

**American College of Radiology  
ACR Appropriateness Criteria®**

**Clinical Condition:**      Myelopathy

**Variant 1:**                Traumatic.

Radiologic Procedure	Rating	Comments	<a href="#">RRL*</a>
CT spine without contrast	9	First test for acute management.	☼ ☼ ☼
MRI spine without contrast	8	For problem solving or operative planning. Most useful when injury is not explained by bony fracture.	O
X-ray spine	7	May be first test in multisystem trauma, especially when CT is delayed. To assess stability.	☼ ☼ ☼
Myelography and postmyelography CT spine	5	MRI preferable.	☼ ☼ ☼ ☼
X-ray myelography	3	Usually performed in conjunction with CT.	☼ ☼ ☼
MRA spine without and with contrast	3	For suspected vascular trauma. Use of contrast may vary depending on technique used.	O
MRA spine without contrast	3	For suspected vascular trauma. Use of contrast may vary depending on technique used.	O
CTA spine with contrast	3	For suspected vascular trauma.	☼ ☼ ☼
Arteriography spine	2		Varies
MRI spine without and with contrast	2		O
CT spine with contrast	2		☼ ☼ ☼
Tc-99m bone scan with SPECT spine	2		☼ ☼ ☼
In-111 WBC scan spine	2		☼ ☼ ☼ ☼
MRI spine flow without contrast	2		O
CT spine without and with contrast	1		☼ ☼ ☼ ☼
Epidural venography	1		Varies
US spine	1		O
X-ray discography	1		☼ ☼ ☼
<b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Clinical Condition:**      Myelopathy

**Variant 2:**                Painful.

Radiologic Procedure	Rating	Comments	<a href="#">RRL*</a>
MRI spine without contrast	8		O
MRI spine without and with contrast	7	If infection or neoplastic disorder is suspected. See statement regarding contrast in text under “Anticipated Exceptions.”	O
CT spine without contrast	7	Most useful for spondylosis.	☼ ☼ ☼
Myelography and postmyelography CT spine	5	For problem solving or if MRI unavailable or contraindicated.	☼ ☼ ☼ ☼
Tc-99m bone scan with SPECT spine	4	Search for associated extraspinal disease.	☼ ☼ ☼
X-ray spine	3	To assess stability.	☼ ☼ ☼
CT spine with contrast	3	Consider for infection or neoplasm, or if MRI is unavailable or contraindicated.	☼ ☼ ☼
X-ray myelography	2	Usually performed in conjunction with CT.	☼ ☼ ☼
MRI spine flow without contrast	2		O
Arteriography spine	2		Varies
In-111 WBC scan spine	2		☼ ☼ ☼ ☼
CTA spine with contrast	2	For problem solving.	☼ ☼ ☼
CT spine without and with contrast	1		☼ ☼ ☼ ☼
US spine	1		O
X-ray discography	1		☼ ☼ ☼
Epidural venography	1		Varies
<b><u>Rating Scale:</u></b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Clinical Condition:**      **Myelopathy**  
**Variant 3:**                **Sudden onset.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><a href="#"><u>RRL*</u></a></b>
MRI spine without contrast	9		O
MRI spine without and with contrast	8	See statement regarding contrast in text under “Anticipated Exceptions.”	O
Myelography and postmyelography CT spine	6		☼ ☼ ☼ ☼
CT spine without contrast	5		☼ ☼ ☼
X-ray myelography	4		☼ ☼ ☼
CTA spine with contrast	4	Anatomic coverage is determined by clinical situation.	☼ ☼ ☼
Arteriography spine	4		Varies
MRA spine without and with contrast	4	When vascular pathology is suspected. See statement regarding contrast in text under “Anticipated Exceptions.”	O
MRA spine without contrast	4	When vascular pathology is suspected.	O
X-ray spine	3	May be useful to follow-up for stability or fracture progression.	☼ ☼ ☼
CT spine with contrast	3		☼ ☼ ☼
Tc-99m bone scan with SPECT spine	2		☼ ☼ ☼
In-111 WBC scan spine	2		☼ ☼ ☼ ☼
MRI spine flow without contrast	2		O
CT spine without and with contrast	1		☼ ☼ ☼ ☼
X-ray discography	1		☼ ☼ ☼
US spine	1		O
Epidural venography	1		Varies
<b><u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate</b>			<b>*Relative Radiation Level</b>

**Clinical Condition:**      Myelopathy

**Variant 4:**                      Stepwise progressive.

Radiologic Procedure	Rating	Comments	<a href="#">RRL*</a>
MRI spine without contrast	9		O
MRI spine without and with contrast	9	See statement regarding contrast in text under “Anticipated Exceptions.”	O
Myelography and postmyelography CT spine	6		☢ ☢ ☢ ☢
Arteriography spine	5		Varies
X-ray myelography	5		☢ ☢ ☢
CT spine without contrast	5		☢ ☢ ☢
CTA spine with contrast	4		☢ ☢ ☢
MRA spine without and with contrast	4	See statement regarding contrast in text under “Anticipated Exceptions.”	O
MRA spine without contrast	4		O
CT spine with contrast	3		☢ ☢ ☢
X-ray spine	3		☢ ☢ ☢
Tc-99m bone scan with SPECT spine	2		☢ ☢ ☢
In-111 WBC scan spine	2		☢ ☢ ☢ ☢
MRI spine flow without contrast	2		O
CT spine without and with contrast	1		☢ ☢ ☢ ☢
X-ray discography	1		☢ ☢ ☢
US spine	1		O
Epidural venography	1		Varies
<b><u>Rating Scale:</u></b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Clinical Condition:**      Myelopathy

**Variant 5:**                Slowly progressive.

Radiologic Procedure	Rating	Comments	<a href="#">RRL*</a>
MRI spine without contrast	9		O
MRI spine without and with contrast	9	See statement regarding contrast in text under “Anticipated Exceptions.”	O
Myelography and postmyelography CT spine	6		☢ ☢ ☢ ☢
CT spine without contrast	5		☢ ☢ ☢
X-ray myelography	4		☢ ☢ ☢
Arteriography spine	4		Varies
CT spine with contrast	4		☢ ☢ ☢
MRA spine without and with contrast	4	See statement regarding contrast in text under “Anticipated Exceptions.”	O
MRA spine without contrast	4		O
CTA spine with contrast	4		☢ ☢ ☢
X-ray spine	3	May be useful for surgical planning and evaluating stability.	☢ ☢ ☢
Tc-99m bone scan with SPECT spine	2		☢ ☢ ☢
In-111 WBC scan spine	2		☢ ☢ ☢ ☢
MRI spine flow without contrast	2		O
CT spine without and with contrast	2		☢ ☢ ☢ ☢
US spine	1		O
Epidural venography	1		Varies
X-ray discography	1		☢ ☢ ☢
<b><u>Rating Scale:</u></b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Clinical Condition:**      Myelopathy

**Variant 6:**                Infectious disease patient.

Radiologic Procedure	Rating	Comments	<a href="#">RRL*</a>
MRI spine without and with contrast	9	See statement regarding contrast in text under “Anticipated Exceptions.”	O
MRI spine without contrast	8		O
CT spine without contrast	6	If MRI is unavailable or contraindicated.	☢ ☢ ☢
X-ray myelography	5	If MRI is not feasible. Usually performed in conjunction with CT.	☢ ☢ ☢
CT spine with contrast	5		☢ ☢ ☢
Myelography and postmyelography CT spine	5	For problem solving or if MRI is unavailable or contraindicated.	☢ ☢ ☢ ☢
In-111 WBC scan spine	4	May be combined with bone scan to diagnose osteomyelitis.	☢ ☢ ☢ ☢
X-ray spine	3	To assess stability.	☢ ☢ ☢
MRA spine without contrast	2	Use of contrast may vary depending on technique used.	O
Arteriography spine	2		Varies
CTA spine with contrast	2		☢ ☢ ☢
MRI spine flow without contrast	2		O
CT spine without and with contrast	2		☢ ☢ ☢ ☢
MRA spine without and with contrast	2	Use of contrast may vary depending on technique used.	O
X-ray discography	1		☢ ☢ ☢
Epidural venography	1		Varies
US spine	1		O
Tc-99m bone scan with SPECT spine	1	Indicated if multifocal disease is suspected.	☢ ☢ ☢
<b><u>Rating Scale:</u></b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			<b>*Relative Radiation Level</b>

**Clinical Condition:**      Myelopathy

**Variant 7:**              Oncology patient.

Radiologic Procedure	Rating	Comments	<a href="#">RRL*</a>
MRI spine without contrast	9		O
MRI spine without and with contrast	8	See statement regarding contrast in text under “Anticipated Exceptions.”	O
CT spine without contrast	6	For problem solving or if MRI is unavailable or contraindicated.	☢ ☢ ☢
Tc-99m bone scan with SPECT spine	6	Search for extraspinal disease.	☢ ☢ ☢
Myelography and postmyelography CT spine	5	If MRI is not feasible.	☢ ☢ ☢ ☢
X-ray myelography	5	If MRI is not feasible. Usually performed in conjunction with CT.	☢ ☢ ☢
CT spine with contrast	4		☢ ☢ ☢
X-ray spine	3	To assess stability or for treatment planning.	☢ ☢ ☢
CT spine without and with contrast	2		☢ ☢ ☢ ☢
Arteriography spine	2		Varies
MRA spine without and with contrast	2	Use of contrast may vary depending on technique used.	O
MRA spine without contrast	2	Use of contrast may vary depending on technique used.	O
In-111 WBC scan spine	2		☢ ☢ ☢ ☢
CTA spine with contrast	2	For treatment planning or problem solving.	☢ ☢ ☢
MRI spine flow without contrast	2		O
Epidural venography	1		Varies
US spine	1		O
X-ray discography	1		☢ ☢ ☢
<b><u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate</b>			<b>*Relative Radiation Level</b>

# MYELOPATHY

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## **Summary of Literature Review**

### **Introduction/Background**

The term myelopathy is used to describe any neurological deficit related to the spinal cord itself [1]. Most frequently, myelopathy is due to compression of the spinal cord by osteophyte or extruded disc material in the cervical spine. Osteophytic spurring and disc herniation may also produce myelopathy localized to the thoracic spine, though this is less common. The next most common causes of myelopathy are spinal cord compression due to extradural mass caused by carcinoma metastatic to bone, and blunt or penetrating trauma. Many primary neoplastic, infectious, inflammatory, neurodegenerative, vascular, nutritional, and idiopathic disorders may also result in myelopathy, though these are much less common than discogenic disease, metastases, and trauma. A variety of cysts and benign neoplasms may also compress the cord; they tend to arise intradurally. The most common of these are meningiomas, nerve sheath tumors, epidermoid cysts, and arachnoid cysts [2-5].

In general, disorders of the spinal cord itself are uncommon and difficult to treat effectively. Therefore, most attention in the radiological evaluation of myelopathy is focused on extrinsic compression of the spinal cord. Classically, radiological evaluation of myelopathic patients consisted of positive contrast myelography. Later, this evaluation was supplemented by computed tomography (CT) and CT myelography, and then magnetic resonance imaging (MRI) became the mainstay in the evaluation of myelopathy [2]. More recently, imaging of the spinal cord has improved to the point that reliable diagnosis of nonexpansile spinal cord lesions is routinely obtained.

Despite the wide variety of causes of myelopathy, diagnosis and treatment rest on demonstration of mechanical stability of the spine, particularly in the cervical region and when tumor or trauma history is present. Depiction of direct neural involvement by a pathologic process is then required for more refined diagnosis and specific treatment decisions. Anatomical diagnosis of myelopathy rests principally on the distinction between extradural, intradural, and intramedullary lesions.

Clinically, the diagnosis of myelopathy depends on the neurological localization of the finding to the spinal cord, rather than the brain or peripheral nervous system and then to a particular segment of the spinal cord. The antecedent clinical syndrome and other details of the patient's course help to refine diagnosis, but imaging plays a crucial role. In general, myelopathy is clinically divided into categories based on the presence or absence of significant trauma, the presence or absence of pain, and the mode of onset (slowly progressive or insidious onset vs a stepwise progression vs a sudden onset). Patients with known tumor history and those in whom infectious disease is likely may also be considered separately [1].

### **Traumatic Myelopathy**

In the patient with traumatic myelopathy, the first priority for the spine is assessing its mechanical stability. Radiographs are useful for this purpose, but CT may be more useful when a high probability of bony injury or ligamentous injury is present. At some centers, routine multidetector CT with sagittal and coronal reconstructions is supplanting the role of radiographs, especially in the setting of multiple trauma.

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MRI is widely considered the study of choice when paralysis is incomplete or under other circumstances where direct visualization of neural or ligamentous structures is clinically necessary. If surgery for herniated disc, hematoma, or other cause of incomplete paralysis is planned, MRI best depicts the relation of pathology to the cord, and it can help predict which patients may benefit from surgery [6-14]. Some less commonly applied techniques may have some value in selected circumstances [15-18]. Positron emission tomography (PET) with quantitative determination of standardized uptake value (SUV) may play a correlate role with prognosis in patients with cervical spondylosis independent of MRI findings in some cases. Functional MRI techniques, diffusion-weighted imaging (DWI) and diffusion-tensor imaging (DTI) can help distinguish epidermoid from arachnoid cysts, and in some cases the DTI may be abnormal in demyelination when the conventional MRI studies are normal [19-25].

### **Painful Myelopathy**

When local or radicular pain accompanies myelopathy, the most likely diagnoses are spondylosis, disk extrusion, tumor, or infection. Radiographs may depict osteophytic narrowing of the spinal canal or bone destruction. CT improves the depiction of both bony encroachment on the spinal canal and compression of neural structures by herniated disc material that is occult to plain radiographic evaluation. Bone destruction and soft-tissue masses are also better seen. MRI has largely replaced CT scanning in the noninvasive evaluation of patients with painful myelopathy because of its superior soft-tissue resolution and multiplanar capability. Invasive evaluation by means of myelography almost always accompanied by CT myelography may be supplemental when visualization of neural structures is required for surgical planning or other specific problem solving, though this is less frequent [2,26-40].

In some circumstances involving myelopathy in young children and infants, ultrasound examination of the spine may be useful. Intraoperative ultrasound may also play a role in optimizing surgical technique [41,42].

Although painful myelopathy is most commonly due to spondylosis and disc herniation, a significant proportion is caused by tumor or infection. Demyelinating disease may present with pain symptoms as well. Occasionally, syringomyelia may present with the anesthetica dolorosa syndrome. The ability of MRI to depict the spinal cord directly, and to assess its contour and internal signal characteristics reliably and noninvasively, has resulted in general acceptance of MRI as the study of choice in evaluating cervical myelopathy when spondylosis or disc herniation is the most likely cause. When MRI is contraindicated or is not available, or to answer specific questions before surgical intervention, myelography and CT myelography may be useful [43-49]. In cases in which infectious spondylitis is considered likely and the etiology of a destructive or compressive mass is in doubt, indium-111 white blood cell (WBC) scan may be useful in carefully selected patients.

### **Slowly Progressive Myelopathy**

In slowly progressive myelopathy, the ability of MRI to depict the spinal cord noninvasively is most valuable. Some specifically treatable disorders may be localized and depicted quite well by means of myelography followed by CT myelography. However, the occasional complications of myelography in cases of spinal block — difficulty in visualizing the upper extent of lesions, and relative blind spots at the cervical thoracic and craniocervical junctions — limit its utility. CT myelographic techniques may help avoid these pitfalls and may be useful to answer specific preoperative questions about bony anatomy [50].

Enlargement of the spinal cord by intramedullary mass is well depicted by myelography only when large masses are present. CT myelography can be extremely useful in supplementing the radiographic examination. These techniques, however, are less useful than MRI because the distinction between solid and cystic masses is usually not possible, even when delayed examination is performed. The distinction of syrinx from tumor, location of tumor nodule, extent of cyst, and distinction of nodule and cyst from edema are crucial in treatment planning for intramedullary disease and virtually necessitate MRI [51-53]. In some cases vascular imaging by means of MR angiography (MRA) or CT angiography (CTA) may be indicated if spinal arteriovenous malformations, especially dural, are considered to be likely causes.

### **Stepwise or Sudden-Onset Myelopathy**

When myelopathy progresses stepwise or is of sudden onset, vascular processes become significant diagnostic possibilities. Vascular malformations, spinal cord infarct, and epidural hematoma account for most of the vascular lesions of the cord. In practice, they are difficult to distinguish clinically from other nontraumatic causes of myelopathy because the classic history is frequently absent or difficult to elicit from a seriously ill patient [54].

If arteriovenous malformation (AVM) is considered clinically likely, gadolinium-enhanced MRI, MRA, and myelography to demonstrate abnormal vasculature may be useful to guide spinal arteriography and intervention

and potentially limit the number of direct vascular injections. More recently, progress in CTA has led to its use in preangiographic evaluation of patients with suspected spinal vascular abnormalities [55]. In particular, search for dural arteriovenous malformations of the spine can be rewarding, as successful treatment may be achieved using endovascular techniques.

### **Painless Myelopathy**

If myelopathy is painless and slowly progressive, the differential diagnosis is quite broad. Neoplastic disease of the spinal cord and extrinsic compression by epidural or intradural tumor may present in this manner. Demyelinating disease, degenerative diseases, and metabolic or deficiency diseases may also present this way. Spondylosis may present painlessly as well, particularly in the elderly. In these cases, visualization of the spine as well as the spinal cord is useful, and this is best accomplished noninvasively by MRI [56-59].

### **Myelopathy in Oncology and Infectious Disease Patients**

In oncology and infectious disease patients, multiple sites of involvement are possible. In these patients it is often necessary to study the entire spine or even the entire skeleton despite a specifically localized myelopathic level. MRI is considered more sensitive at an individual site, but the convenience of radionuclide bone scanning makes it useful in this setting as well. AIDS patients may present with myelopathy due to primary cord disease caused by HIV infection [60-68]. No high-quality evidence supports the use of discography, thermography, epidural venography, ultrasound, or cerebrospinal fluid (CSF) flow studies in the evaluation of myelopathy. Radionuclide bone scan may play an adjunctive role — for example, to locate a safer biopsy site in patients with suspected metastatic cord compression.

### **Clinical Correlation with Radiologic Findings**

An important limitation of MRI in the diagnosis of myelopathy is its high sensitivity. The ease with which the study depicts expansion and compression of the spinal cord in the myelopathic patient may lead to false positive examinations and inappropriately aggressive therapy if findings are interpreted incorrectly. For example, transverse myelitis due to demyelinating disease may demonstrate cord enlargement and be mistaken for tumor. Spondylosis, which occurs with normal aging, may be mistaken for clinically significant osteophytic compression of the spinal cord in a patient who is myelopathic for other reasons. These problems are minimized by experienced observers and meticulous clinical correlation with radiologic findings. Similar problems are present in the interpretation of any anatomical study of the spinal cord and are not unique to MRI. Careful patient selection and clinical correlation are essential in interpretation of imaging findings everywhere [2,69-75].

### **Summary**

- CT is usually the preferred first test in suspected spinal trauma.
- MRI is usually the preferred first test in nontraumatic myelopathy.
- Gadolinium contrast administration is preferred in oncology, infection, inflammation, and suspected vascular causes of myelopathy.
- Spinal angiography (invasive and/or CTA/MRA) is crucial in the evaluation of selected patients with suspected treatable causes of vascular myelopathy.

### **Anticipated Exceptions**

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie,  $<30$  mL/min/1.73m<sup>2</sup>), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates  $<30$  mL/min/1.73m<sup>2</sup>. For more information, please see the [ACR Manual on Contrast Media](#) [76].

### **Relative Radiation Level Information**

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at

inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☼	<0.1 mSv	<0.03 mSv
☼ ☼	0.1-1 mSv	0.03-0.3 mSv
☼ ☼ ☼	1-10 mSv	0.3-3 mSv
☼ ☼ ☼ ☼	10-30 mSv	3-10 mSv
☼ ☼ ☼ ☼ ☼	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies”.		

## Supporting Documents

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Information](#)
- [Evidence Table](#)

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.