Myelopathic cervical spondylotic lesions demonstrated by magnetic resonance imaging

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Eighteen cases are presented in which magnetic resonance (MR) imaging demonstrated two types of lesions in patients with cervical spondylotic myelopathy. In the first type, localized spinal cord changes at the level of compression, consistent with myelomalacia, were revealed best with T2-weighted images as high-intensity spinal cord signals. In the second type, lesions consistent with either cystic necrosis or secondary syrinx were noted locally, and/or extending longitudinally up, and/or down inside the spinal cord. These latter lesions were best revealed as low-intensity signals on T1-weighted MR images and as a signal-void sign (moving fluid) on proton-density or T2-weighted MR images.

It is suggested that segmental lesions at the level of the spondylotic bar represent early proton changes from pressure in and around the same zones that evolve into gray-matter enhancement regions shown as “snake-eyes” on delayed computerized tomography (CT) after myelography. The longitudinal lesions are thought to be the same pencil-shaped zones of cystic necrosis evolving into a secondary syrinx in the late stages (and usually found in the anterior portion of the dorsal columns during delayed CT after myelography). As spinal MR imaging continues to improve, these lesions will be demonstrated more clearly within the cord substance.

KEY WORDS  cervical spondylosis  syringomyelia  magnetic resonance imaging  myelopathy

In 1981, Lucci, et al., reported on two cases in which computerized tomography (CT) demonstrated hypodense intramedullary cavitation of the spinal cord at, and extending beyond, levels of cord compression from cervical spondylosis. In 1983, Mossman and Jestico illustrated a large syrinx in a post-laminectomy case of cervical spondylotic myelopathy (CSM); this was demonstrated by enhancement on CT 6 hours after intrathecal injection of metrizamide.

Recently, investigators from Japan and Saudi Arabia, using delayed CT scanning after cerebrospinal fluid (CSF) enhancement with water-soluble contrast medium, have revealed that most patients with CSM may have the following lesions. The gray matter at and near the spondylotic bar may show a delayed enhancement that gives a “fried-eggs” or “snake-eyes” appearance on the axial CT image of the cervical spinal cord. Additional CT scanning above and below the level of spondylosis may also reveal pencil-shaped lesions, at times extending as far as the C-1 level and down to the conus medullaris. The “snake-eyes” or “fried-eggs” appearance strongly correlates with findings (necrosis in the central gray matter) shown by pathologists in the few reported CSM cases that have come to autopsy. The pencil-shaped lesions have been seen by pathologists in various cases of spinal cord compression or ischemia. These pathologists demonstrated that pressure on the spinal cord effects remote and progressive necrosis and subsequent cavitation, especially in the anterior portions of the dorsal columns.

From January, 1986, through March, 1987, we managed 18 patients with CSM who had undergone magnetic resonance (MR) imaging at a variety of imaging centers during their evaluation and treatment at the University of Mississippi Medical Center and the Veterans Administration Medical Center at Jackson. The spin-echo imaging studies demonstrated abnormalities which, we believe, are associated with the same two types of spinal cord changes demonstrated by the delayed CT-myelography technique. In addition to the intramedullary abnormalities, spinal cord atrophy was evident in seven patients. Table 1 lists the abnormalities seen in each patient.
Representative Cases

Case 1

This 46-year-old male pulpwood hauler presented in June, 1986, with a 6-month history of dragging his left foot due to weakness. On examination there was some weakness of his left deltoid muscle and the proximal muscles of the left lower extremity. Sensation was intact. Hyperactive deep-tendon reflexes throughout, a left ankle clonus, a left Babinski sign, and bilateral Hoffman reflexes were present.

Myelography revealed a spondylotic bar at C4-5. On delayed CT after myelography no intramedullary lesions were seen. An MR image with $T_1$ weighting did not indicate any definite spinal intramedullary abnormality (Fig. 1 left). The $T_2$-weighted scan was abnormal and demonstrated a high-intensity signal of the cervical cord segment at the C4-5 level only (Fig. 1 right).

An anterior discectomy was performed in July, 1986. Follow-up examination in September, 1986, revealed no weakness, although the abnormal reflexes persisted.

Case 2

This 76-year-old man had diabetes, gout, and prostatic carcinoma. He first presented in August, 1986, with numbness and weakness in his hands. Electrodiagnostic studies at that time confirmed polyneuropathy. He returned for evaluation in February, 1987, unable to walk. Examination revealed bilateral atrophy and weakness in the biceps, hand muscles, hip flexors, and knee extensors. The deep-tendon reflexes were normal. Myelography demonstrated multiple levels of severe cervical spondylosis.

An MR study showed spondylosis throughout the cervical spine with prominent disc protrusion at the C3-4 and C4-5 levels. A central low-intensity signal was noted on $T_1$-weighted imaging at the C3-4 level on both sagittal and axial studies (Fig. 2). A decompressive laminectomy was performed at the C3-5 level without sequelae.

Case 3

This 62-year-old man first presented in 1977 with upper-limb weakness, hyperactive arm and leg deep-tendon reflexes, and bilateral Babinski responses. Myelography confirmed severe stenosis of the cervical canal for which a C3-6 laminectomy was performed. He improved slightly and was in stable condition for 7 years, after which he deteriorated neurologically. When seen in February, 1986, he had a suspended sensory deficit involving the entire right arm and the C5-6 dermatomes of the left arm. Proprioception was markedly impaired in all limbs. He required a walker for assistance in ambulating, and there was evidence of progressive weakness of the arms. Deep-tendon reflexes were brisk in the legs and absent in the arms. Bilateral Hoffman and Babinski signs were present.

A delayed CT-myelography study demonstrated a cystic intramedullary lesion, consistent with necrosis or cavitation, extending longitudinally throughout the central portion of the cervical spinal cord. A $T_1$-weighted MR image revealed a zone of low signal intensity.

![Fig. 1. Case 1. Left: Magnetic resonance (MR) $T_1$-weighted image (TR 416 msec, TE 20 msec), sagittal view, demonstrating a protruding C4-5 disc. The spinal cord appears normal. Right: A $T_2$-weighted MR image (TR 2000 msec, TE 100 msec), sagittal view, revealing a high-intensity signal in the C4-5 spinal cord segment (arrow).](image-url)
extending longitudinally throughout the cervical and into the thoracic cord (Fig. 3).

In February, 1986, a cervical laminectomy was performed and a syrinx was diagnosed and drained. The patient's condition has remained unchanged.

Case 4

This 70-year-old man first presented to another hospital in June, 1985. At that time he had bilateral hand-muscle atrophy and weakness of grip. There were fasciculations in the left biceps muscle. No long-tract signs could be found. Myelography demonstrated spondylotic cervical stenosis, and a decompressive laminectomy was carried out at C3–7. Immediately following surgery, the strength in his arms worsened, but then progressive improvement occurred. However, 5 months later he was noted to have increasing weakness and atrophy in the left arm and hand. The ankle jerks were hyperactive. Repeat myelography demonstrated osteophytic bars at C3–6. In February, 1986, anterior cervical fusion was carried out at these three interspaces.

In June, 1986, the patient presented to our institution. Examination revealed atrophy, weakness, and fasciculations in the left arm. An MR study was obtained. On the proton-density image two types of abnormalities were noted. High-intensity signals were seen in the regions of the anterior horn cells and in the anterior portion of the dorsal columns (Fig. 4 left). On subsequent axial section, there was absence of signal in the region of the anterior horn cells, and this was considered to be consistent with a signal-void sign from moving fluid during respiratory activity (Fig. 4 right). To date, no additional surgery has been performed.

Case 5

This 56-year-old man with diabetes and hypertension presented with a 2-year history of left upper-limb weak-
ness and pain. Five months prior to admission he noted reduced sensation on the medial aspect of the left arm and in the left hand as well as progressive weakness of the left arm (especially in the hand muscles). Examination in December, 1986, revealed confirmation of the sensory and motor changes, with atrophy of the left intrinsic hand muscles and biceps and triceps fasciculations. The deep-tendon reflexes were absent in the lower limbs, 2+ in the right arm, and 1+ in the left arm. Pain and temperature sensations were reduced only in the left arm.

Electromyography showed acute denervation potentials in the left arm and cervical paraspinal musculature. Cervical spondylosis and spinal cord atrophy at all levels were noted on cervical myelography and CT. During the next month, the neurological condition of his left arm worsened, and an MR image was obtained. This confirmed the presence of spinal cord atrophy and, at all cervical levels from C4–6, a highly intense signal was seen on the T2-weighted images (Fig. 5). These signals were located bilaterally in the central gray zones, giving a “snake-eyes” appearance on the axial images. As of this date, no surgery has been performed on this patient.

Case 6

This 57-year-old man had previously undergone amputation of his left leg. He was admitted in April, 1987, with a recent history of walking difficulties and weakness in his right lower extremity. His neurological examination revealed fasciculations in the right upper extremity, mild weakness of the deltoid muscle bilat-
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erally, and weakness of the hip flexors bilaterally. He had absent triceps reflexes. The remaining deep-tendon reflexes were 3+, with a Babinski sign in the right leg. Delayed CT after myelography demonstrated cervical spondylosis. Magnetic resonance studies revealed bilateral areas of increased signal intensity flanking areas of decreased signal intensity located in the region of the posterior columns. The low-intensity signal was consistent with a signal-void sign from moving fluid (Fig. 6).

Discussion

Delayed CT after myelography with introduction of water-soluble contrast medium has revealed intramedullary lesions developing chronically opposite levels of compression from cervical spondylosis. These lesions correlated with the cystic necrosis present largely in the gray matter, as described by pathologists. The additional discovery of longitudinal pencil-shaped lesions, which we believe results secondarily during the evolution of necrosis into cavitation, is also visualized by delayed CT-myelography studies. However, very exact timing, positioning, and electronic window settings must be used if the lesions are not to be missed.

Until recently, MR imaging technology has not provided adequate resolution or sufficiently clear-cut imaging of the spine to identify these lesions. However, this diagnostic method has been useful in delineating tumors, primary and secondary syringes, and posttraumatic cavitations of the spinal cord. When the intramedullary cavity is large, identification of this fluid-containing cavity (that is, syrinx) may be simple on MR imaging; however, Lee, et al., stated that MR imaging does not differentiate adequately between primary syringomyelia (hydromyelia) and secondary syringomyelia (unless the tumor or other causative factor is visualized). Pajunas and associates noted that it may be difficult to determine on spinal cord MR images whether the lesion is a neoplasm, cyst, or myelomalacia. Sherman and colleagues agreed that “there is a striking similarity in the appearance of many syrinx cavities regardless of the cause.” In their imaging sequences, they were able to identify the syrinx fluid clearly, both on T2-weighted images (the fluid being imaged as a zone of high signal intensity) and on T1-weighted images (the fluid being imaged as a zone of low signal intensity). It would appear that the presence of a signal-void sign (loss of signal giving a black image where pulsatile fluid movement occurs) on proton-density or T2-weighted images would rule out simple necrosis or tumor within the zone of this finding.

However, an intramedullary pencil-shaped lesion (a phrase originally used by pathologists) of small diameter may not be resolved using the currently available imaging techniques in terms of differentiation between necrosis (myelomalacia) or fluid (syringomyelia). With proper spin-echo imaging sequences, gliosis and/or edema (giving high signal intensities with T2 weighting) may be seen surrounding less intense cystic fluid in the spinal cord, suggesting that with advancing technology it may be possible to differentiate between malacia and fluid inside the spinal cord.

Recently, Quencer, et al., investigating the chronically injured cervical spinal cord, were optimistic regarding the ability of modern MR imaging to differentiate between myelomalacia and intramedullary cysts. They concluded that “the difference in relaxation times between normal spinal cord tissue, myelomalacia, and intramedullary cysts is the factor that allows MRI to be more accurate than delayed metrizamide CT in portraying the pathologic changes present in an injured cord.” They found that myelomalacia can mimic CSF as a low-intensity signal on T1-weighted images; but on T2-weighted images myelomalacia will show a signal intensity resembling that of either the spinal cord or the CSF, depending on how the images are generated and how the echo time and the repetition time are set. This requires the direct participation by the imaging specialist and attention to electronic window settings.

It is our preliminary impression that the first MR image-demonstrated change in the spinal cord itself (aside from displacement) is the high signal intensity of the whole cord diameter at the level of primary compression. This may precede the “snake-eyes” appearance of myelomalacia (or cystic-necrotic changes) of the gray matter noted by pathologists and demonstrated by delayed CT after myelography or by MR imaging. Eventually, a longitudinally extending cystic necrosis of the spinal cord evolves (the pathogenesis is unknown, see earlier publications). The latter is the most likely cause for the neurological changes distant from the original compression site (such as weakness and fasciculations of the hand muscles with midcervical spondylosis). As this myelomalacia progresses further, the necrotic tissue is phagocytized, leaving a secondary cavity (syrinx) within the atrophied spinal cord. Appropriate therapy should be undertaken before permanent cord changes progress if it is to be most successful. This would be true for any lesion compressing the spinal cord (not just the cervical spondylosis shown here). Hence, at present, MR imaging and delayed CT-myelography studies are complementary diagnostic studies which may assist in determining the extent of abnormal spinal cord alterations and the prognosis for therapy in cases of spondylosis, spinal cord compression from any cause, spinal cord injuries, and myelopathies of diverse etiologies.

References


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