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CONTINUING EDUCATION

MRI OF MYELITIS*

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MRI of myelitis

The diagnosis of myelitis relies on MRI. The purpose of this review is to describe the imaging findings in patients with myelitis through clinical cases. MR findings in Multiple Sclerosis, Neuromyelitis Optica and others Transverse Myelitis are highlighted.

Multiple sclerosis

The spinal cord is frequently involved in Multiple Sclerosis (MS) (1). The MS spinal cord lesions are typically small, peripherally located, involving less than two vertebral segments in length and less than half the cross-sectional area of the cord (Fig. 1) (1, 2). On axial MR images, the MS lesions have a wedge shape with the basis at the cord surface (Fig. 1). Concomittant intracranial lesions are a key concept in differentiating MS from other myelitis (3). Enhancement of the spinal cord MS lesions is less frequent than in the brain lesions (Fig. 2). MS may rarely presents as transverse myelitis but follow-up imaging will demonstrate new lesions occurring in cord and brain. Patients with MS may also exhibit spinal cord atrophy mainly related to axonal degeneration. The spinal cord atrophy correlates with clinical disability (4).

Transverse myelitis

Transverse myelitis (TM) is an acute inflammatory condition characterized by rapid onset of bilateral motor, sensory, and autonomic dysfunction (5). TM is mainly observed in the second and fourth decades and the thoracic spine is most commonly involved (6). Diagnostic criteria of TM were previously defined by the «Transverse Myelitis Consortium Working Group» and include: 1) clin-

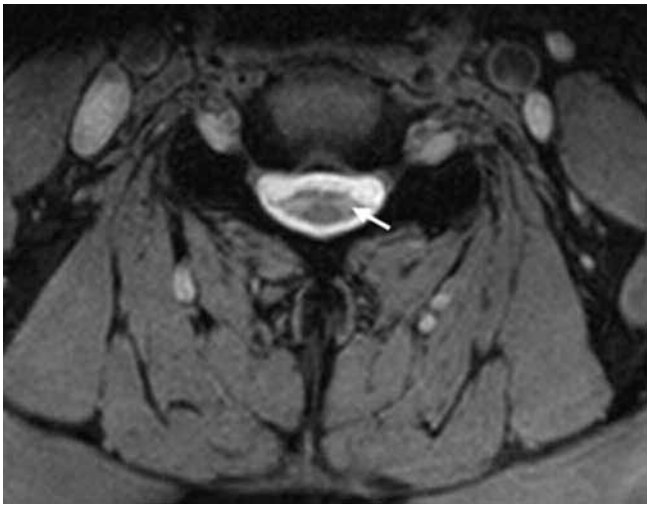

Fig. 1. — Patient with Multiple Sclerosis. Hyperintense, wedge-shaped, peripherally located lesions (arrow) were observed on axial T2-weighted MR image at the C4 level. These cord lesions occupyied less than half the crosssectional area of the cord.

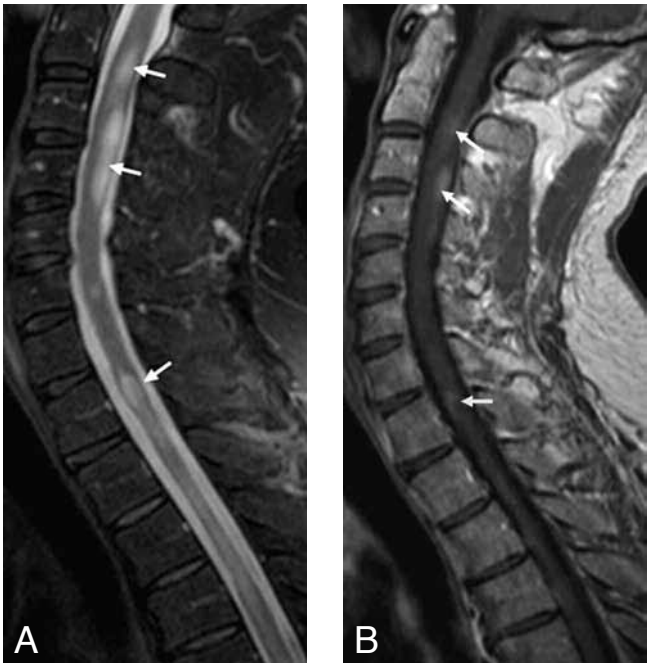

Fig. 2. — Patient with MS and active spinal cord lesions. Sagittal T2-weighted MR image (A) of the cervical spinal cord showed several focal hyperintense spinal cord lesions (arrows). On sagittal post-contrast T1-weighted MR image (B), nodular enhancement of the MS lesions was observed consistent with active inflammatory lesions (arrows).

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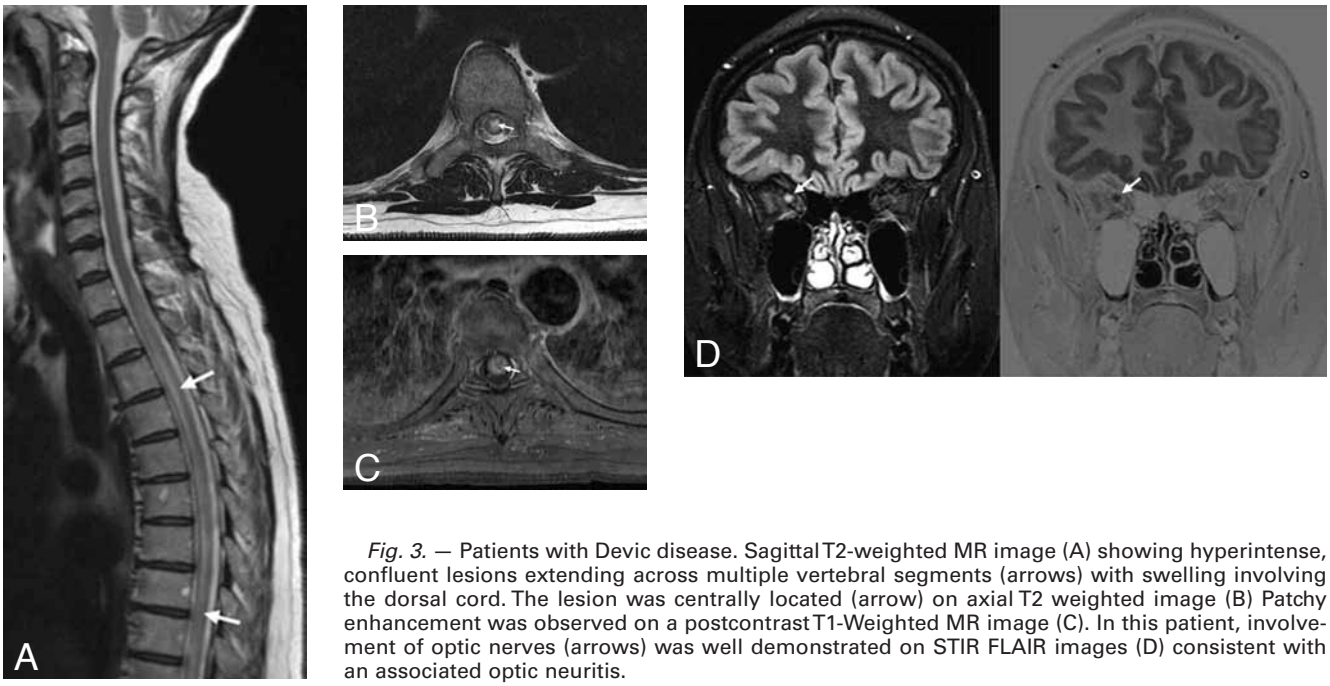


Fig. 3. — Patients with Devic disease. Sagittal T2-weighted MR image (A) showing hyperintense, confluent lesions extending across multiple vertebral segments (arrows) with swelling involving the dorsal cord. The lesion was centrally located (arrow) on axial T2 weighted image (B) Patchy enhancement was observed on a postcontrast T1-Weighted MR image (C). In this patient, involvement of optic nerves (arrows) was well demonstrated on STIR FLAIR images (D) consistent with an associated optic neuritis.

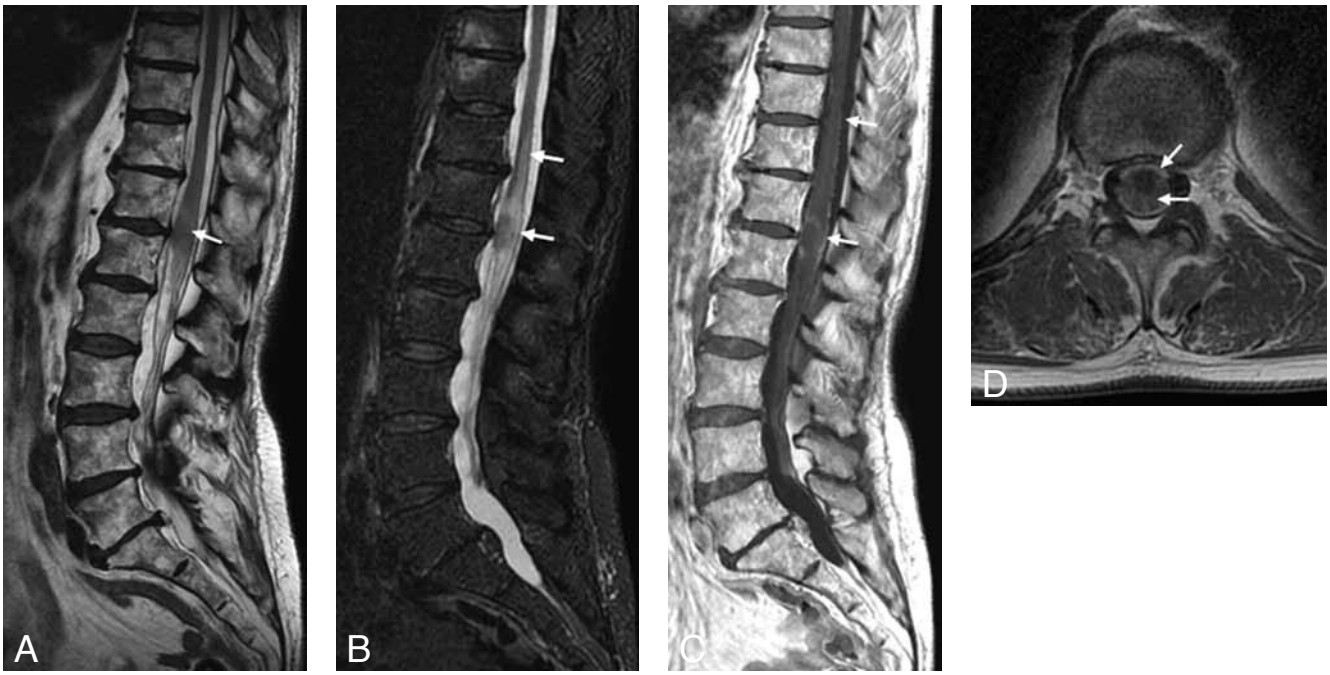


Fig. 4. — Patient with Sarcoidosis. (A) On the sagittal T2-Weighted MR images, intramedullary high-signal-intensity lesion was detected at the conus medullaris with a mild increase in signal intensity (arrow). (B) On the STIR MR sequence, the lesion showed a marked increase in signal intensity and is more easily appreciated (arrow). Note the combination of leptomeningeal and peripheral intramedullary enhancement (arrows) using sagittal (C) and axial (D) T1 weighted sequence.

ical symptoms referable to the spinal cord, 2) progression to clinical nadir between 4 hours and 21 days 3) confirmation of an active inflammatory process by MR examination or CSF examination 4) exclusion of extra-axial compressive etiology. The prognosis is variable.

Idiopathic is distinguished from disease-associated TM. Disease-associated transverse myelitis may be related to neuromyelitis optica, autoimmune conditions, sarcoidosis or para-infectious conditions. In patients with TM, MRI typically demonstrates a thoracic cord T2-hyperintense lesion centrally located, extending over more than three vertebral segments, and involving all or most of the cross section of the cord (7, 8). On post contrast T1 weighted images, gadolinium enhancement can be observed, with a peripheral enhancement of the central lesion (9).

Devic disease

Devic disease or neuromyelitis optica (NMO) is a demyelinating dis-

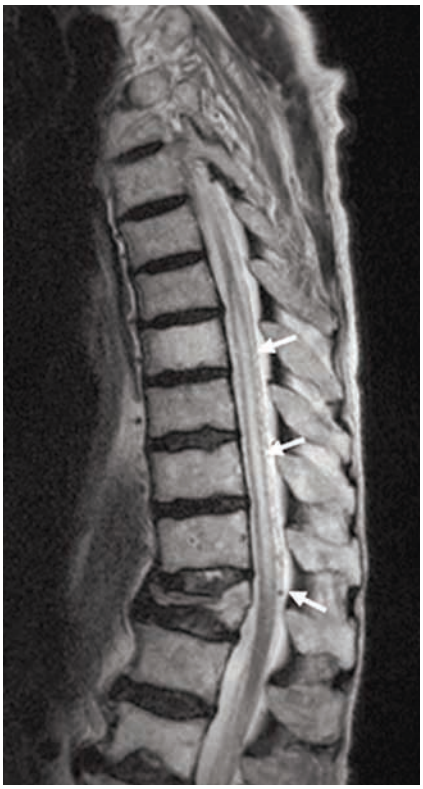


Fig. 5. — Patient with a Spinal Vascular Malformation. Sagittal T2 weigted images showed T2 hyperintensity of the spinal cord with vascular flow voids (arrows) around the cord suggesting the diagnosis of arteriovenous malformation.

ease characterized by visual disturbance and transverse myelopathy. The 2006 revised diagnostic criteria for NMO (10) include: NMO IgG positivity, longitudinally extensive cord lesion, or onset MR imaging of the brain which is nondiagnostic for multiple sclerosis. MRI typically demonstrates a longitudinally extensive transverse myelitis with T2-hyperintense dorsal cord lesions, centrally located, spanning more than three vertebral segments (Fig. 3) (11). Enhancement and cord swelling are common in such patients (12). The myelitis can extend cranially involving the brainstem. MRI is also of use to depict the associated neuromyelitis optica (Fig. 3).

Autoimmune conditions

TM has also been described in various autoimmune conditions without specific MR findings (11). Several NMO patients have a coexistent autoimmune disorder such as Systemic Lupus Erythematosus (SLE), Sjögren syndrome, myasthenia gravis or Neuro-Behcet's disease (11).

Sarcoidosis

Sarcoidosis is a noncaseating granulomatous disease that may involve central nervous system. MRI typically demonstrates intramedullary lesions with enhancement extending more than three levels. A keypoint is the associated leptomeningeal enhancement commonly observed in such patients (11, 13) (Fig. 4).

Infectious

Transverse myelitis may be associated with a history of infectious syndrome or vaccination preceding clinical onset. In such cases, MR findings are usually nonspecific but a leptomeningeal and/or nerve root enhancement can be observed. In AIDS patients, HIV myelitis must be distinguished from vacuolar myelopathy (14, 15). In patients with vacuolar Myelopathy, MRI typically reveals nonenhancing symmetric dorsolateral T2-signal hyperintensity of the thoracic cord (15, 16).

Vascular malformations

Patients with spinal arteriovenous malformation may exhibit sudden onset or progressive myelopathy (17). MRI typically demonstrates a transverse myelitis associated with vascular flow voids around the cord (Fig. 5). MRI may also reveal spinal cord hematoma, siderosis or subarachnoid hemorrhage. The diagnosis still relies on conventional angiography.

Differential diagnosis of transverse myelitis

Cord ischemia

Patient with cord infarction exhibit a sudden onset motor, sensory,

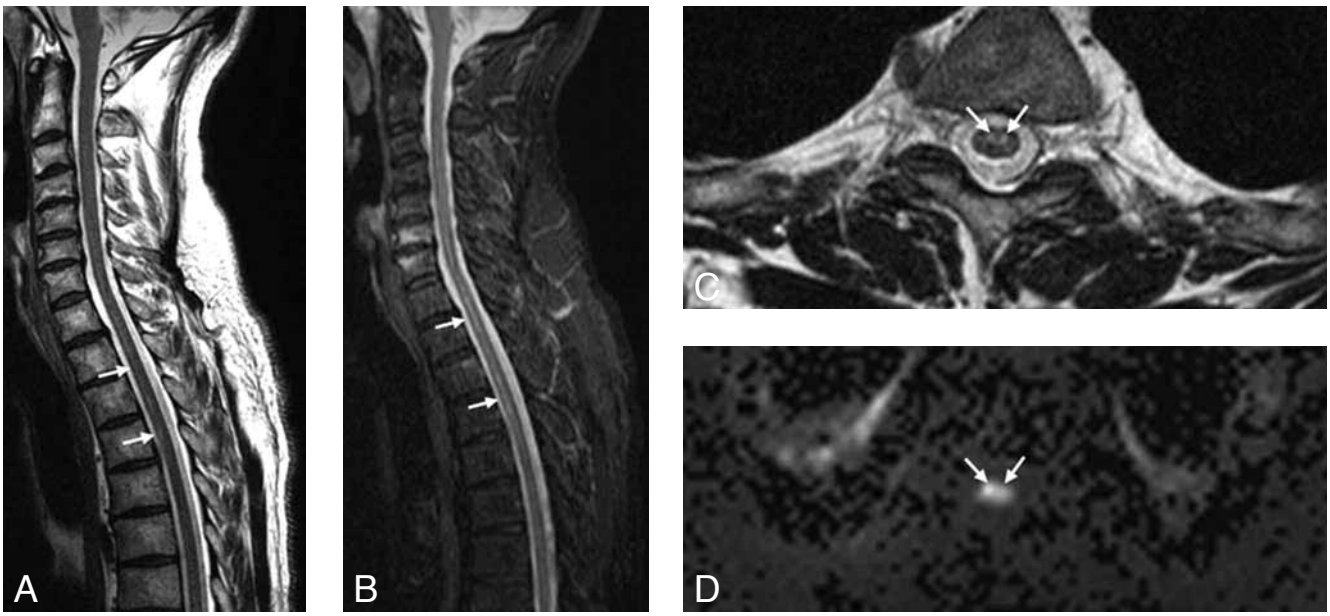


Fig. 6. — Patient with Cord Ischemia. Sagittal T2-Weighted (A) and STIR (B) demonstrated abnormal T2 hyperintensities involving the anterior columns of the spinal cord with a "snake-eyes" appearance (arrows) on axial T2 images (C). Note the increase signal on diffusion images (D) related to a restricted diffusion.

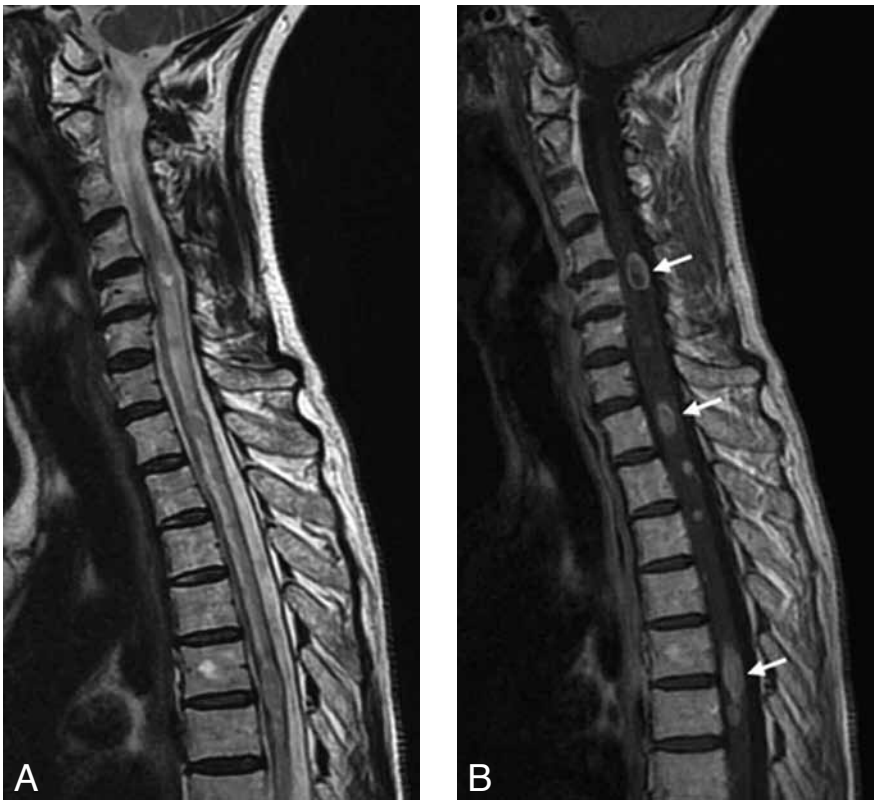


Fig. 7. — Patient with spinal cord metastases. Sagittal T2 weigted images (A) showed an extensive hyperintensity of the spinal cord with nodular enhancement (arrows) on postcontrast T1-Weighted MR images (B) related to metastases of a lung cancer.

and autonomic disturbance. The anterior spinal artery that supplies the corticospinal tracts and most of gray matter is frequently involved. MRI typically demonstrates abnormal T2 hyperintensities of the anterior columns with a "snake-eyes" appearance (Fig. 6) (18). The whole central cord may be invloved with a rim of spared peripheral white matter (19). MR conventional sequences may show negative results in the acute phase. Diffusion-weighted imaging (DWI) of the spinal cord may show signal abnormalities in such cases due to a restriction of diffusion related to the infarction (Fig. 6).

Tumors

Cavernomas appear as a cord lesion with a hypointense related to susceptibility artifacts from hemosiderin deposits (20). Spinal cord metastasis can be observed with edema and mass effect mimicking a longitudinal transverse myelitis (Fig. 7).

Delayed radiation myelopathy

In such patients MRI reveals increased T2 signal of the cord with swelling corresponding to the irradi-

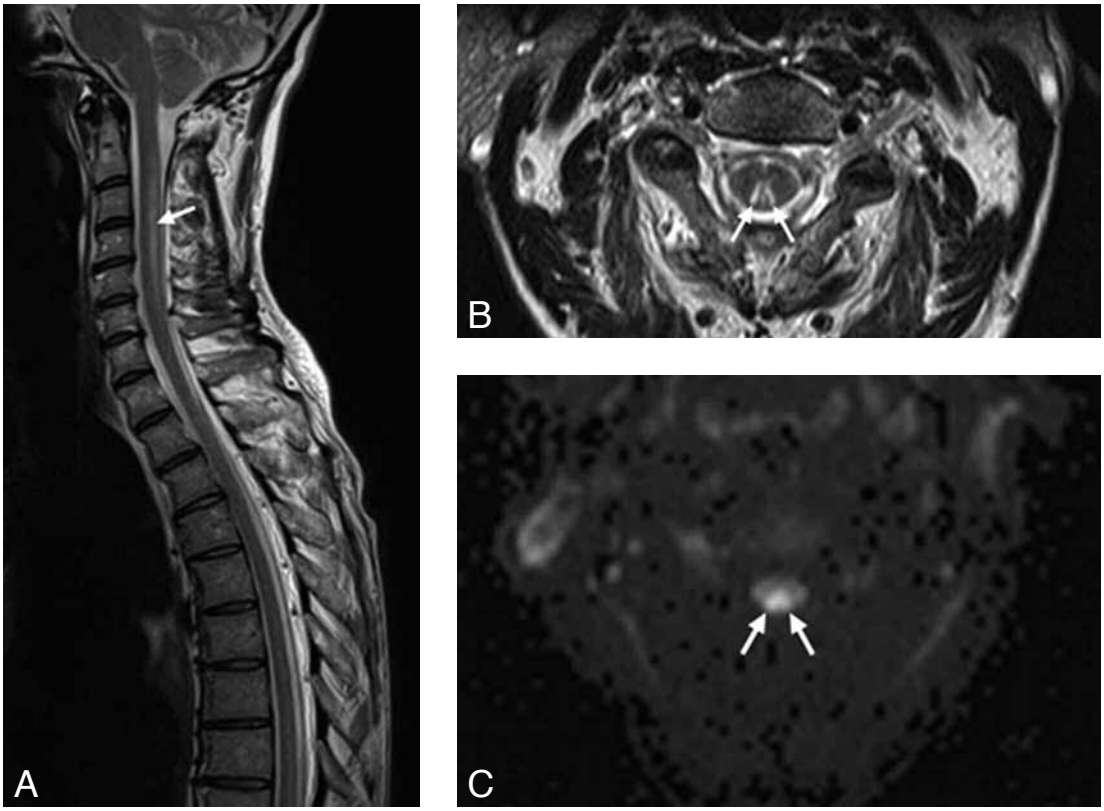
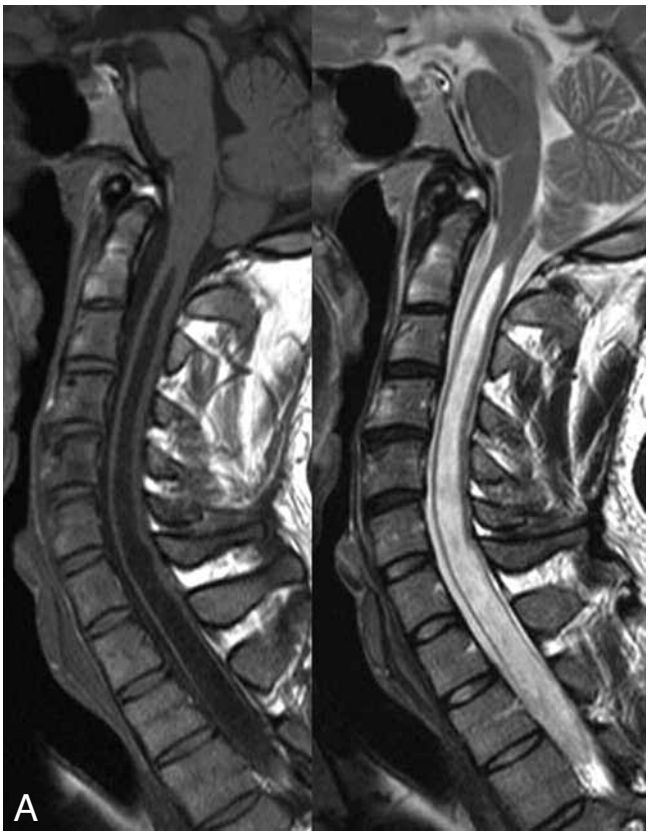


Fig. 8. — Patient with Cobalamin Deficiency. Sagittal T2-Weighted images (A) demonstrated a longitudinal hyperintensity of the dorsal columns of the cervical cord with an "inverted V" appearance (arrows) on the axial T2 images (B). Note the increased signal on diffusion images (C).



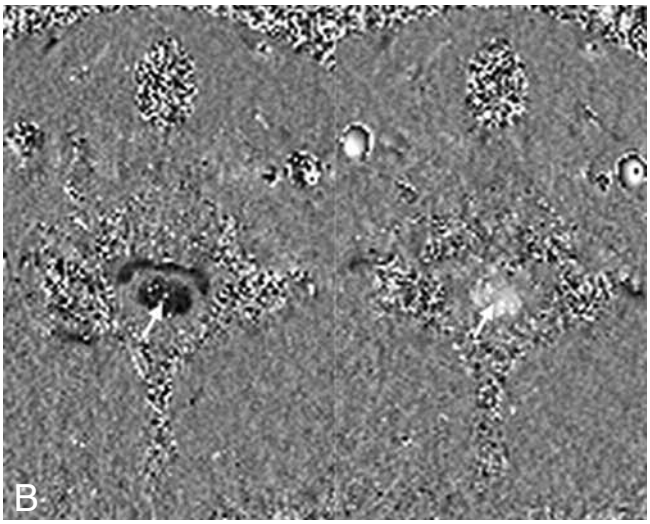
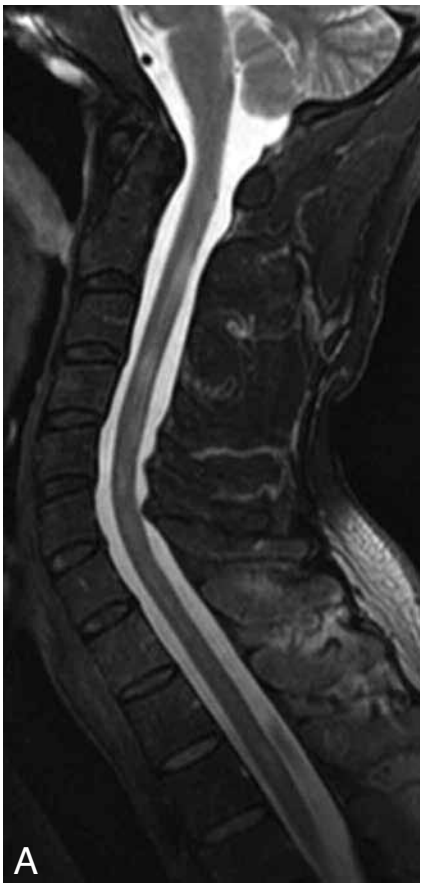


Fig. 9. — Patient with Syringohydromyelia. Sagittal T2 and T1-Weighted images (A) revealed a central cystic lesion of the spinal cord with CSF intensity and flow related artifacts. Through Plane - Cine Phase Contrast Imaging (B) confirmed the diagnosis of syringohydromyelia showing a pulsatile CSF flow (black: systolic CSF flow; white: diastolic CSF flow) within the cavity.



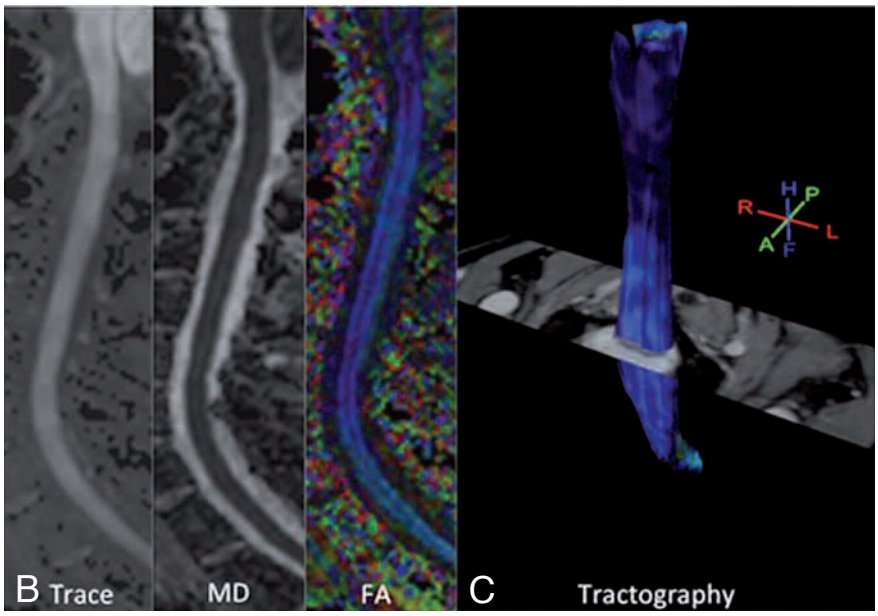


Fig. 10. — Patient with MS explored with Diffusion Tensor Imaging. Sagittal T2 weigted images (A) showed an extensive myelitis with atrophy. DTI parametric maps (B) and tractography images (C) revealed a marked increase in diffusivity values with reduced FA values.

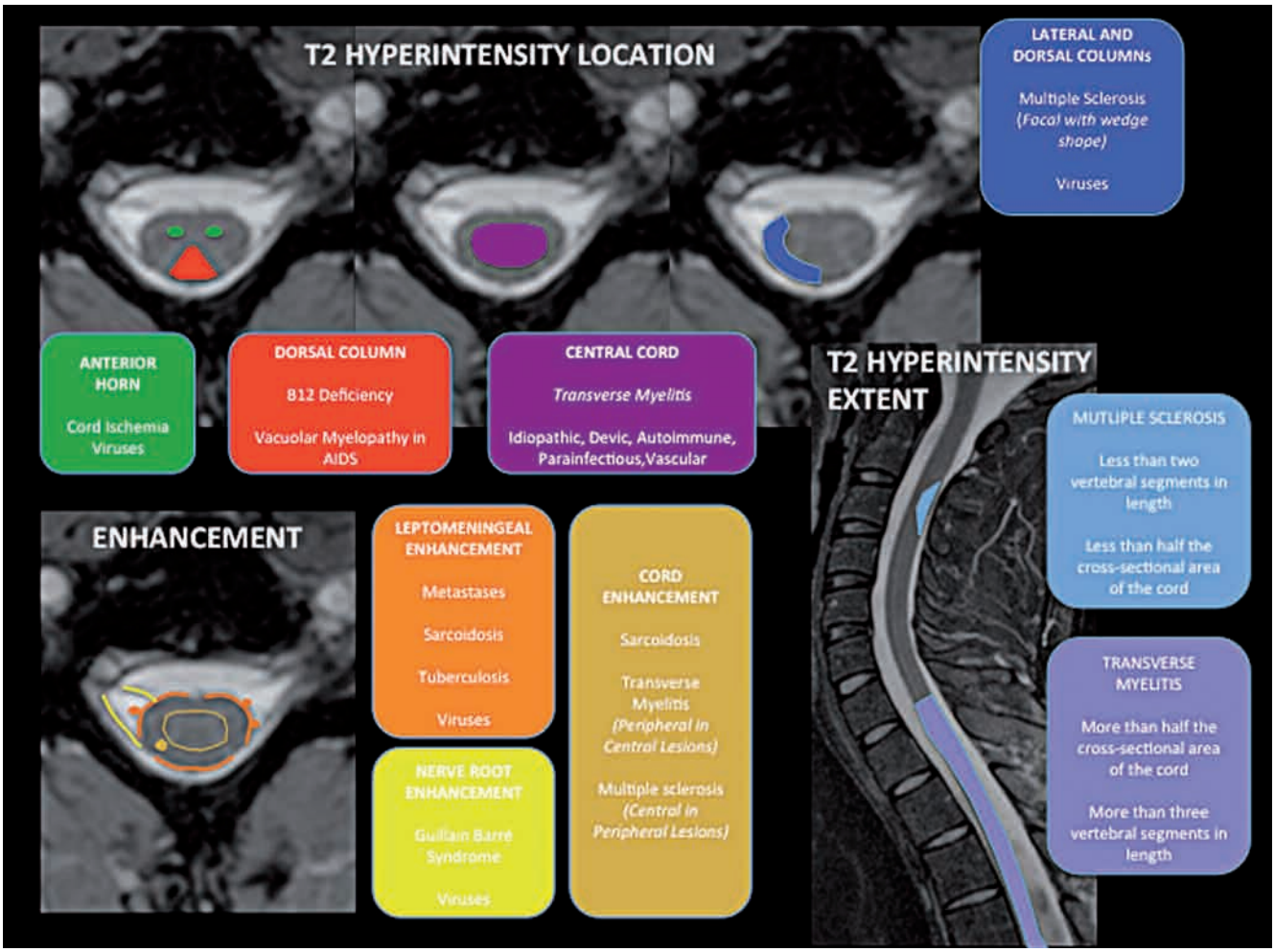


Fig. 11. — Schematic drawing of the diagnostic work-up in patients with myelitis.

ation port. Signal abnormalities may occur several months after the irradiation. Enhancement can be observed.

Cobalamin Deficiency

MRI demonstrates symmetric T2 hyperintensities of the dorsal columns, with an "inverted V" appearance on axial images (Fig. 8) (21). Increased signal on diffusion images can also be observed in such patients. Signal abnormalities may decrease after treatment.

Syringohydromyelia

In patients with syringohydromyelia, MRI reveals a central cystic lesion of the spinal cord with CSF intensity in all sequences (Fig. 9). This must be distinguished from a cystic central canal of the spinal cord. Cerebrospinal fluid flow related artefacts can be observed in the cavity on T2 weighted images. Cine Phase Contrast Imaging may be of use to confirm the diagnosis showing a pulsatile flow within the cavity (22).

MR protocol

The entire spinal cord should be imaged in patients who have spinal symptoms and who have a known or presumptive diagnosis of MS. Slice thickness should not exceed 3 mm, with a maximum interslice gap of 10% (23). The imaging protocol should include the following sequences: sagittal T2-WI, T1-WI, axial T2-WI for exact anatomic location of the lesion, and contrast-enhanced T1-WI. Studies have shown the superiority of short-time inversion-recovery sequences to Fast Spin Echo sequences in the detection of lesions in the spinal cord (24, 25). Recently the value of the PSIR sequence was reported for the detection of spinal cord lesions (26).

Diffusion Tensor Imaging (DTI) is a promising technique for the imaging of myelitis (Fig. 10). Indeed this technique provides information about the tissue microstructure. DTI parameters such as Fractional Anisotropy (FA), Mean Diffusivity (MD) may help to distinguish myelin repair from axonal loss or improve the detection of occult spinal cord pathology (27-29).

Diagnostic work-up

The presence of hyperintense T2 lesions in the spinal cord remains a nonspecific finding. The first step of the diagnostic work-up is to rule out spinal cord compression, a surgical emergency. Clinical data and NMO IgG are very useful in the work-up of transverse myelitis. MR findings may help to differentiate inflammatory myelitis from mimics according to T2-hyperintensities and gadolinium enhancement on post contrast T1 weighted images. A schematic drawing summarizing these findings is shown in Fig. 11.

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