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# Presentation of spinal cord and column tumors

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**Abstract**

Metastatic spine disease occurs in more than 10% of all cancer patients. Advances in systemic treatment for cancer has led to improved overall survival for many types of cancer, which has increased the overall incidence of spinal metastases. The most common presenting complaint of patients with spinal metastases is pain. Pain originating from spinal metastases can be oncological, mechanical, and/or neurological in nature. Early recognition of these symptoms is helpful to guide treatment and accurately gauge patient prognosis. Unfortunately, the prevalence of degenerative back pain in the general population can complicate early clinical recognition of patients with metastatic spine disease. Therefore, back pain in any patient with a history of malignancy should prompt clinicians to perform an expedited workup for metastatic disease of the spine. Diagnostic imaging and laboratory studies are part of the initial work up. Obtaining pathology via biopsy to establish tumor histology is essential to determine the appropriate treatment.

**Keywords**

cancer | epidural cord compression | NOMS | spine metastases | spine tumor

Tumors originating from the spinal column can be either primary or metastatic. Whereas primary spinal tumors are rare, metastatic spine disease is quite common.[1,2] The skeletal system follows the lung and liver as the third most affected by metastatic disease, and within the skeletal system the spine is the most frequently involved bone structure.[3–5] The estimated incidence of symptomatic spinal metastases in all cancer patients is greater than 10%.[6] Vertebral metastases are a significant cause of pain and suffering in cancer patients, and can affect neurological function, mobility, and quality of life.[7] The continued improvement of systemic treatments and overall survival for cancer patients has led to an increased overall incidence of spinal metastases.[8]

## Clinical Presentation

The most common presenting complaint for patients with metastatic lesions in the spine is pain. The pain can be either isolated back pain or radicular pain, depending on lesion extent and location in the spine. Back pain can be divided into local (or regional) pain and mechanical pain. Local pain is primarily oncologic in nature and results from periosteal stretching by intraosseous tumor and neoplastic inflammatory mediators. This pain is often nocturnal, has a deep aching quality, and is often responsive to anti-inflammatory medications and palliative radiation. On the other hand, patients suffering from mechanical pain experience pain worsening with standing, weight bearing, and/or ambulation. Mechanical pain typically improves in the recumbent position. Mechanical pain results from loss of integrity of the spinal column, with resultant inability of the spine to provide structural stability. This type of spinal pain rarely responds to analgesics or palliative radiation. Patients frequently require external spine orthotics or instrumented spinal stabilization to achieve adequate pain relief. Radicular pain is described as a sharp or burning pain that radiates into the extremities, or in a band-like distribution across the chest and abdomen. The location of the pain usually follows a dermatomal distribution. Radicular pain occurs when metastatic tumors extends into the neural foramina, causing

direct nerve root compression, or when the neural foramina are indirectly narrowed because of vertebral body collapse secondary to pathological fracture. It is not uncommon for patients with metastatic lesions to experience all of these pain types as the disease progresses.

Neurological dysfunction is the second most common presenting symptom of spinal metastatic disease. Neurological symptoms often result from significant extension of vertebral body tumors into the spinal canal or neural foramen, which can result in nerve root or spinal cord compression. Pathological fractures can also cause bony retropulsion into the spinal canal, leading to compression of neural elements. Depending on the degree of tumor invasion and the levels involved, neurologic deficits can range from radiculopathy to myelopathy. Radiculopathy results as weakness or sensory loss that corresponds with the associated nerve root myotome and dermatome. Myelopathy is due to spinal cord compression in the cervical, thoracic, or upper lumbar spine and usually presents with a specific sensory level of impairment as well as bilateral extremity weakness. In the early stages of myelopathy, weakness can manifest as difficulty with climbing stairs or standing. This often progresses to further difficulty with ambulation, urinary and/or bowel dysfunction, saddle anesthesia, and sexual dysfunction. Neurologic examination will often reveal depression of reflexes earlier in disease, which eventually progresses to hyperreflexia.

Early recognition of these symptoms is essential to maximize treatment options and accurately gauge patient prognosis. It should be emphasized that early in the course of disease, back pain is the most common presenting symptoms. The prevalence of degenerative back pain in the general population can complicate clinician recognition of possible metastatic disease and make it difficult to determine which patients should undergo more thorough diagnostic workups. As such, new-onset back pain in any patient with a history of malignancy, even if relatively remote, should prompt clinicians to perform an expedited workup for possible metastatic disease of the spine. Other "red-flag" symptoms include rapidly progressive weakness, sensory loss, or bowel/bladder dysfunction. Associated constitutional findings such as fever, weight loss, night sweats, and lymphadenopathy should also raise suspicion for neoplastic disease. Studies suggest that early recognition and treatment lead to improved clinical outcomes and possible avoidance of surgical intervention for metastatic spinal cord compression.[9–11] Up to 90% of patients who present with neurological deficit and spinal cord compression had preceding back pain for an average period of 3 months prior, suggesting that a valuable diagnostic window often exists prior to progression of spinal metastatic disease to significant nerve root or spinal cord compression.[12] Even in cases of mild sensory symptoms, patients had a 2-month delay from time to reporting to their general practitioner to treatment of spinal metastasis.[12] It is therefore important for general practitioners to counsel patients with a history of cancer on the importance of seeking prompt evaluation should such early symptoms develop. National Institute for Health and Care Excellence guidelines also suggest further workup is indicated in patients with known malignancy who present with neck or thoracic pain, or with persistent worsening lumbar pain.[13] Once spinal metastases are suspected, activation and consultation with a multidisciplinary treatment team can lead to early diagnosis and improved outcomes.[14]

## Diagnostic Workup

Performing a detailed history and physical exam is perhaps the most vital step in ultimately diagnosing a neoplastic spinal process. In patients with known cancer history and new back pain, a diagnostic workup should be initiated even in the absence of neurological dysfunction. The workup typically consists of laboratory tests and imaging.

### Laboratory Tests

Laboratory serum studies, such as a complete blood cell count, can reveal abnormalities that raise suspicion for malignancy. Anemia, thrombocytopenia, and neutropenia/leukocytosis can all be associated with malignancy. More specific serum studies, such as prostate-specific antigen, may point to specific pathology. If multiple myeloma is suspected, a serum protein electrophoresis and urine protein electrophoresis can be useful. A bone marrow biopsy is used to confirm suspicion of a hematologic malignancy such as multiple myeloma. Specific laboratory tests should be tailored to the specific neoplastic history of each individual patient.

### Imaging

#### *Plain radiographs*

Plain-film radiographs often serve as the initial imaging modality in the evaluation of patients with back pain because of their low cost and widespread availability. Despite their many limitations, plain films can help identify abnormalities, such as compression fractures with significant loss of height, or scoliosis and other spinal deformity caused by large lytic lesions. In the event of mechanical neck or back pain, flexion-extension plain films can be helpful in determining whether there is associated dynamic radiographic instability. However, plain films are a poor screening tool for visualizing metastatic lesions of the spine and are unable to reliably detect subtler findings that are of clinical significance. For this reason, in patients with known malignancy or high suspicion of metastatic lesions, x-ray is usually skipped, and more advanced volumetric imaging studies such as CT and MRI are typically performed.

#### *CT*

CT obtains high-resolution images of the spine and surrounding structures with excellent bony detail. Osteolytic and osteoblastic metastases both can be visualized on CT (Figure 1). Malignancies typically producing osteolytic lesions include lung, gastrointestinal, renal cell, melanoma, and multiple myeloma metastases. Osteoblastic lesions

include osteosarcomas, prostate, and medullary thyroid carcinoma metastases, and appear as sclerotic and hyperdense on CT.

Although CT is cheaper and often more accessible than MRI, it has far less soft-tissue resolution and therefore cannot assess spinal cord or nerve root compression as accurately as MRI in cases where involvement of neural elements is suspected. CT myelography may be useful in determining the presence of epidural tumor compression in patients unable to undergo MRI.

### *MRI*

MRI is the gold-standard imaging modality for evaluating all spinal tumors because of its superior ability to visualize tumor and paraspinal soft tissue, as well as to assess involvement of neural elements.[15] Metastatic vertebral lesions are identified on MRI by comparing bone marrow density to normal parameters based on the patient's age. Metastatic lesions to the bone are hypointense on T1-weighted sequences because of the replacement of bone marrow with tumor. Intravenous gadolinium administration significantly improves the detection of extravertebral tumor, including both epidural and paraspinal extension (Figure 2).[16]

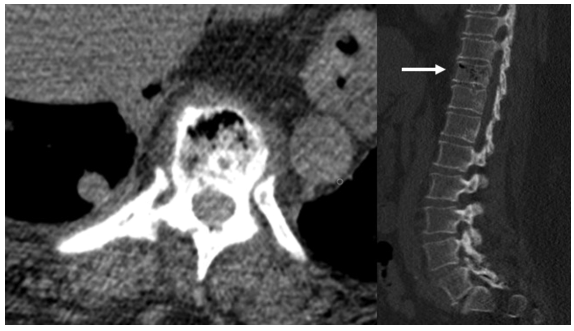

**Fig. 1** CT Demonstrating Metastatic Infiltration of the T10 Vertebral Body, Including Signs of Early Endplate Collapse in A, Axial, and B, Sagittal Views

### *PET*

PET imaging detects increased metabolic activity by identifying the uptake of fluorine-18 deoxyglucose ($^{18}$FDG) in metabolically active tissues. $^{18}$FDG-PET/CT is frequently used in clinical staging for metastatic disease. The National Comprehensive Cancer Network recommends PET for evaluation of patients with newly diagnosed lung, anaplastic thyroid, and some head and neck cancers.

### *Technetium 99 bone scan*

A nuclear bone scan can detect osseous metastatic lesions by identifying areas of increased osteoblastic activity in the skeleton. 99m Tc-methylene diphosphonate tracer ($^{99}$Tc) accumulates in areas of increased bone turnover ("hot spots") and can detect lesions as small as 2 cm.[17] A $^{99}$Tc study can be an excellent screening modality for diffuse bony involvement as well as individual lesions, since the entire skeletal system can be evaluated at once for the presence of osseous metastatic disease. Limitations of this modality include its inability to identify lesions with little or no osteoblastic activity, such as multiple myeloma.[18,19] Furthermore, bone scans cannot differentiate between

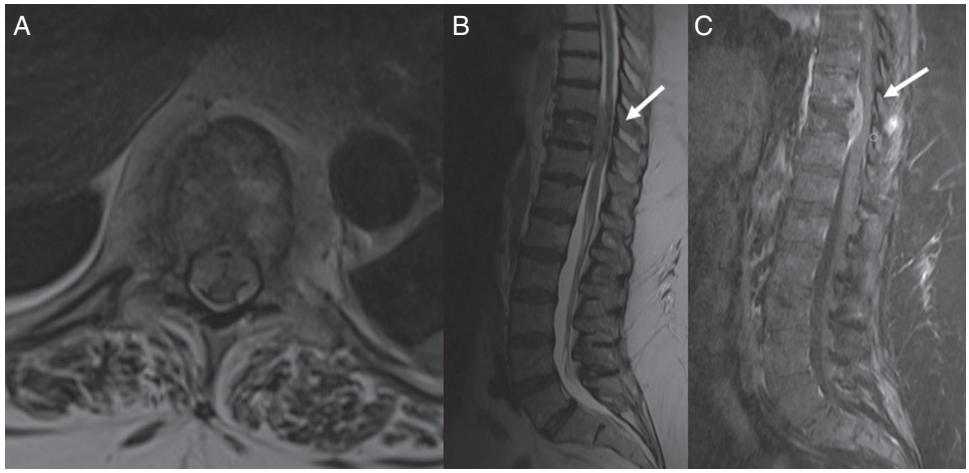


**Fig. 2** MRI From a 73-Year-Old Female Patient With Lung Metastases to the Thoracic Spine Who Underwent Posterior Corpectomy and Fusion at T9 to T11 for High-Grade Epidural Spinal Cord Compression A, T2-weighted axial image at T10 showing near-circumferential epidural metastatic disease compressing the spinal cord. B, T2-weighted midsagittal image showing epidural disease extending from the middle of T9 through the superior endplate of T11. C, T1-weighted postcontrast midsagittal image demonstrating enhancing epidural metastatic disease centered at the T10 vertebral body.

benign and malignant lesions; lesions positive on a bone scan can reflect a neoplastic process, but the differential also includes infection, inflammation, or trauma.

### *Biopsy*

Biopsy is an essential part of the diagnosis and staging of spinal tumors. In patients with no known primary tumor who are found to have likely metastatic spinal disease, this will allow the treatment team to establish a diagnosis and plan further treatment approaches. Biopsy can be performed on the spinal lesion itself, but if another more accessible lesion is found on workup, biopsy of the least risky site should be undertaken. For biopsy of spinal metastatic lesions, CT guidance is often used.

## Treatment Decision Making

The treatment goal for metastatic tumors of the spine is typically palliative in nature, specifically including relief of pain, improvement or preservation of neurological functioning, and maintenance of mechanical stability of the spine. Developed at Memorial Sloan Kettering Cancer Center, one of the most-used decision paradigms for selecting appropriate management options for spinal metastatic disease based on patient presenting characteristics is referred to as the NOMS framework. This system takes into account neurologic, oncologic, mechanical and systemic considerations to aid in determining optimal multidisciplinary therapy for patients suffering from metastatic spinal disease (Figure 3).[20] The NOMS paradigm aims to integrate radiation oncology, medical oncology, surgical approaches, and interventional radiology to lead clinicians to the most suitable treatment for patients based on their specific tumor histology and stage of disease. The framework will be discussed briefly as follows. The details of the NOMS framework will be discussed further in the subsequent parts of this multipart series.

### Neurologic Assessment

The neurologic assessment portion of the decision framework takes into consideration the degree of epidural spinal cord compression and myelopathy/radiculopathy through clinical and radiological evaluation. For the radiographic assessment, the Spine Oncology Study Group designed and validated a 6-point grading scale for the degree of epidural spinal cord compression. Axial T2 images at the site of the most severe compression are used to assign a grade of 0, 1a, 1b, 2, or 3. Grade 0 denotes metastatic lesions confined to bone, grade 1 indicates tumor extension into the epidural space without compression of the spinal cord, grade 2 refers to cases with spinal cord compression where cerebrospinal fluid is still visible, and grade 3 is reserved for those cases with complete cerebrospinal fluid obstruction due to the degree of tumor compression.[20]

### Oncologic Assessment

The oncologic assessment portion of the NOMS framework examines the responsiveness of tumors, depending on histology, to currently available treatment options. Specifically, this section considers tumor response to radiation therapy, currently the least invasive and most effective approach to local tumor control. Tumors are categorized as radiosensitive or radioresistant based on their degree of response to conventional external beam radiation therapy.

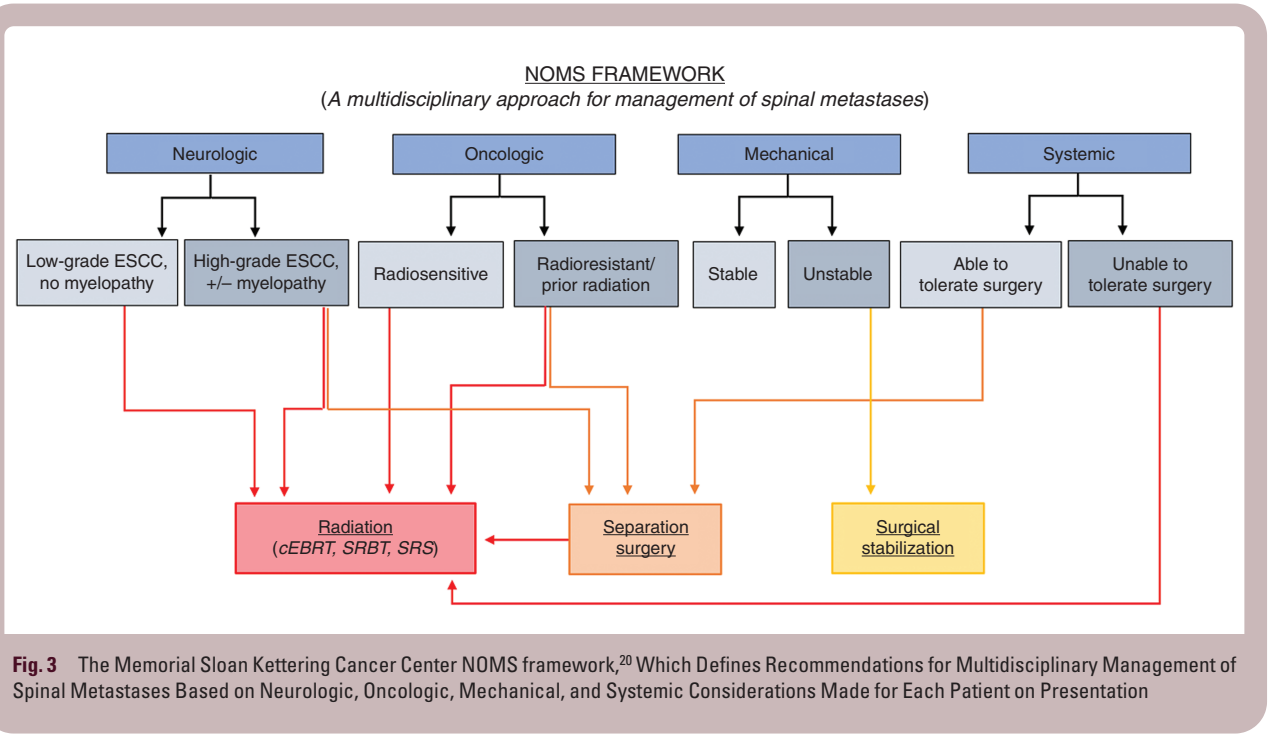


**Fig. 3** The Memorial Sloan Kettering Cancer Center NOMS framework,[20] Which Defines Recommendations for Multidisciplinary Management of Spinal Metastases Based on Neurologic, Oncologic, Mechanical, and Systemic Considerations Made for Each Patient on Presentation

### Mechanical Assessment

The mechanical assessment portion of the NOMS framework takes spinal stability into consideration. Spinal instability due to a neoplastic process is defined by the Spine Oncology Study Group as loss of the spine's ability to maintain its role as a support structure for the spinal cord and nerve roots under physiological stress without resulting in movement-related pain, progressive deformity, or neurological deficits. The Spinal Instability Neoplastic Score (SINS) is an 18-point system that grades degree of mechanical instability based on both clinical and radiological criteria, specifically tumor location (junctional, mobile, semirigid, or rigid segments of the spine), presence of mechanical pain, spinal alignment, degree of vertebral body collapse, osteolysis, and posterior element involvement (Table 1).[21]

### Systemic Assessment

Last, the systemic assessment portion of the NOMS framework determines the ability of individual patients to tolerate different treatment modalities based on extent of metastatic disease, systemic illnesses/comorbidities, and tumor histology. There have been multiple scoring systems devised to help clinicians predict survival in patients with metastatic spinal disease.[22–26] The most well known is the Tokuhashi score, which has been validated as strongly predictive of patient prognosis across multiple cohorts.[27–32] This scoring system provides clinicians with an estimated survival time for patients based on 6 categories: KPS, number of extraspinal bone metastases, number of vertebral levels involved, presence of metastases to major organ systems, type of primary tumor, and neurological status based on Frankel grading system (Table 2).[23,24]

**Table 1.** Spinal Instability Neoplastic Score Criteria for Determining Stability Associated With Spinal Metastases to Aid in Determining the Need for Operative Fixation

| | Score |
|---|---|
| Location | |
| Junctional (occiput-C2, C7-T2, L11-L1, L5-S1) | 3 |
| Mobile (C3-C6, L2-L4) | 2 |
| Semirigid | 1 |
| Rigid | 0 |
| Pain | |
| Yes—mechanical | 3 |
| Yes/Occasional—not mechanical | 1 |
| No | 0 |
| Type of bony lesion | |
| Lytic | 2 |
| Mixed | 1 |
| Blastic | 0 |
| Spinal alignment on imaging | |
| Subluxation/Translation | 4 |
| De novo kyphosis/scoliosis | 2 |
| Normal alignment | 0 |
| Presence of compression of affected VB | |
| > 50% collapse | 3 |
| < 50% collapse | 2 |
| No collapse; > 50 VB involvement | 1 |
| None | 0 |
| Posterior element involvement | |
| Bilateral | 3 |
| Unilateral | 1 |
| None | 0 |
| Total score | |
| Stable | 0-6 |
| Indeterminate | 7-12 |
| Unstable | 13-18 |

**Abbreviation:** VB, vertebral body.

## Intradural Metastases

Spinal metastases rarely manifest as intradural disease, with estimated rates of intradural involvement ranging from 0.5% to 6% (at the lower end when not including metastases of primary CNS tumors such as ependymomas).[33,34] Lung and breast cancer are the 2 most common primary tumor causes of intradural metastatic disease.[34] Intradural disease may be intramedullary or extramedullary, with the former slightly less common than the latter.[35]

Presentation is similar to that seen with extradural metastatic disease, though follows a much more rapid onset when compared to primary intramedullary lesions.[35] Pain manifestation differentiates epidural and bony metastases from intradural disease. While intradural metastases do not generate spinal column instability, they instead generate neurological pain via compression of neural elements. Clinically, patients may also have concomitant extradural disease, making the clinical picture difficult to delineate.

Given the overall rarity of these lesions, there are limited data on optimal management strategies. Older and more recent studies both suggest a role for surgical resection in appropriate patients with reasonable expected survival.[36,37] Most patients in surgical series had stable or improved exams at follow up and operative mortality was low.

## Conclusion

The continued improvement of systemic treatments and overall survival for cancer patients has led to an increased overall incidence of spinal metastases, highlighting the importance of standardized, evidence-based multidisciplinary management and guidelines. The most common presenting complaint for patients with metastatic lesions in the spine is pain, which can be oncological, mechanical, neurological, or a combination of the three. Early recognition of these symptoms is paramount for prompt diagnosis, treatment

**Table 2.** Tokuhashi Revised Evaluation System for Prognosis of Metastatic Spine Tumors

| Characteristic | Score |
|---|---|
| General condition/KPS | |
| Poor (10%-40%) | 0 |
| Moderate (50%-70%) | 1 |
| Good (80%-100%) | 2 |
| No. of extraspinal bone metastases | |
| ≥ 3 | 0 |
| 1-2 | 1 |
| 1 | 2 |
| No. of vertebral body metastases | |
| ≥ 3 | 0 |
| 1-2 | 1 |
| 1 | 2 |
| Metastases to major internal organs | |
| Nonremovable | 0 |
| Removable | 1 |
| None | 2 |
| Cancer primary site | |
| Lung, osteosarcoma, stomach, bladder, esophagus, pancreas | 0 |
| Liver, gallbladder, unknown | 1 |
| Others | 2 |
| Kidney, uterus | 3 |
| Rectum | 4 |
| Thyroid, breast, prostate, carcinoid tumor | 5 |
| Palsy | |
| Complete (Frankel A, B) | 0 |
| Incomplete (Frankel C, D) | 1 |
| None | 2 |
| Prognosis based on total score | |
| ≤ 6 mo | 0-8 |
| ≥ 6 mo | 9-11 |
| ≥ 1 y | 12-15 |

guidance, and accurate prognostication. Unfortunately, the prevalence of degenerative back pain in the general population can confound suspicion of spinal metastatic disease for general practitioners, and sometimes hinder prompt, targeted workups early in disease progression. New-onset back pain in any patient with a history of malignancy should prompt clinicians to perform an expedited workup for metastatic disease of the spine.

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