Imaging of Spine Neoplasm

John T. Wald, MD

KEYWORDS

• Spine • Neoplasm • Tumor • Pain • Intramedullary • Intradural • Innervation • MRI • CT

KEY POINTS

- The typical clinical history of spinal tumors can help direct advanced imaging in the evaluation of spinal pain syndromes.
- Innervation of the spine includes the ventral ramus, dorsal ramus, recurrent meningeal nerve, and the sensory fibers that course with the sympathetic nerves.
- Seventy-five percent of vertebral body lesions are malignant, whereas benign lesions predominate in the posterior elements (70%).
- Two-thirds of all spinal column lesions in children (<18) are benign, but this figure is reversed in adults.
- A multimodality approach (computed tomography, magnetic resonance imaging, positron emission tomography) is often necessary to define the characteristics and extent of extradural spine neoplasm.

The back and pain—these words have been linked since man began to walk upright. Although most often back pain is of benign origin, it can occasionally be a harbinger of a more serious spinal condition, including spine neoplasm. Knowledge of the typical clinical history of spinal tumors and an understanding of the innervation of the spine and surrounding supporting structures may allow us to better understand when to pursue advanced imaging in the evaluation of spinal pain syndromes.

Many radiologists have divided the differential diagnosis of neoplasms of the spine into compartments. These compartments include the extradural compartment, intradural/extramedullary compartment, and the intramedullary compartment. This division not only allows the clinician to evaluate neoplasms in a logical, concise manner but it also allows one to better understand the origin of pain associated with neoplasm based on the innervation of the spine and surrounding structures.

THE ORIGIN OF SPINE PAIN

There are 4 main sources of neural innervation to spinal structures: anterior primary division/ventral ramus, posterior primary division/dorsal ramus, recurrent meningeal nerve, and sensory fibers that course with the sympathetic nerves (**Fig. 1**).[1] The ventral ramus transmits afferent input from pain generators originating in the psoas muscles, intertransversarii muscles, quadratus lumborum muscle, and pain referred from the lumbar plexus.[1] Retroperitoneal tumors and tumors originating in the paraspinal soft tissues, including Ewing sarcoma, are possible pain generators in this region.

The dorsal ramus provides innervation to the deep muscles of the back, zygapophysial joints, interspinous ligaments, ligamentum flavum, and periosteum of the posterior vertebral arch. The recurrent meningeal (sinuvertebral nerve) nerve supplies the periosteum of the posterior vertebral body, epidural veins and basivertebral plexus, anterior epidural space, anterior spinal dura matter, and posterior longitudinal ligament.[1,2] There is sensory input from adjacent spinal levels, which can result in pain referred to adjacent spinal segments. The sympathetic trunk and the gray rami communicans innervate the periosteum of the anterior and lateral vertebral body, the intervertebral disks, and the anterior longitudinal ligament.[1]

Department of Radiology, Division of Neuroradiology, Mayo Clinic, 200 First Street Southwest, Rochester, MN 55901, USA
E-mail address: wald.john2@mayo.edu

Radiol Clin N Am 50 (2012) 749–776
doi:10.1016/j.rcl.2012.04.002
0033-8389/12/$ – see front matter

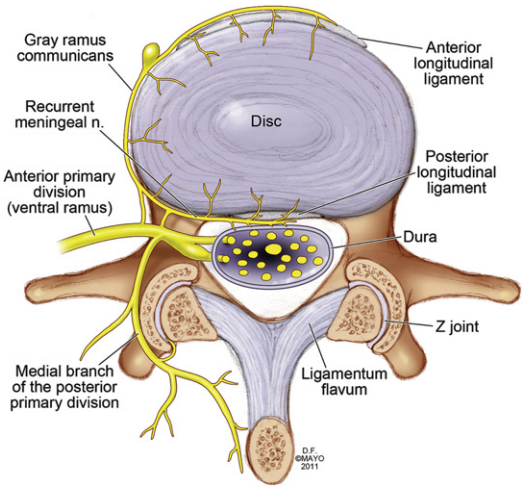

Fig. 1. Primary innervation of the spine and paraspinal soft tissues. Z, zygapophysial joint; n, nerve. (*Courtesy of* Mayo Clinic, Rochester, Minnesota; with permission.)

The interwoven relationship between the sympathetic trunk and the innervation of the anterior spinal structures can lead to pain syndromes characterized by the stimulation of the sympathetic system.[3]

Most neoplasms originating in the vertebral body and anterior paraspinal soft tissues will register pain through the ventral ramus, including branches of the sinuvertebral nerve and the gray rami communicates. Lesions in the vertebral body do not necessarily need to breech the periosteum to generate pain. Branches of the sinuvertebral nerve accompany basivertebral veins into the vertebral bodies and surround blood vessels in the spinal canal.[2] Thus, even small vertebral body lesions or spinal canal lesions can stimulate pain fibers.

Extradural Neoplasm

Axial pain is the most common presenting sign of extradural spinal tumors. Pain is more common (96%) and intense in malignant tumors compared with benign tumors (76%). Associated spinal cord compression is seen in 52% of malignant tumors, and greater than 90% of these patients will have pain.[4,5] Seventy-five percent of vertebral body lesions are malignant, whereas benign lesions predominate in the posterior elements (70%). Two-thirds of all spinal column lesions in children (<18 years of age) are benign, but this figure is reversed in adults.[5] Epidural tumors produce pain and dysfunction by compression, demyelination, ischemia, and tissue edema. The release of excitatory amino acids by injured neurons may promote further ischemia and pain.[6]

Metastatic Spine Disease

Autopsy studies have demonstrated an incidence of 30% to 90% of spinal metastasis in patients with a history of primary malignancy.[4] Metastasis to the spine most often involves the thoracic spine, followed by the lumbar and cervical spine.[7] Metastatic lesions to the spine are 3 to 4 times more common than primary spine neoplasms.[6] Virtually all patients with malignant epidural spinal cord compression present with pain. Fifty percent of patients presenting with epidural spinal cord compression do not carry a diagnosis of cancer at the time of presentation.[6]

Metastatic Spine Disease: Imaging

Magnetic resonance imaging (MRI) imaging is the preferred imaging modality in the evaluation of patients with suspected spinal metastasis. Metastatic disease is primarily a process of trabecular bone; radiography is a cortical bone imaging modality. There must be 50% to 75% bone destruction for plain radiographs to identify tumors.[4] Computed tomography (CT) scanning can demonstrate both lytic and blastic metastasis but lacks the sensitivity to identify marrow lesions, epidural tumor extension, and paraspinal or nerve root involvement (**Fig. 2**). Technetium (99mTc) bone scanning offers a high sensitivity for larger lesions, which typically involve bony cortex,[8] but it also lacks the specificity to define the extent of spinal bone involvement and the soft tissue extension of tumors. Single-photon emission CT (SPECT)/CT imaging improves specificity[9] but does not offer the lesion definition seen in MR imaging.

MR imaging with and without contrast allows imaging of the spine in one setting with greater sensitivity than bone scan for marrow-based lesions.[8] It can also delineate the soft tissue extension of neoplasm into the paraspinal and epidural soft tissues. The bilobed appearance or drawn-curtain sign of abnormal tissue within the ventral epidural space can be helpful in discriminating neoplasm from other pathological conditions in this location (**Fig. 3**).[10] Typical MR imaging multiplanar sequences include T1-weighted images with and without contrast and fast spin echo (FSE) T2 images, including fat saturation or short tau inversion recovery (STIR) techniques.[11] Inherent image contrast between low T1 signal tumor infiltration and high T1 marrow signal easily defines even subtle bone lesions without the use of intravenous contrast. Fat saturation and inversion recovery sequences are more helpful in defining tumors than simple FSE T2 sequences because the typical prolonged T2 signal of tumor infiltration blends into the prolonged T2 signal of marrow fat. By decreasing