



# DIAGNOSTIC IMAGING UPDATE

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## IMAGING OF SPINAL CORD INFARCTION

Spinal cord infarction (SCI) is a relatively rare diagnosis. Approximately 1.2% of all central nervous system infarctions are SCI's. Given this rarity, the diagnosis is often not an initial consideration in the setting of acute focal neurological deficits. The diagnosis can be difficult because 17-45% of clinical SCI's are not apparent on initial MRI. Newer imaging with spinal cord diffusion imaging (DWI) has made detection of SCI's more sensitive and specific.

### Incidence

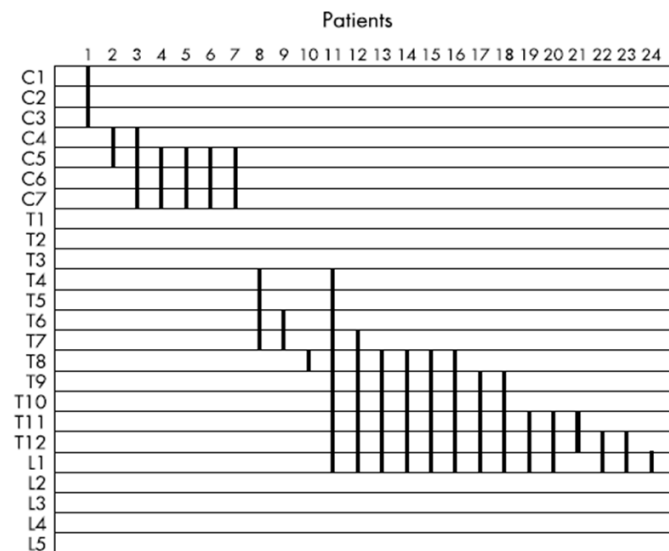
There are no large series of spinal cord infarctions and incidence is a rough estimate, likely between 2-12/100,000 each year. There is no significant difference in gender. The age range in cord infarction includes pediatric to elderly patients. The median age is the mid 50's.

### Clinical Presentation

A vital part of the clinical history for SCI is the speed of onset. Onset is usually rapid, with a progression to maximum deficit within hours. Less often, the onset is prolonged with symptoms increasing over 1-2 days.

Presenting symptoms depends on the involved vessel, size and length of cord involved, and cross sectional location in the cord. Paraparesis or paraplegia is the most common pattern of

weakness with tetraparesis or tetraplegia the next most common pattern. Most patients also have sensory symptoms. Spinothalamic tract symptoms are more common than dorsal column symptoms. This pattern occurs because the spinothalamic tract involves the anterior spinal artery distribution, which is a more common pattern of infarction. The frequency of dorsal column symptoms is more than expected for the frequency of posterior spinal artery infarctions, likely secondary to a mixed blood supply. Bladder and bowel dysfunction is also a common finding, involving 75% of involved patients. Spine pain has been reported as both a common and uncommon finding in separate studies. Both acute and persistent spinal pain is more common with spinothalamic tract involvement.



**Figure 1** Location and extent of the infarcts, related to vertebral bodies, evaluated in 24 patients whose MRI showed the infarct. Black areas represent the spinal areas involved in the infarct in each patient on T2 weighted MR images.

*Masson C, Pruvo J, Meder J, et al. Spinal cord infarction: clinical and magnetic resonance imaging findings and short term outcome. J Neurol Neurosurg Psychiatry, 2004;75:1451-55.*

# Imaging of Spinal Cord Infarction

## Risk Factors/Etiology

Analysis of risk factors is limited. Proposed risk factors in decreasing order include: Hypertension, atherosclerotic disease (previous MI, peripheral vascular disease), hyperlipidemia, diabetes, cigarette smoking, and atrial fibrillation.

## Etiology

Common sited etiologies for SCI include: aortic aneurysm, vertebral artery dissection, thromboembolic disease, vascular surgery, spinal surgery, hypotension, cocaine abuse, spinal vascular malformations, trauma, and vasculitis.

## Diagnosis

The history of present illness and physical evaluation are vital to guide the diagnosis and work-up. Lab work from both blood and CSF are used to evaluate for signs of infection. Work up for inflammatory diseases such as any cause of vasculitis, or AIDP (Guillain-Barre syndrome) are necessary. CSF analysis is usually nonspecific for SCI, but is necessary to exclude other entities. Imaging is vital for the diagnosis. Other entities besides infarction can lead to rapid onset symptoms such as: cord hematoma, epidural hematoma/abscess, intradural extramedullary metastatic disease, or other rapidly growing spinal mass.

## Imaging Technique

A standard MRI with sagittal T1, T2, and STIR and axial T1 and T2 should be performed. If there is abnormal cord signal or concern for meningitis/abscess, post-gadolinium images are indicated. If clinically concerned for SCI, diffusion sequences should be added. Both sagittal and axial images are preferred. Axial diffusion images are more sensitive than sagittal images, but involve longer acquisition times. Because diffusion images are more sensitive to artifact, spinal diffusion is more difficult than standard brain diffusion images, and artifact is often present. Repeat imaging is often necessary to obtain adequate diffusion images.

Repeat MRI should be utilized if necessary. Because 17-45% of clinical SCI cases are negative on initial imaging, repeat short-term MRI is beneficial. Diffusion imaging may detect early infarction that was not present on T2 images, decreasing initial false positive results.

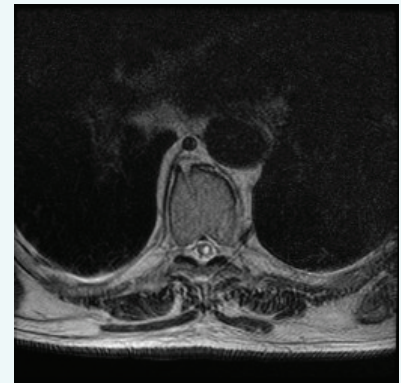
## Imaging Findings of SCI

The most common areas of involvement are the cervical and thoracolumbar cord. Figure 1 shows the length and location of involvement of 24 patients in a study by Masson et al. SCI's are hyperintense on T2 and STIR, usually involving 2-7 vertebral body segments in length. Infarcts are hypointense or isointense on T1 (figures 2-3). Post-gadolinium imaging is negative in

*Figure 2 - Sagittal T2 weighted image shows a spinal cord infarction involving 3 vertebral body segments with mild cord edema.*



*Figure 3 - Axial T2 weighted image. This is a pattern of central cord involvement. The involved area is eccentric to the left.*



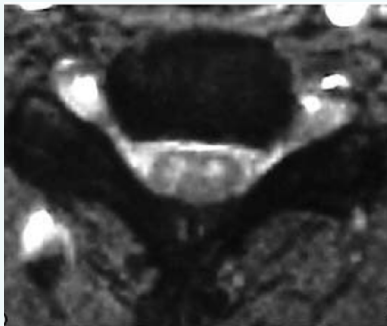
the acute setting. Enhancement is variable in the subacute setting. Even though post-gadolinium imaging is negative in acute SCI, it is necessary to differentiate a spinal cord infarction from a spinal cord tumor or transverse myelitis, both which usually enhance. Spinal cord edema with mild to moderate cord enlargement is common of acute and subacute infarcts. However, as in cerebral infarction, early imaging of acute infarctions may not demonstrate cord enlargement. As the SCI's become chronic, there is progression to volume loss.

There are multiple cross sectional patterns of involvement. The anterior spinal artery is most commonly involved (67-94%). Patterns of involvement of the anterior spinal artery include the 'owl's eye' pattern, gray matter involvement, and central cord involvement. The 'owl's eye' pattern involves the anterior horns of the gray matter (figure 4). The gray matter pattern involves the central gray matter, sparing the white matter. The gray matter is more sensitive to hypoxia, and may be damaged by an insult that does not damage the white matter. The central pattern involves the gray matter and the adjacent white matter. The peripheral white

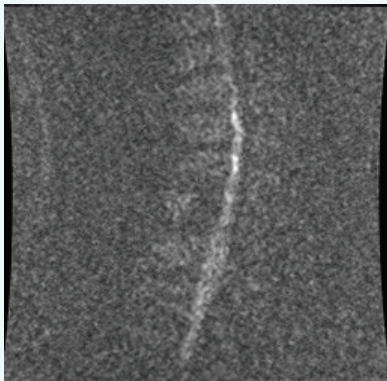
## Imaging of Spinal Cord Infarction

matter is spared. A possible theory behind this pattern is that the peripheral white matter is spared because of pial perforators. Unilateral infarcts are between 12-40% of all infarcts. Posterior spinal artery involvement is seen both in unilateral and bilateral patterns.

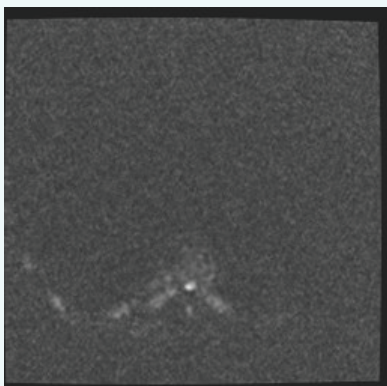
Similar to cerebral infarctions, diffusion signal may be increased prior to T2/STIR images (figures 5-6). All studies of diffusion imaging show positive diffusion signal in the acute setting. The contrast resolution between the infarction and normal cord is more distinct on DWI imaging when compared to T2 images in early infarctions. In the spinal cord, the diffusion signal may not persist as long as in a cerebral infarction. In the study by Kuker et al, diffusion signal in SCI had resolved by 7 days, in contrast to cerebral infarctions where the diffusion signal can persist for 2 months. Imaging with T2 in the subacute phase is more sensitive than diffusion to delineate the final involved area. Although



*Figure 4 - Axial T2 weighted image shows hyperintense T2 signal in the anterior horns of the spinal gray matter known as the 'owl's eyes' pattern. This pattern is a type of anterior spinal artery involvement. (Masson C, Pruvo J, Meder J, et al. Spinal cord infarction: clinical and magnetic resonance imaging findings and short term outcome. J Neurol Neurosurg Psychiatry, 2004;75:1451-55.)*



*Figure 5 - Sagittal diffusion image shows a diffusion hyperintensity along the involved segment of thoracic cord. Correlative ADC signal was hypointense.*



*Figure 6 - Axial diffusion image demonstrates hyperintense diffusion signal in the anterior cord eccentric to the left. Correlative ADC signal was hypointense.*

additional research is needed to evaluate diffusion signal in additional lesions, the ability to exclude or include infarction in a differential is of great value in evaluating spinal lesions.

### Imaging Differential Diagnosis

- Spinal cord tumor – Spinal cord tumors usually demonstrate enhancement. Mass effect for a tumor is greater than a SCI. Spinal cord tumors do not typically restrict on DWI.
- Transverse myelitis – Transverse myelitis may be indistinguishable from infarct. Although transverse myelitis may enhance, a lesser but significant portion do not enhance. Cord enlargement is present, similar to SCI. Cross sectional involvement usually includes the majority of cord. The most common area of involvement is the conus. Transverse myelitis may diffusion restrict similar to SCI.
- Multiple sclerosis – Involvement is usually multifocal with smaller lesions less than 2 spinal segments in length. These lesions will enhance in the acute phase. Involvement is usually peripheral in the white matter and involves less than half of the cord. Spinal cord findings are almost always associated with brain findings.
- Neuromyelitis optica (Devic disease) - Cord involvement is multifocal and irregular with relatively rapid progression.
- Syringohydromyelia – Syringohydromyelia is typically a discreet elongated collection of CSF intensity in the central cord without enhancement.
- ADEM - ADEM usually demonstrates multifocal cord involvement. Usually there is absent or mild cord edema. Enhancement is variable. Spinal cord findings are almost always with associated brain findings. The age range is predominately in children or young adults.

### Conclusion

Spinal cord infarcts usually present with an acute onset and progress to a maximum deficit within hours. Infarctions usually involve 2-7 segments, show cord edema, and more commonly involve the anterior spinal artery distribution. Cross sectional patterns include an 'owl's eye' pattern, a gray matter only pattern, or a central pattern with gray matter and central white matter involved. Diffusion weighted imaging of the spinal cord can increase both sensitivity and specificity for spinal cord infarction. Diffusion imaging should be added to routine imaging when spinal cord infarct is suspected.

# Meet Our Radiologists

## References

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**Roy C. Hammond, M.D.** Dr. Roy Hammond first made the personal goal of joining Utah Valley Radiology Associates while in college at Brigham Young University. He was excited to accomplish that goal in 2001 after graduating with Honors from medical school at the University of California, San Francisco and completing a Diagnostic Radiology residency and fellowship at the University of Utah.

Dr. Hammond's fellowship was in Body Imaging with an emphasis in Body and Musculoskeletal MRI. He is board-certified in Diagnostic Radiology.

Dr. Hammond's current areas of special interest include MRI, coronary artery CT angiography and digital mammography. He has been working with several of the cardiologists and radiologists on implementing the coronary artery CT angiography program at UVRMC.

Dr. Hammond maintains professional membership in the American College of Radiology, Radiological Society of North America (RSNA), American Roentgen Ray Society, American Medical Association, Utah Medical Association and Huntsman-Intermountain Cancer Care Program.



**Kurtis R. Kendell, M.D.** Dr. Kurtis R. Kendell is fellowship trained and board certified in diagnostic radiology. He specializes in musculoskeletal radiology and MRI. He co-chairs sports medicine and musculoskeletal conferences at the Utah Valley Regional Medical Center.

Dr. Kendell graduated from the John Hopkins School of Medicine in Baltimore, Maryland. He attended the Mayo Clinic in Rochester, Minnesota, where he completed an internship in orthopedic surgery, a post-graduate MRI research fellowship, a diagnostic radiology residency, and a musculoskeletal radiology fellowship.

He has been honored with several awards including the C. Allen Good Award from the Mayo Clinic, American Roentgen Ray and Radiological Society of North America Introduction to Research Award, The Mack Thomas Rozelle Chemistry Award from the University of Utah, and the National Collegiate Student Government Award.

