Spinal cord swelling with abnormal gadolinium-enhancement mimicking intramedullary tumors in cervical spondylosis patients: Three case reports and review of the literature

Toru Sasamori, M.D., Kazutoshi Hida, M.D., Shunsuke Yano, M.D., Aoyama Takeshi, M.D., Yoshinobu Iwasaki, M.D.

Department of Neurosurgery, Hokkaido University Graduate School of Medicine, Sapporo, Japan

Objective: Spinal cord swelling with abnormal gadolinium (Gd) enhancement is a rare preoperative radiological finding in patients with cervical spondylosis. In the presence of progressive myelopathy, timely surgical decompression can be curative.

Case presentation: We report 3 patients with cervical spondylotic myelopathy. Preoperative magnetic resonance imaging (MRI) revealed spondylotic changes and intramedullary lesions in the cervical spine. We noted cervical cord swelling with high intensity on T2-weighted MRI and abnormal Gd-DTPA enhancement. Laminoplasty resulted in marked improvement of their neurological condition and postoperative MRI revealed gradual regression of the intramedullary lesions during the first year.

Conclusion: We posit that the intramedullary lesions in our patients were reflective of spinal cord edema with blood-brain-barrier disturbance in the cervical cord, possibly due to minor recurrent spinal cord injury and disturbed venous circulation. Spinal cord edema is a rare condition in patients with cervical spondylosis and an accurate diagnosis and timely surgery are necessary for cure. Therefore, this unusual condition must be considered in spondylosis patients manifesting as intramedullary lesions on MRI of the cervical spinal cord. Careful evaluation of the postoperative course can be used to confirm the diagnosis and help in selecting a subsequent therapeutic strategy.

Keywords: cervical spondylosis, gadolinium enhancement, intramedullary lesion, spinal cord edema, spinal cord swelling

Introduction

Many non-neoplastic intramedullary lesions mimic intramedullary neoplasms. They may be due to infectious disorders, demyelination, granulomatous disease, vascular lesions, and syringomyelia. Characteristically, such non-neoplastic lesions present as cord swelling associated with intramedullary abnormal intensity on magnetic resonance imaging (MRI) studies, i.e. as high intensity on T2-weighted images and as gadolinium (Gd) enhancement.

Moderate spinal cord enlargement with intramedullary high intensity on T2-weighted MRI has been reported in patients with cervical spondylosis. Al-Mefty et al. identified high intensity areas on T2-weighted images in cervical spondylosis as myelomalacia. Although Gd enhancement has been documented in cervical spondylosis patients, the clinical conditions and the mechanism underlying spinal cord enhancement in cervical degenerative disorders remain unclear.

We report 3 patients with cervical spondylosis whose MRI scans revealed spinal cord swelling with abnormal Gd enhancement.
that mimicked intramedullary tumors. This condition is relatively rare in patients with cervical spondylosis and an accurate diagnosis and timely surgery are necessary for cure. Therefore, this unusual condition must be considered in spondylosis patients manifesting as intramedullary lesions on MRI of the cervical spinal cord.

Case Reports

Case 1

Medical History and Examination. This 47-year-old man first presented in January 2004 with numbness of both hands. He had no history of spinal trauma. He reported that weakness and numbness involving all 4 extremities developed gradually and that his gait disturbance worsened significantly during the 3 months preceding his presentation. Despite steroid pulse therapy neither his neurological nor radiological findings improved. In April 2007 he was referred to our institute for a second opinion prior to undergoing open biopsy of an intramedullary lesion in the cervical spine. He also suffered bladder dysfunction. He had visited a local hospital in February 2006 and was suspected of having a cervical intramedullary lesion due to demyelination disorder or neurosarcoidosis. At the time of admission to our hospital we observed motor weakness of all 4 extremities and unsteady gait. The bilateral exaggerated deep tendon reflex of the lower extremities was significant and both Babinski and Chaddock reflexes were positive bilaterally. The superficial sensation of his upper extremities was significantly hyperesthetic below the elbow level, mainly on the ulnar side. MRI revealed marked C5-6 cord compression with extensive intramedullary high intensity on T2 weighted images from C5 to C7 (Fig. 1A). T1-weighted MRI revealed moderate spinal cord enlargement below the C5-6 level (Fig. 1B). Gadolinium (Gd)-enhanced MRI demonstrated spinal cord enhancement at the level of C5-6 (Fig. 1C). Axial Gd-enhanced MRI revealed that primarily the right dorsal part of the white column was enhanced (Fig. 1D). No vascular abnormality was found.

Operation and Postoperative Course. He underwent posterior decompressive laminoplasty from C3 to C7 in May of 2007. There was significant postoperative improvement in motor and sensory functions. MRI performed one

Figure 1. Case 1: Preoperative MRI. A: Sagittal T2-weighted image revealing marked C5-6 cord compression with extensive intramedullary high intensity from C5 to C7. B: Sagittal T1 weighted image demonstrating moderate spinal cord enlargement below the C5-6 level. Sagittal (C) and axial (D) T1-weighted Gd-enhanced images show spinal cord enhancement at the C5-6 level mainly at the right dorsal part of the white column.
month after surgery demonstrated no significant changes in the intramedullary lesion (Figs. 2A and B). In the course of one year after the operation his neurological condition gradually improved. At 15 months postoperatively, the intramedullary high intensity on T2-weighted MRI had markedly regressed (Fig. 2C). Gd-enhanced MRI revealed diminution of the enhanced lesion at C5-6 (Fig. 2D).

**Case 2**

*Medical History and Examination.* This 62-year old carpenter with a few-month history of gradually increasing weakness and numbness of both hands was referred to us for evaluation. He had no history of spinal injury. He also experienced gait disturbance during the 2 months preceding presentation. On admission to our hospital in June 2007 we observed motor weakness of the bilateral upper extremities and unsteady gait. We noted significant bilateral exaggerated deep tendon reflexes in the lower extremities and both the Babinski and Chaddock reflexes were positive bilaterally. The superficial sensation of the upper extremities was decreased significantly below the elbow level, mainly on the ulnar side. MRI revealed moderate C5-6 cord compression with extensive intramedullary high intensity on T2-weighted images from C5 to C7 (Fig. 3A). T1-weighted MRI demonstrated slight spinal cord enlargement below the C5-6 level (Fig. 3B) and Gd-enhanced MRI showed spinal cord enhancement at that level (Fig. 3C). On axial Gd-enhanced MRI mainly the bilateral white columns were enhanced (Fig. 3D). No vascular abnormality was found.

*Operation and Postoperative Course.* He underwent posterior decompressive laminoplasty from C3 to C6 in September 2007. There was slight postoperative improvement of the weakness and numbness of the upper extremities. A month after surgery MRI demonstrated diminution of the intramedullary high intensity on T2 weighted images (Fig. 4A) and regression of the Gd-enhanced lesion at C5-6 (Fig. 4B). During the year following surgery he experienced gradual improvement of his neurological condition. At 10 months postoperatively, the intramedullary high intensity on T2-weighted MRI had markedly regressed (Fig. 4C). Gd-enhanced MRI revealed apparent regression of the enhanced lesion at C5-6 (Fig. 4D).

![Figure 2. Case 1: Postoperative MRI. A month after surgery sagittal T2-weighted (A) and T1-weighted Gd-enhanced images (B) demonstrated no significant changes of the intramedullary lesion. At 15 months, the intramedullary high intensity on sagittal T2-weighted images was markedly decreased (C). Sagittal T1-weighted Gd-enhanced image revealing diminution of the enhanced lesion at C5-6 (D).](image)
Figure 3. Case 2: Preoperative MRI. A: Sagittal T2-weighted image revealing marked C5-6 cord compression with extensive intramedullary high intensity from C5 to C7. B: Sagittal T1-weighted image demonstrating slight spinal cord enlargement below the C5-6 level. Sagittal (C) and axial (D) T1-weighted Gd-enhanced images show spinal cord enhancement at the C5-6 level mainly at the bilateral dorsal part of the white column.

Figure 4. Case 2: Postoperative MRI. A month after surgery, sagittal MRI demonstrated diminution of the intramedullary high intensity on T2-weighted images (A) and regression of the Gd-enhanced lesion at C5-6 (B). At 10 months postoperatively, sagittal T2- (C) and T1-weighted Gd-enhanced images (D) revealed nearly complete disappearance of the intramedullary lesion.
Case 3
Medical History and Examination. This 60-year-old man first presented with numbness of both hands in March 2007. In September 2007 he was referred to us for evaluation with a several-month history of numbness of both hands that had gradually worsened during the month preceding presentation. At the time of admission we observed motor weakness of all 4 extremities and unsteady gait. We noted significant bilateral exaggerated deep tendon reflexes in the lower extremities; both the Babinski and Chaddock reflexes were positive bilaterally. The superficial sensation of the upper extremities was significantly hypesthetic below the elbow level, mainly on the radial side. MRI revealed slight C3-4 cord compression with extensive intramedullary high intensity on T2-weighted images from C3 to C5 (Fig. 5A). Dynamic T2-weighted MRI showed C3-4 cord compression exacerbated by neck extension (Fig. 5B) and T1-weighted MRI revealed moderate spinal cord enlargement below the C3-4 level (Fig. 5C). Gd-enhanced MRI demonstrated slight spinal cord enhancement at the C3-4 level (Fig. 5D). No vascular abnormality was noted.

Operation and Postoperative Course. In October 2007 he underwent posterior decompressive laminoplasty. Postoperatively, his motor weakness involving all 4 extremities improved significantly; his unsteady gait also improved. However, the sensory disturbance of his upper extremities improved only slightly. A month after surgery MRI demonstrated significant diminution of the intramedullary high intensity on T2-weighted images (Fig. 5E). During the 6 months after surgery he exhibited gradual improvement of his neurological condition. At 11 months postoperatively, the intramedullary high intensity on T2-weighted MRI was limited at the C3-4 level (Fig. 5F).

Discussion
On T2-weighted MRI, non-neoplastic lesions mimicking intramedullary neoplasms characteristically present with cord swelling associated with intramedullary abnormal intensity and some exhibit Gd enhancement. Similar radiological findings were seen in patients with chronic degenerative disorders of the spine.

Takahashi et al. reported a 74-year-old man with cervical herniated disc and spondylosis at the level of C3-4. T2-weighted MRI revealed an intramedullary high intensity lesion and Gd enhancement. He presented with myelopathy, however, no details about his treatment and clinical course were offered.

Figure 5. Case 3: Preoperative MRI. A, B: Sagittal T2-weighted dynamic MRI revealing C3-4 cord compression exacerbated by neck extension. C: Sagittal T1-weighted image demonstrating moderate spinal cord enlargement below the C3-4 level. D: Sagittal T1-weighted Gd-enhanced images showing spinal cord enhancement at the C3-4 level. Postoperative MRI. Sagittal T2-weighted image (E) acquired one month after surgery shows significant diminution of the intramedullary high intensity. At 11 months, the intramedullary high intensity on T2-weighted image was limited at the C3-4 level (F).
In 6 patients with cervical spondylotic myelopathy, postoperative MRI revealed spinal cord swelling with abnormal Gd-enhancement. Although the authors failed to provide histopathologic evidence, they suggested that the intramedullary lesions reflected spinal cord edema possibly induced by venous- and cerebrospinal fluid (CSF) circulation disturbance due to spinal cord compression. In a patient with cervical spondylotic myelopathy, the presence of spinal cord enhancement led to the suggestion that the focal area of intramedullary enhancement was consistent with cord substance disruption or reorganization, resulting in a blood-brain barrier breakdown and Gd uptake. Cabraja et al. also reported atypical cervical spondylotic myelopathy mimicking intramedullary tumor. Intramedullary biopsy returned a definitive diagnosis of myelopathy and histopathology excluded a neoplastic origin. Rather, the microscopic tissue changes suggested an inflammatory reactive process with pronounced edema.

The 12 reported patients with chronic degenerative spine disorders who manifested spinal cord swelling and abnormal Gd-enhancement, including our cases, consisted of 11 men and 1 woman; their ages ranged from 36 to 74 years (Table 1). Most of the patients initially presented with motor weakness and/or sensory disturbance of the upper extremities and preoperative physical examination of all patients revealed cervical myelopathy.

Preoperative T2-weighted MRI of all these patients revealed extensive intramedullary high intensity at the compressed disc level and at the adjacent caudal area immediately below the involved disc level (Table 2). They also showed slight or moderate spinal cord enlargement immediately below the disc level exhibiting marked compression. Of our 3 patients, cases 1 and 2 manifested intramedullary enhancement of the dorsal white matter on preoperative Gd-enhanced MRI scans. This finding coincides with the observation of Lee et al. As shown in Table 2, 11 of the 12 patients underwent surgical treatment; 7 were treated by posterior decompression, 3 by anterior fusion, and one received both posterior decompressive surgery and anterior fusion. Postoperatively, 10 of the 11 patients manifested neurological improvement without any deterioration; in one patient the clinical symptoms remained unchanged. We detected no significant association between the clinical outcome and symptom duration before surgery.

The MRI follow-up ranged from 3 - 46 months. In 2 patients (cases 6 and 12) there was no improvement; in the remaining 10 patients, complete neurological recovery occurred in 6 patients and partial neurological recovery occurred in the remaining 4 patients. We detected no significant association between the clinical outcome and symptom duration before surgery.

| Author, Year | Case | Age/Sex | Symptom at onset | Neurological Findings on Admission | Duration from onset to Op |
|--------------|------|---------|------------------|-----------------------------------|--------------------------|
| our cases    | 1    | 47M     | bilat UE numbness| mild quadripareisis; bilat Babinski sign (+); SD of bilat UE & LR | 28 mos                   |
|              | 2    | 62M     | bilat UE motor weakness & numbness | mild quadripareisis; bilat Babinski sign (+); SD of bilat UE | 7 mos                    |
|              | 3    | 60M     | bilat UE numbness | mild quadripareisis; bilat Babinski sign (+); SD of bilat UE & LR | 8 mos                    |
| Takahashi, 1989 | 4    | 74M     | unknown | cervical myelopathy | unknown                  |
| Lee, 2003    | 5    | 65M     | bilat UE numbness | mild quadripareisis; bilat Babinski sign (+); SD of bilat UE & LR | 18 mos                   |
|              | 6    | 44M     | gait disturbance | mild quadripareisis; bilat Babinski sign (+); SD of bilat UE & LR | 4 mos                    |
|              | 7    | 72M     | rt UE motor weakness & pain | mild quadripareisis; bilat Babinski sign (+); SD of bilat UE & LR | 14 mos                   |
|              | 8    | 51M     | rt UE numbness | mild hemianpareisis; dysesthesia of lt UE & LR | 7 mos                    |
|              | 9    | 50M     | rt UE numbness | motor weakness of UE; rt Chaddock sign (+); SD of rt UE & LR | 2 mos                    |
|              | 10   | 45M     | rt UE & LR numbness | mild quadripareisis; bilat Babinski sign (+); SD of bilat UE & LR | 3 mos                    |
| Boet, 2004   | 11   | 60F     | bilat UE numbness | mild quadripareisis; bilat hyperreflexia; SD of bilat UE & LR | more than 1 year         |
| Cabraja, 2008 | 12   | 36M     | bilat cervicobrachialgia | unsteady gait; SD of bilat UE; bladder disfunction | more than 3 mos          |

M = male; F = female; bilat = bilateral; UE = upper extremity; LE = lower extremity; Op = operation; SD=sensory disturbance; (+) = positive
no change in the intramedullary lesions at 3 months after surgery while in 2 (cases 2 and 11), both intramedullary high intensity on T2-weighted MRI and Gd enhancement had disappeared almost completely within the first postoperative year. The other 7 patients experienced gradual regression of their intramedullary lesions. In particular, 2 patients with longer follow-up periods (27-46 months, cases 5 and 10) manifested gradual disappearance of spinal cord swelling and mild atrophy.

All 3 of our patients were referred to our outpatient clinic under the suspicion of intramedullary spinal cord tumors. They showed progressive myelopathy resistant to conservative treatments. As chronic spinal cord compression may result in irreversible neurological deterioration in such patients, an accurate preoperative diagnosis and timely decompressive surgery are necessary as is careful evaluation of their postoperative course by MRI.

The mechanism underlying spinal cord edema in cervical degenerative disorders has been studied. Lee et al. suggested that venous circulation disturbance due to spinal cord compression results in local venous hypertension at the affected level that would eventually lead to venous ischemia or hyper-permeability of the intramedullary vessels with consequent spinal cord edema at the compression site and adjacent spinal cord parenchyma. Based on animal studies, others postulated that disturbed CSF circulation may play a role in the development of spinal cord edema. In the series of Lee et al., spinal cord edema was aggravated 1 - 6 weeks after decompressive surgery.

We propose a third mechanism for spinal cord edema in cervical spondylosis. This unique condition may be associated not only with static- but also dynamic factors since the degree of cord compression with the neck in neutral position does not always reflect an increased susceptibility for this condition. In fact, in our case 3, MRI obtained with the neck in extension position revealed spinal cord compression (Fig. 6C), although in the neutral position, the degree of compression was lower.

We posit that normal neck movement may produce transient but iterative impingement of the spinal cord at the compressed disc level. In our 3 cases, dynamic MRI showed that neck extension resulted in exacerbation of cord swelling with abnormal gadolinium-enhancement mimicking intramedullary tumors in cervical spondylosis patients: Three case reports and review of the literature

Table 2. Summary of the reported cases of spinal cord swelling with Gd-enhancement in cervical degenerative disorders.

| Author, year | Case Level of Compression | Preoperative MRI | Postoperative course | Follow-Up MRI (interval from Op) |
|--------------|---------------------------|------------------|----------------------|---------------------------------|
| Takahashi, 1989 | C3-4 & C5-6 | C3-4 laminoplasty (C3-7) & C5-6 laminoplasty (C5-6) | Improved | IMH at C3-4 & Gd enhancement (10 mos) |
| Lee, 2003 | C4-5 & C5-6 | C5-6 laminoplasty (C4-7) | No change | Atrophic cord & IMH at C5-6 (27 mos) |
| | C5-6 | C5-6 ant. fusion (C5-6) | Improved | Cord swelling & Gd enhancement at C5-6 (3 mos) |
| | C6-7 & C7-T1 | C5-6 laminoplasty (C3-7) | Improved | Mild cord swelling & Gd enhancement at C7-T1 (11 mos) |
| | C5-6 | C5-6 laminoplasty (C3-7) | Improved | Cord swelling improved; IMH at C5-6 (19 mos) |
| | C4-5 & C5-6 | C5-6 no exam | Ant. fusion (C5-6 & C5-6) | No exam | Atrophic cord & IMH at C5-6 (27 mos) |
| | C3-4 & C6-7 | C5-6 no exam | Laminoplasty (C3-7) | Improved | Atrophic cord & IMH at C5-6 (27 mos) |
| Bo et al., 2004 | C5-6 | C5-6 ant. disectomy & fusion (C5-6) | Improved | Near complete disappearance of IMH & Gd enhancement (12 mos) |
| Cabrera, 2008 | C4-5 & C5-6 | C1-T1 | Laminectomy (C4-5) & Ant. Fusion (C4-6) | Improved | Almost unchanged (3 mos) |

C = cervical; T = thoracic; IMH = intramedullary high intensity on T2-weighted MR imaging; Op = operation; ant. = anterior
compression at the affected level (Fig. 6A-C) with simultaneous worsening of their neurological symptoms. According to Terae et al. 23, 3 of 8 patients manifested Gd-enhancement at 1 - 14 weeks post-injury. They speculated that the enhancement reflects vascularized granulation in a reparative phase. Shimada et al. 19 also noted Gd enhancement of the acutely injured spinal cord in 10 of 16 patients. Although there was no histopathological evidence in our cases, our dynamic MRI findings suggest that transient but repetitive cord compression is associated with spinal cord swelling and Gd enhancement in patients with chronic degenerative disorders.

Spinal cord edema is a rare condition in patients with cervical spondylosis and an accurate diagnosis and timely surgery are necessary for cure. Therefore, this unusual condition must be considered in spondylosis patients manifesting intramedullary lesions on MRI of the cervical spinal cord. Careful evaluation of the postoperative course can be used to confirm the diagnosis and help in selecting a subsequent therapeutic strategy.

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