecific, resulting in delayed diagnosis. If left untreated, severe neurologic deficits and death may occur [2-6]. Early diagnosis prior to the onset of neurologic deficits is of paramount importance, as it has been shown that neurologic deficits are usually permanent and are associated with a higher rate of death.

Prior to the introduction of MR imaging, myelography with CT had been the primary diagnostic method for evaluating spinal epidural infection [7, 8]. MR imaging has revolutionized the evaluation of the vertebral column and its contents, reducing the need for myelography in most cases [9, 10]. The efficacy of MR in detecting and evaluating spinal epidural abscess has been established [11-14]. In these reports, epidural abscess characteristically appeared as a mass isointense with the spinal cord on T1-weighted images and high in signal intensity on T2-weighted

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images. Despite the high sensitivity of noncontrast MR imaging for detecting inflammatory processes throughout the body, some epidural abscesses may be overlooked [12, 15].

Contrast-enhanced MR imaging appears to increase the sensitivity and specificity of MR for lesions of the spinal cord [16]. In a recent study of experimentally induced chemical and bacterial abscesses, contrast-enhanced images were superior to routine spin-echo sequences in characterizing the abscess [17].

On the basis of this information, we undertook this study to answer two questions: What is the pattern of enhancement of spinal epidural abscess after administration of gadopentetate dimeglumine? and Are contrast-enhanced images beneficial in evaluating spinal epidural abscess compared with routine T1- and T2-weighted sequences?

Materials and Methods

The MR scans of seven patients with spinal epidural abscess were reviewed retrospectively. In five of the seven patients MR imaging was performed on a 1.5-T unit, while in the remaining patients examinations were performed on a 0.35-T unit. T1-weighted spin-echo images, 500–1000/20–40 (TR/TE), and T2-weighted spin-echo images (1500–2400/70–85) or T2* multiplanar gradient recalled (MPGR) images were obtained with contiguous 3- to 5-mm-thick sagittal or axial sections. Gadopentetate dimeglumine was injected intravenously, 0.1 mmol/kg body weight (corresponding to 0.2 ml/kg body weight). Repeat T1-weighted images were obtained immediately after injection of contrast agent except in case 1, where a 30-min delay occurred because of analgesic requirements. Directed supplementary 5- to 10-mm-thick images were obtained as needed.

The T1-weighted pre- and postcontrast images were analyzed to determine the pattern of contrast enhancement. Additionally, T1-weighted contrast-enhanced images were compared with available T2-weighted images to evaluate the conspicuity and extent of epidural involvement as well as to determine any increased differentiation between the infectious component and adjacent thecal sac, CSF, or spinal cord.

Results

Seven patients (one female and six males), ranging in age from 8 to 67 years, were included in this study. The clinical data are summarized in Table 1. Four patients presented with predominantly localized severe back pain, while in the remain-

ing three patients myelopathic symptoms dominated the clinical presentation. None of the patients had prior surgery on the vertebral column. Four patients underwent decompressive laminectomy while the remaining three patients were treated conservatively with IV antibiotics for 4–6 weeks. All patients recovered with minimal neurologic deficit, if any.

The infecting organism was *Staphylococcus aureus* in all cases; the risk factors for spinal epidural infection are outlined in Table 1. No dominant location of epidural abscess within the vertebral column was noted. All areas of infection were localized over two to nine spinal segments. In addition to the epidural component, three patients had associated diskitis, osteomyelitis, or prevertebral extension of the infection. The remaining patients had isolated epidural abscess.

MR abnormalities indicative of epidural infection were identified in all patients. The MR images of the epidural infection had characteristic features in six of the seven cases. On T1-weighted images, the epidural collection showed signal intensity hypo- or isointense with the spinal cord. T2-weighted images were obtained in six of the seven cases and demonstrated an increase in signal intensity of the epidural component in a homogeneous fashion (Fig. 1). All the epidural abscesses were well-defined masses except for the atypical case in which the epidural infection infiltrated the posterior epidural fat (case 3) (Fig. 2). In this patient, increased signal in the epidural fat corresponding to infection was identified on T2-weighted images. The epidural infection could be readily separated from the adjacent thecal sac, spinal cord, or cauda equina on routine unenhanced T1- or T2-weighted sequences except in one individual (case 2). In this patient, delineation between the epidural infection and thecal sac was obtained only after the administration of contrast agent (Fig. 3). In the three cases of osteomyelitis and diskitis, the MR findings were similar to those previously described by Modic et al. [18]. These findings included decreased signal in the marrow and disk on T1-weighted images with signal from the marrow and disk space on T2-weighted images. Irregular endplate margins and decreased disk height were also prominent features. Of note, in all three patients with osteomyelitis, enhancement of the marrow space and disk-end endplate interface occurred after the administration of contrast material (Figs. 3 and 4).

Two basic patterns of contrast enhancement were noted in epidural abscesses (Table 1). In three patients, a homogeneous increase in signal in the area of infection was observed

TABLE 1: Clinical Symptoms and Pattern of Contrast Enhancement in Seven Patients with Spinal Epidural Abscess

Case No.	Age (yr)	Sex	Symptom Duration (wks)	Symptom Level	Predisposing Factor	Source	Enhancement Pattern
1	31	F	1	Lumbar	IVDA	Blood	Homogeneous
2	62	M	5	Lumbosacral	Myelodysplasia	Blood	Homogeneous
3	57	M	3	Thoracic	Trauma	Laminectomy	None discernible
4	43	M	2	Cervical	IVDA	Laminectomy	Rim/homogeneous
5	8	M	1	Thoracic	Trauma	Blood	Rim
6	29	M	1	Cervical, thoracic	None	Laminectomy	Homogeneous/rim
7	67	M	8	Thoracic	Empyema	Blood, lami- nectomy	Homogeneous

Note.—In every case the infecting organism was *S. aureus*. IVDA = intravenous drug abuse.

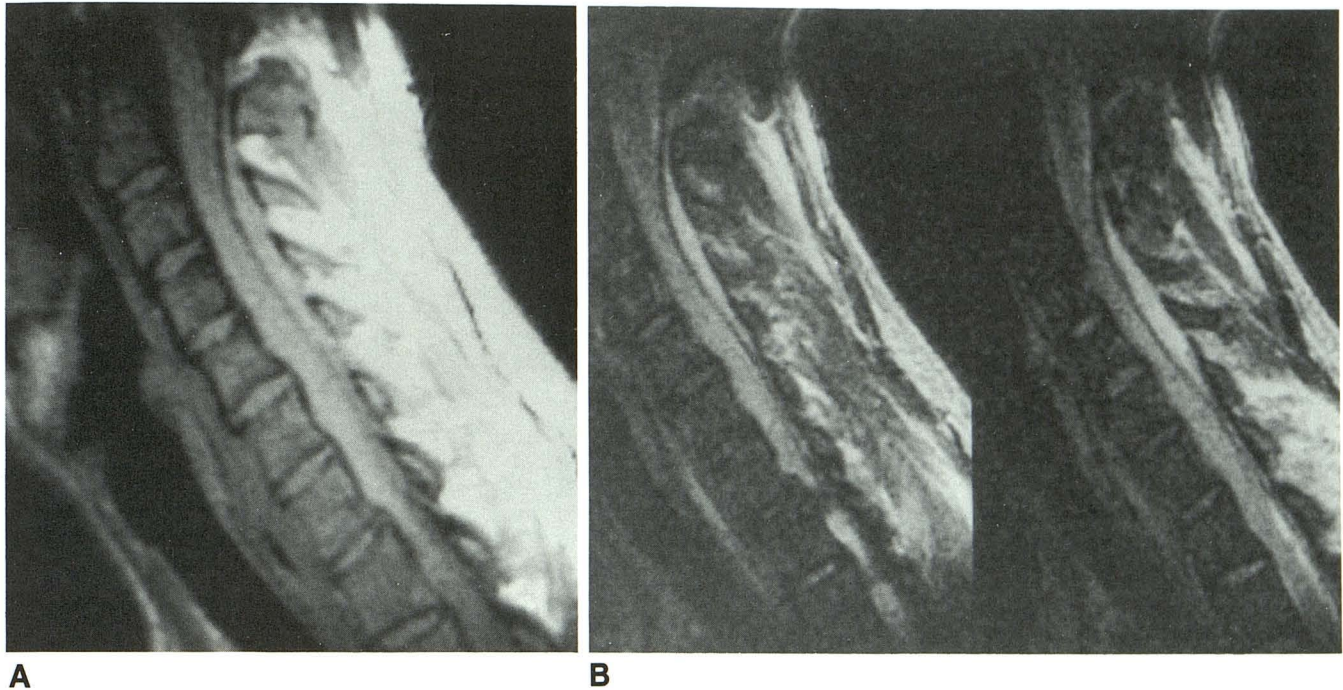


Fig. 1.—Epidural abscess in 29-year-old patient with AIDS.

A and B, T1-weighted (600/20/4) (A) and T2-weighted (2400/80/1) (B) sagittal MR images of cervical spine show a posterior crescentic well-defined epidural mass compressing the spinal cord. In A, the mass is isointense with spinal cord while in B it has a homogeneously increased signal intensity, isointense with CSF.

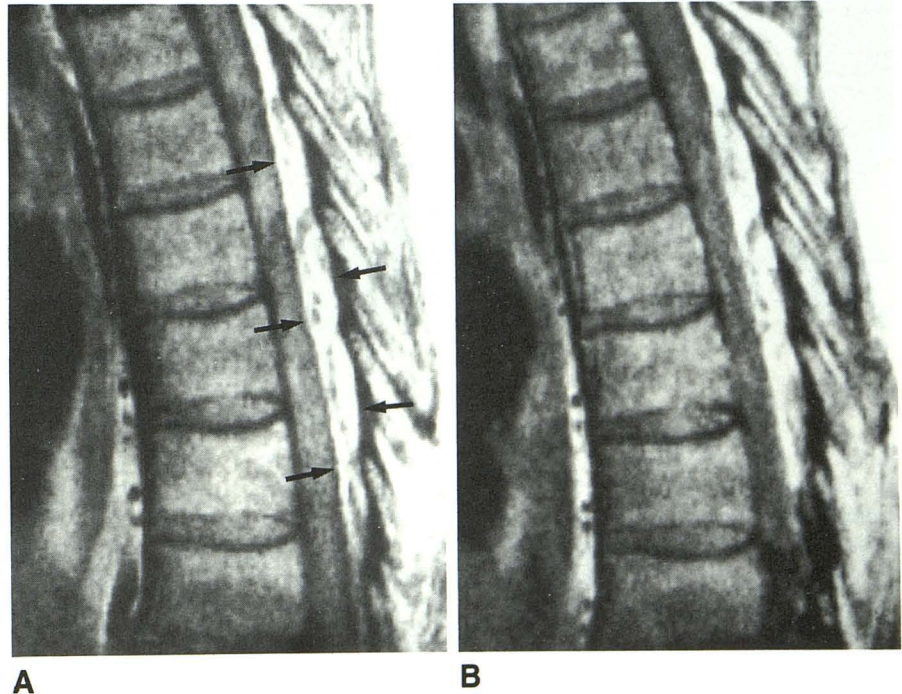


Fig. 2.—Epidural abscess presenting as infiltration of the posterior epidural fat in 57-year-old man.

A and B, T1-weighted (500/24/4) sagittal images of midthoracic spine were obtained before (A) and after (B) administration of gadopentetate dimeglumine. On both the unenhanced and enhanced images, multiple low-signal-intensity areas infiltrate and enlarge the posterior epidural fat over three vertebral segments (arrows). Mild mass effect on thecal sac is evident by attenuation of CSF posterior to cord. No significant enhancement is identified on contrast-enhanced images. Enhancement is not appreciated because of the high signal from the fat. Incidentally noted is high signal in the spinal cord, which represents motion artifact from adjacent great vessels.

(Fig. 3). In one patient, peripheral enhancement around an area of liquid abscess was shown (Fig. 5). In two patients, a combination of peripheral enhancement in one portion of the infection and homogeneous enhancement in the remainder of the epidural component was present (Fig. 4). In the remaining

patient, MR was performed during an early stage of abscess development within the posterior epidural fat, and any discernible contrast enhancement could not be distinguished from the high signal intensity of the fat (Fig. 2).

Enhanced T1-weighted images were equivalent to unen-

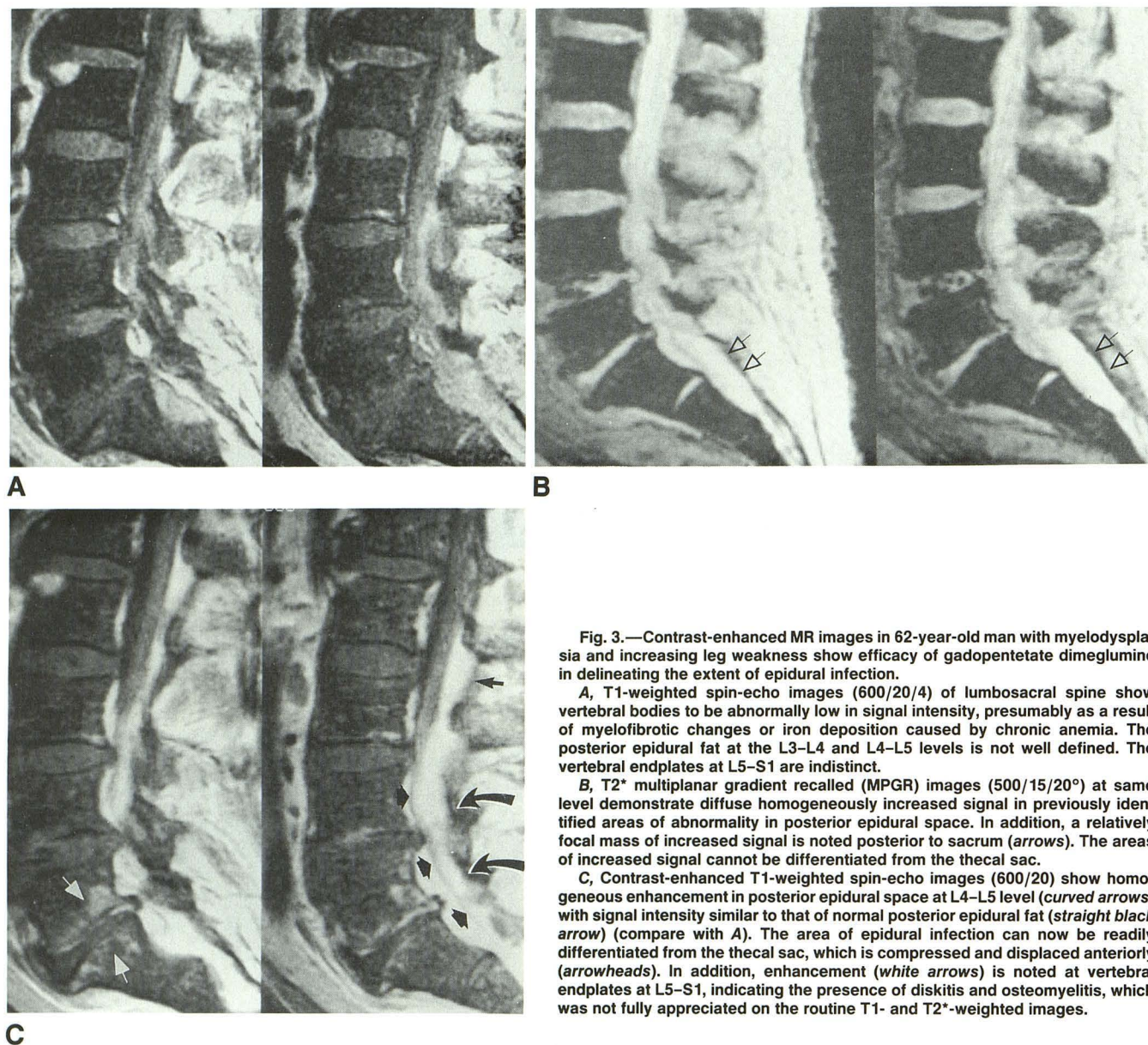


Fig. 3.—Contrast-enhanced MR images in 62-year-old man with myelodysplasia and increasing leg weakness show efficacy of gadopentetate dimeglumine in delineating the extent of epidural infection.

A, T1-weighted spin-echo images (600/20/4) of lumbosacral spine show vertebral bodies to be abnormally low in signal intensity, presumably as a result of myelofibrotic changes or iron deposition caused by chronic anemia. The posterior epidural fat at the L3-L4 and L4-L5 levels is not well defined. The vertebral endplates at L5-S1 are indistinct.

B, T2* multiplanar gradient recalled (MPGR) images (500/15/20°) at same level demonstrate diffuse homogeneously increased signal in previously identified areas of abnormality in posterior epidural space. In addition, a relatively focal mass of increased signal is noted posterior to sacrum (arrows). The areas of increased signal cannot be differentiated from the thecal sac.

C, Contrast-enhanced T1-weighted spin-echo images (600/20) show homogeneous enhancement in posterior epidural space at L4-L5 level (curved arrows) with signal intensity similar to that of normal posterior epidural fat (straight black arrow) (compare with A). The area of epidural infection can now be readily differentiated from the thecal sac, which is compressed and displaced anteriorly (arrowheads). In addition, enhancement (white arrows) is noted at vertebral endplates at L5-S1, indicating the presence of diskitis and osteomyelitis, which was not fully appreciated on the routine T1- and T2*-weighted images.

hanced T2-weighted images in detecting the extent of epidural involvement in cases where T2-weighted images were obtained. However, in one case, only the contrast-enhanced T1-weighted sequence differentiated infection from the adjacent thecal sac (Fig. 3). Additionally, in another case, contrast-enhanced images demonstrated meningeal inflammation that was not discernible on T2-weighted images (Fig. 4).

Discussion

Spinal epidural infection is a relatively rare disorder that can result in devastating neurologic sequelae or death if not diagnosed early [1, 2]. MR is uniquely suited to early detection of spinal inflammation, obviating the risks of myelography, which include CSF leakage, contrast-related myelopathy, and inadvertent puncture of the epidural infection [12, 13]. The

efficacy of MR in localizing the site of infection as well as demonstrating the extent of the epidural abscess and degree of effect on the adjacent thecal sac and spinal cord has been well demonstrated [11-14]. Despite the high sensitivity of noncontrast MR for recognizing inflammatory changes, cases of epidural abscess may escape detection on routine unenhanced MR images [12]. Since the risk of adverse outcome is directly related to the delay and time until specific diagnosis and treatment is instituted [1], any diagnostic methodology that improves the sensitivity and specificity in the diagnosis of spinal epidural abscess is advantageous.

In our study, spinal abscess appeared to have two basic patterns on imaging. The first pattern was that of homogeneous enhancement of the abnormal area. This may correlate with the phlegmonous stage of infection corresponding pathologically to granulomatous thickened tissues with embedded

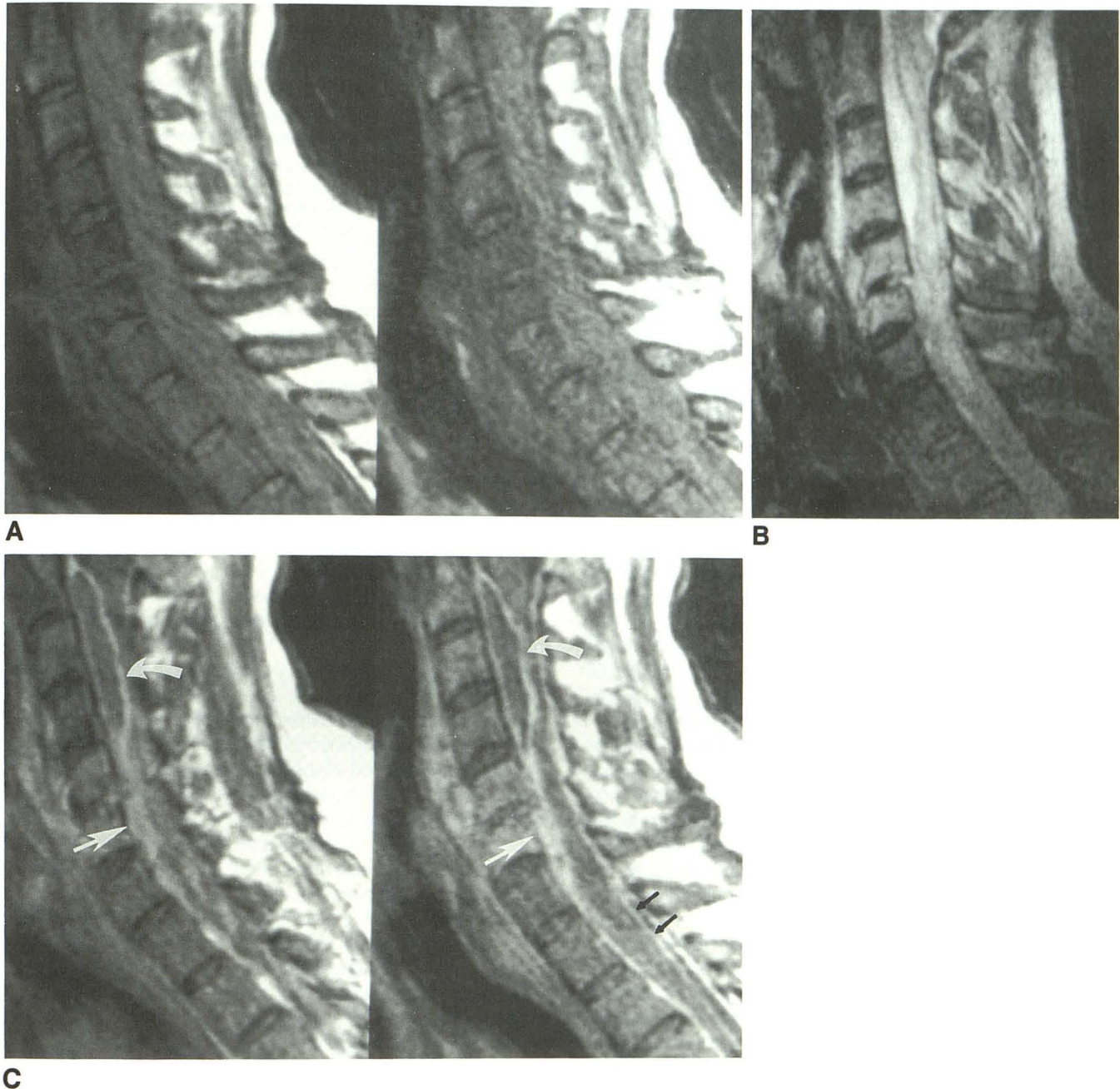


Fig. 4.—Patterns of contrast enhancement in epidural abscess in 43-year-old man with history of IV drug abuse.

A, T1-weighted (600/20) sagittal images of cervical spine show soft-tissue-intensity material completely filling the spinal canal. Posterior epidural fat is obliterated and CSF spaces and spinal cord cannot be differentiated. Also noted is decreased signal intensity in C5 and C6 vertebral bodies with spondylolisthesis of C5 on C6, decrease in height of the C5–C6 disk, and focal thickening of anterior prevertebral soft tissues.

B, On T2-weighted (1500/85/1) sagittal image, a large epidural mass posterior to C3 and C4 vertebral bodies shows a homogeneous increase in signal intensity. Increased signal is also noted in prevertebral mass as well as in intervertebral disk and vertebral bodies at C5–C6. These findings are indicative of diskitis with osteomyelitis. Note, although the spinal cord can be identified, it is not well demarcated.

C, With the administration of gadopentetate dimeglumine, T1-weighted (600/20) images show homogeneous enhancement of prevertebral mass and epidural component immediately posterior to C5–C6 (*large straight arrows*). Enhancement of C5 and C6 vertebral bodies is consistent with osteomyelitis. The epidural mass posterior to C3–C4 shows peripheral enhancement (*curved arrows*). At surgery, a large liquid abscess was noted at the C3–C4 level, while friable but nondrainable granulation tissue was demonstrated at the C5–C6 level. Additionally, enhancement of the dural surface (*small black arrows*) suggestive of leptomeningitis is detected only after contrast enhancement. This was not discernible on routine T2-weighted images.

microabscesses without a significant drainable pus collection. The second pattern was that of a liquid abscess core surrounded by inflammatory tissue. The core did not enhance with contrast administration, while varying degrees of periph-

eral enhancement were seen. In three of our seven cases of spinal epidural infection, peripheral enhancement of the epidural abscess occurred. The area of peripheral enhancement corresponds to the edema, granulation tissue, and inflam-

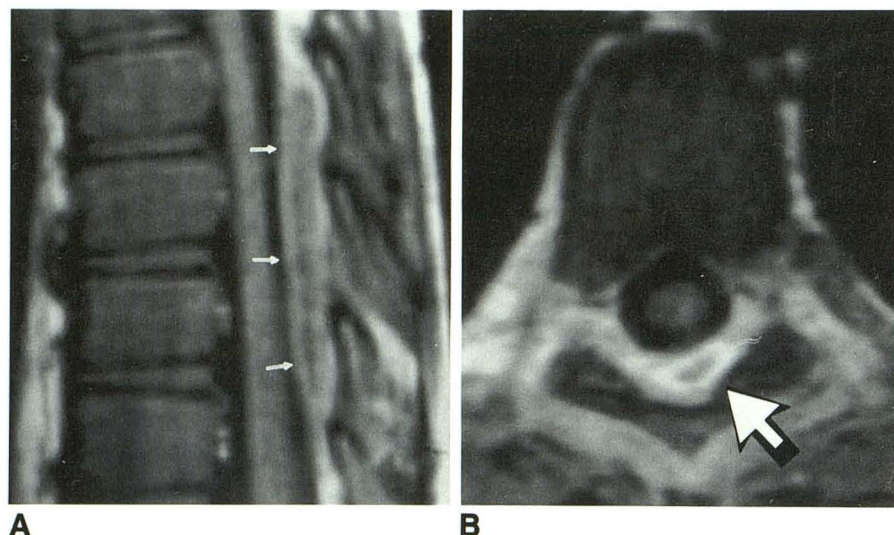


Fig. 5.—Peripheral enhancement in epidural abscess after contrast administration in 7-year-old previously healthy boy who presented with increasing back pain and fever 1 week after being struck in the back while playing soccer.

A, T1-weighted (600/20) sagittal image of lower thoracic spine shows focal oval low-signal-intensity area within posterior epidural fat (arrows).

B, T1-weighted (600/20) contrast-enhanced axial image at level of abscess shows peripheral enhancement of epidural abscess (arrow) with signal greater than adjacent epidural fat.

mation surrounding the necrotic liquified core of the abscess. As would be expected, the necrotic center of the abscess is not perfused and is a relatively inaccessible extravascular space with resultant low accumulation of contrast material and associated low signal on the T1-weighted enhanced images [19]. The demonstration of an abscess cavity might influence the clinical approach, since the relatively avascular core will not be accessible to IV antibiotics and may require more aggressive surgical decompression and drainage. However, as the neurologic outcome does not appear to differ in those patients with acute and chronic abscesses, this distinction may have little relevance. Other authors [14] have indicated that routine T2-weighted images can demonstrate the histologic components of the abscess with the discrete areas of markedly increased signal intensity corresponding to the central necrotic liquified avascular core. In our study, there was no differentiation between the necrotic core and surrounding zone of inflammation and granulation on the precontrast T1- or T2-weighted images. Only after the administration of contrast agent could these histologic zones of the abscess be delineated. These results conform closely to a study of experimentally induced bacterial abscesses where, despite heavy T2-weighting, signal differentiation from the various abscess zones was not obtained without contrast enhancement [17].

In addition to determining the histologic components of an abscess, contrast administration allows differentiation of epidural infection from adjoining CSF. Epidural abscess has a similar signal intensity to CSF on T2-weighted images. Because of this similar signal intensity, several authors have hypothesized that epidural collections may be overlooked [18]. Such a situation may have occurred in a recent study designed to evaluate MR imaging of spinal infection [12]. We have also had a similar case in which epidural infection could not be separated from adjoining CSF on T2-weighted images (Fig. 3). Differentiation between CSF and infection occurred only after contrast administration produced increased signal of the infectious component while the CSF retained its low

signal intensity on T1-weighted images. Incidentally, in another case, meningeal enhancement, distinct from the epidural component, was differentiated from adjacent CSF and detected only after contrast administration (Fig. 4). This meningeal involvement was not discernible on routine T2-weighted images.

In three patients, there was homogeneous enhancement of the epidural component after contrast administration. Additionally, in cases where a prevertebral component existed, there was also homogeneous enhancement. In contradistinction to the well-defined abscess with a liquid core, this second type of enhancement likely correlates with subacute epidural infection in which small focal collections of pus are embedded in relative friable white granulation tissue [20]. While these collections may produce mass effect and neurologic sequelae similar to liquid abscesses, they are not as amenable to surgical debridement. In the remaining patient, an early infection within the posterior epidural fat demonstrated no significant discernible enhancement and, in fact, was difficult to differentiate from surrounding normal epidural fat. The possibility exists that there may have been enhancement that could not be detected because of the similar signal intensity of the enhanced infection and adjacent fat. Because of the high signal from the epidural fat, especially in the lumbosacral area, significant enhancement may be missed. Fat-saturation techniques may play a valuable role in increasing the conspicuity of the lesions by eliminating the signal from the adjacent fat.

As described by Modic [18], characteristic changes in the vertebral bodies suggestive of diskitis with osteomyelitis were also detected in three of the patients in this study. These changes consisted of areas of decreased signal intensity in the vertebral body marrow on T1-weighted images with increase in signal intensity in the same areas on T2-weighted images. Contrast enhancement at the interface between the infected disk space and vertebral bodies occurred. Thus, administration of gadopentetate dimeglumine may be a valuable adjuvant in evaluating osteomyelitis and diskitis.

In summary, spinal epidural abscess can usually be detected on routine T1- and T2-weighted images; however, the appearance may be nonspecific. Characteristically, the epidural infection appears as a mass of low signal intensity on T1-weighted images and demonstrates homogeneously increased signal on T2-weighted images. Subsequent to administration of the paramagnetic contrast agent gadopentate dimeglumine, there may be homogeneous or peripheral enhancement of the epidural infection. Contrast-enhanced images aid in the differentiation of necrotic liquid abscess from phlegmonous granulation tissue with embedded microabscesses. Demonstration of a drainable abscess may influence the clinical management, requiring a more aggressive clinical approach to the treatment. Also, as demonstrated in this study, enhanced images may help differentiate the infectious component from surrounding CSF in some cases.

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