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SPIR MRI in Spinal Diseases

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Abstract: We report on our experience with the fat suppression technique of spectral presaturation with inversion recovery MR in imaging certain spinal disorders. This technique may assist in demonstrating or excluding the presence of fat within a lesion (such as lipoma, dermoid, teratoma) or within a normal structure (i.e., vertebral body or epidural space). The method can also be used to suppress normal fat (such as marrow or epidural fat) thus increasing the conspicuity of adjacent high signal intensity lesions seen on T1-weighted images (such as blood and contrast-enhancing tumors or inflammatory lesions).
Index Terms: Spine, diseases—Magnetic resonance imaging, techniques—Spine, neoplasms–Magnetic resonance imaging, SPIR technique.

The purpose of this paper is to assess the spectral presaturation with inversion recovery (SPIR) MRI in the evaluation of certain spinal diseases, including fat-containing lesions of the spine, metastatic disease, and spinal infection. In most instances, SPIR has been used in conjunction with intravenous injection of Gd-DTPA.

MATERIALS AND METHODS

A total of 25 patients were evaluated with MRI of the spine (in most patients both without and with Gd-DTPA) for congenital lesions (8 patients), metastatic disease (10 patients), and spinal infection (7 patients). A Philips S15-HP 1.5 T Gyroscan system was used for the study. T1-weighted [repetition time (TR) 400–650 ms, echo time (TE) 15–20 ms] and multiecho (TR 2,000 ms, TE 15–80 ms) sagittal sequences were obtained. Following intravenous injection of Gd-DTPA, additional T1-weighted sagittal and axial scans as well as SPIR images were obtained.

SPIR

The SPIR technique was first described by Oh et al. (1) (Fig. 1). The sequence is initiated with a fat selective inversion pulse (FS180°) that inverts only the fat magnetization while leaving the water resonances unperturbed. The FS180° pulse selectively inverts the fat resonance on the basis of chemical shift. The water and fat protons resonate at two frequencies (chemical shift) as a function of B_o field strength; therefore a narrow bandwidth pulse can affect a selected resonance. The FS180° pulse is followed by a delay period called the inversion time (TI), which allows the inverted fat resonance to return to the null point. The usual spin-echo pulse sequence then follows the FS180° and TI. Figure 2a shows that TI is chosen so that longitudinal magnetization (M_z) of the fat proton is zero at the 90° pulse. The 90° pulse nutates any longitudinal magnetization into the transverse plane for detection. Figure 2b shows the transverse magnetization ($|M_{xy}|$) for the fat and water resonances. Since the fat protons have no longitudinal magnetization, they are never nutated into the transverse plane (Mxy) and, therefore, do not contribute any signal. The SPIR sequence is a useful technique because water proton sensitivity is preserved while fat proton intensity is significantly attenuated. This technique is different from STIR, which will suppress both the lipid and the paramagnetically relaxed water.

Five representative cases illustrating the use of the SPIR technique are summarized in the following paragraphs.

CASE REPORTS

Case 1

A 25-year-old man complained of mild weakness of all four extremities and some numbness of the right lower

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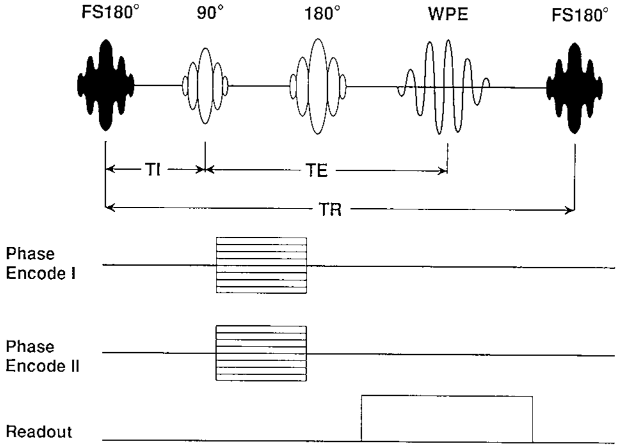


FIG. 1. 3D SPIR pulse sequence.

extremity following trauma to the back. Physical examination revealed mildly increased deep tendon reflexes involving all four extremities. Outside MRI of the spine revealed a high signal intensity lesion within the central portion of the spinal cord on T1-weighted images. A diagnosis of hematomyelia had been made and the patient was referred to us for surgery.

Following admission, repeat MRI (without Gd-DTPA) including SPIR scans was performed. A high signal intensity lesion with lobulated margin was seen within the spinal cord on T1-weighted images (Fig. 3a). The lesion showed a low to intermediate signal intensity on T2-weighted images. The SPIR sequence (Fig. 3b) revealed the lesion to be fat (suppressed on the SPIR sequence). A diagnosis of spinal cord lipoma was made and surgery was avoided. The patient was subsequently observed clinically for 1 year. Follow-up MRI revealed persistence of the high signal intensity lesion within the cord. This high signal was again suppressed with the SPIR sequence.

Case 2

A 26-year-old man complained of progressive weakness in the right lower extremity with muscle wasting and increased deep tendon reflexes. Magnetic resonance imaging showed abnormalities of the cord with alternating areas of thinning (C7 to T2) and expansion (T3 to T6). Some high signal intensity tissue was evident on T1-weighted images on the posterior aspect of the cord at C7 and T3–T6 (Fig. 4a). On post-Gd-DTPA MRI some patchy enhancement was seen in the area of cord widening on T1 scans (Fig. 4b). A SPIR sequence (Fig. 4c) clearly showed abnormal postcontrast enhancement involving the cord extending from T3 through T6; in addition, enhancement was also seen within the lipomatous area. A diagnosis of dermoid of the spinal cord was made on MRI. At surgery, a dermoid was found involving the dorsal cord with a large amount of fat seen on the posterior aspect of the lesion.

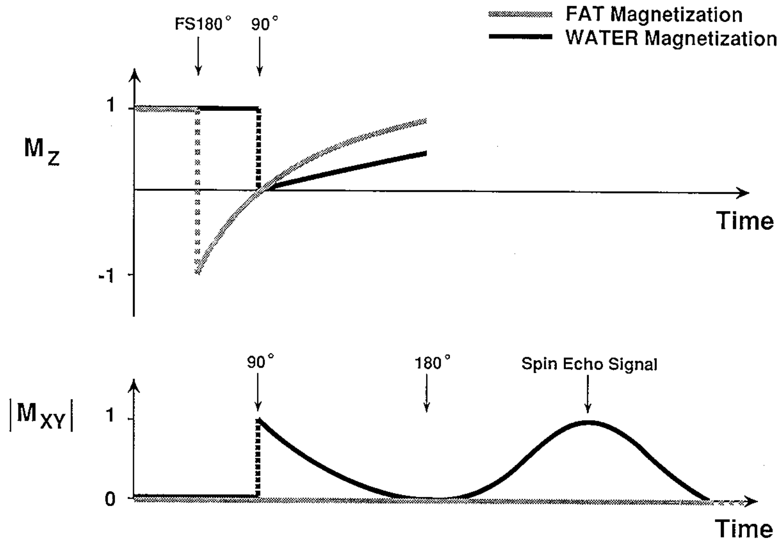
Case 3

A 59-year-old woman was known to have breast cancer. Metastatic disease was found in the lungs and adrenals. Gd-DTPA MRI of the lumbosacral spine (Fig. 5a) showed an inhomogeneous texture at T12 and L1. High signal intensity areas were seen at the inferior aspect of L5 and in the distal epidural space. A SPIR sequence (Fig. 5b) clearly showed abnormal enhancement within the vertebral bodies of T11, T12, L1, L2, L3, and sacrum. The high signal intensity area seen at the inferior aspect of L5 and the distal spinal canal was actually fatty tissue. The patient was treated with chemotherapy for her extensive metastatic disease.

Case 4

A 61-year-old man complained of low back pain and fever. Physical examination revealed weakness of both lower extremities and decreased deep tendon reflexes. Gd-DTPA MRI (Fig. 6a) showed abnormal enhancement of the vertebral body of L5 and possibly S1. Contrary to our usual policy, noncontrast T1-weighted images were not obtained. Some high signal intensity material was seen at the distal spinal canal, compatible with epidural

FIG. 2. SPIR magnetization vectors.



3a,b

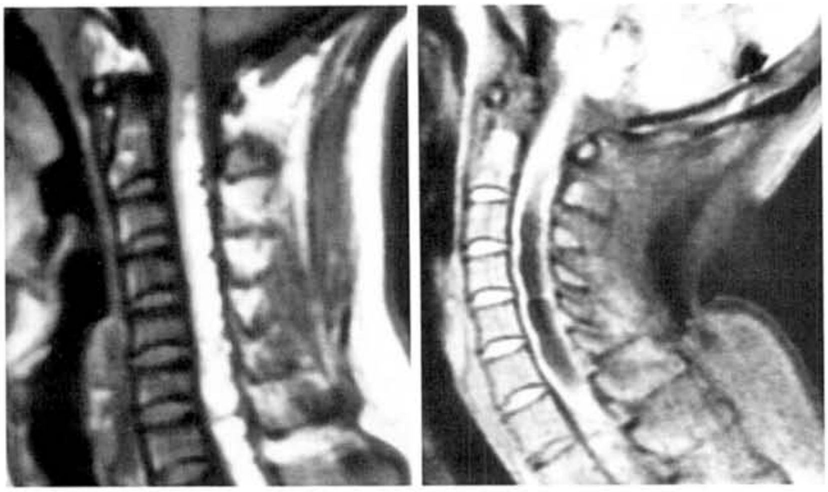


FIG. 3. *Case 1.* **a:** Sagittal T1-weighted image (SE 500/20) shows a hyperintense lesion with lobulated margin within the cervicothoracic cord. **b:** SPIR sequence shows the cervical lesion to be fat (suppressed on the SPIR sequence). Note that the signal intensity of the subcutaneous fat is also suppressed.

fat or epidural abscess with enhancement. A SPIR sequence (Fig. 6b) clearly demonstrated the presence of an enhancing epidural abscess and enhancement of the bodies of L5 and S1 and of the tissue anterior to these two vertebrae. At surgery, an epidural abscess and anterior paraspinal abscesses were drained. Culture of the pus revealed *Staphylococcus aureus*.

Case 5

A 29-year-old man with a history of intravenous drug abuse complained of low back pain radiating to the right lower extremity and night sweats for the past month. The patient was found to have a low grade fever. Magnetic resonance imaging of the lumbar spine (Fig. 7a). showed narrowing of disk space at the L3–L4 level with irregular endplates and questionable abnormal enhancement of the L3 and L4 vertebral bodies on post-Gd-DTPA images. A SPIR sequence (Fig. 7b) vividly showed abnormal enhancement of L3 and L4. The loss of bony cortices contiguous with the L3–L4 disk space was better demonstrated on the SPIR sequence. An aspiration biopsy yielded granulation tissue, but no organism could be cultured. The patient was treated with gentamycin with satisfactory response and with resolution of the clinical symptoms.

DISCUSSION

The advent of MRI has revolutionized imaging of spinal disease (2–5). The spinal cord can be directly

4a–c

FIG. 4. *Case 2.* **a:** Sagittal T1-weighted image (SE 500/20) shows cord atrophic changes (C7 to T2) and focal expansion (T3 to T6). Some high signal intensity tissue is seen at the posterior aspect of the cord at C7 and T3–T6 on the T1-weighted images. **b:** Post-Gd-DTPA image (SE 500/20) demonstrates patchy enhancement within the area of cord widening. **c:** Post-Gd-DTPA SPIR sequence clearly shows abnormal enhancement of the cord from T3 through T6. Note fat suppression of posterior lower cervical fatty tissue. A diagnosis of dermoid of the spinal cord was made.

5a,b

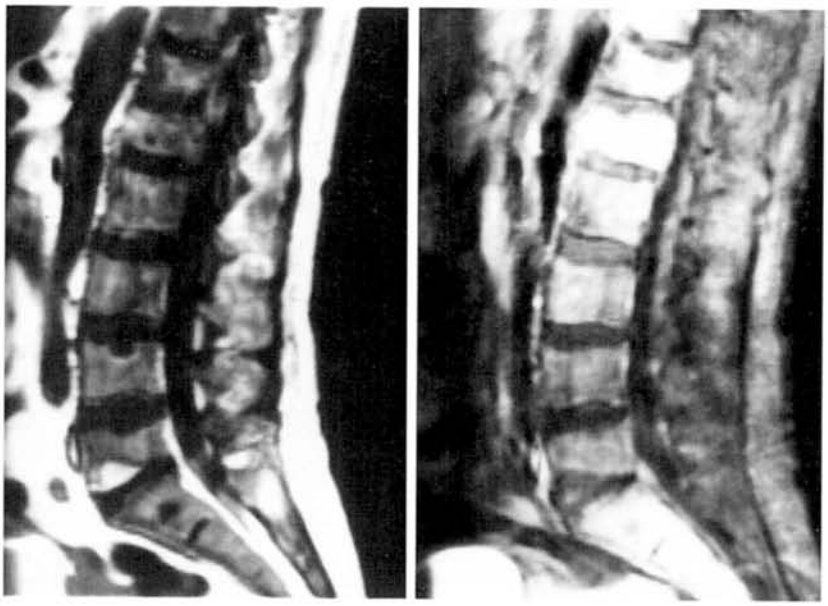


FIG. 5. *Case 3.* **a:** Post-Gd-DTPA MR image (SE 500/20) of the lumbosacral spine shows inhomogeneous texture at T12 and L1. A high signal intensity area is seen at the inferior aspect of L5. Some high signal intensity tissue is also seen in the distal spinal canal, which could represent epidural fat or metastases. **b:** Post-Gd-DTPA SPIR sequence shows abnormal enhancement within the vertebral bodies T11, T12, L1, L2, L3, and sacrum. The high signal intensity areas seen at the inferior aspect of L5 and the distal spinal canal are suppressed, demonstrating their fatty nature.

visualized on MRI, making it possible, in some instances, to characterize the tissue within the spinal cord. The SPIR technique further enhances the ability of MRI to evaluate spinal disorders in two ways: first, by demonstrating or excluding the presence of fat within a lesion or normal structure and, second, by increasing the contrast enhancement in abnormal tissue and differentiating it from normal epidural fat and fatty marrow.

In the majority of cases a hyperintense lesion of the spinal cord on T1-weighted images showing low to intermediate signal intensity on T2-weighted images would be consistent with a fat-containing lesion (such as lipoma, dermoid, teratoma). However, similar signal intensity features may be seen in non-fat-containing lesions (such as blood). In our Case 1 the high signal intensity lesion within the cord on T1-weighted images was initially misdiagnosed as hematomyelia. By applying the SPIR technique, a diagnosis of spinal cord lipoma was made with confidence. In our Case 2 contrast enhancement of the mass lesion within the cord could be appreciated only on the SPIR sequence after suppression of the fat signal. The presence of fat within the lesion was shown on T1-weighted images and was confirmed on the SPIR sequence.

In the studies in which Gd-DTPA is used, SPIR represents a valuable adjunct to T1-weighted images, due to its ability to increase lesion conspicuity, particularly in cases of spinal metastatic disease

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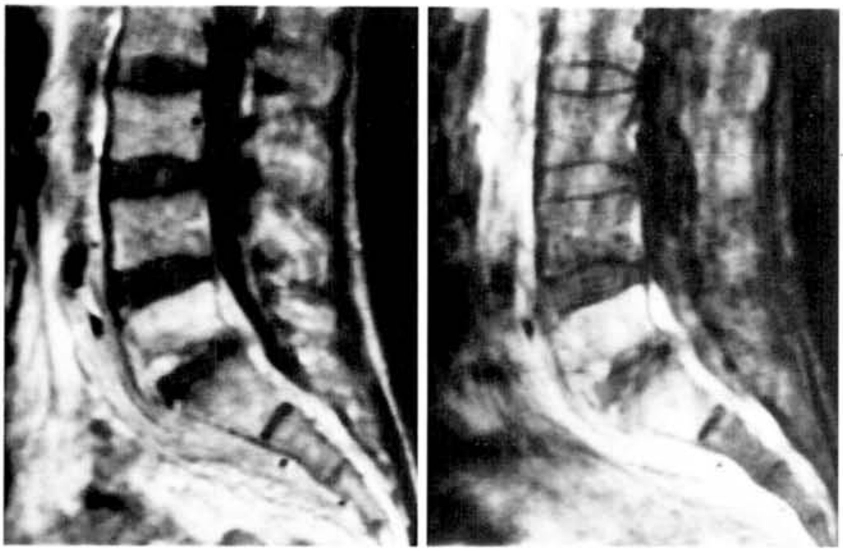

FIG. 6. *Case 4.* **a:** Post-Gd-DTPA MR image (550/15) shows abnormal enhancement of the vertebral bodies of L5 and possibly S1. Some high signal intensity tissue is seen in the distal spinal canal. Without a precontrast scan it would be difficult to distinguish epidural fat from epidural abscess with enhancement. **b:** Post-Gd-DTPA SPIR sequence clearly demonstrates the presence of an enhancing epidural abscess as well as abnormally enhancing vertebral bodies of L5 and S1. Abnormal enhancement of the tissue anterior to L5 and S1, consistent with anterior paraspinal abscess, is also detected.

7a,b

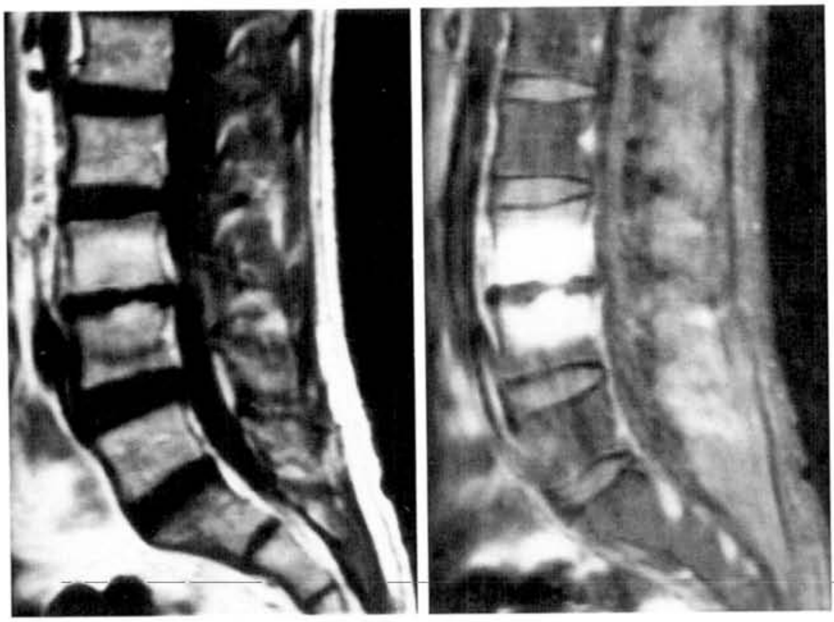

FIG. 7. *Case 5.* **a:** Post-Gd-DTPA MR image (SE 500/20) of lumbar spine shows narrowing of disk space at L3–L4 level with irregular vertebral body endplates and an enhancing anterior paraspinal abscess. Enhancement of the vertebral bodies of L3 and L4 made them almost isointense with adjacent normal bone marrow. **b:** Post-Gd-DTPA SPIR sequence vividly shows abnormal enhancement of L3 and L4 in addition to a better defined anterior paraspinal abscess. The loss of bony cortices at the level of the L3–L4 disk space is better demonstrated on SPIR sequence due to the absence of chemical shift artifact.

and infection. More experience is needed to determine the feasibility of eliminating, in the interest of time-saving, some sequences (the post-Gd-DTPA T1 or the precontrast SPIR).

The potential of chemical shift imaging in spinal and spinal cord diseases to increase the capability of appraising tissue composition was pointed out by Di Chiro et al. in 1985 (3). One of the chemical shift imaging techniques, SPIR, allowed us to differentiate between fat and methemoglobin (Case 1) and to demonstrate gadolinium enhancement within a dermoid, despite the presence of fat tissue (Case 2).

The depiction of paramagnetic contrast enhanced lesions can be improved by using chemical shift imaging for fat suppression in combination with gadolinium enhancement. Improved lesion detection and finer anatomic staging have been reported for orbital, pituitary, and musculoskeletal abnormalities. It has been suggested that the combination of any lipid suppression technique based on the frequency offset of the lipid and water protons with paramagnetic contrast agent will serve the same purpose (5). The SPIR technique, however, is different from STIR, which will suppress both lipid and the paramagnetically relaxed water. We have demonstrated the usefulness of SPIR to increase conspicuity of contrast enhancement in abnormal tissue imbedded or surrounded by normal epidural fat and/or normal fatty marrow.

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