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# Metastatic spine disease: epidemiology, pathophysiology, and evaluation of patients

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Spinal metastasis represents an ominous extension of neoplastic disease. Early detection and accurate diagnosis provide the best chance to ameliorate consequences and to optimize the quality of an afflicted patient's remaining life [1].

## Epidemiology

### *Incidence*

Most patients with systemic cancer develop skeletal secondaries, and the spine is most commonly involved [2–6]. Careful postmortem examination has demonstrated spinal metastasis in more than 70% of terminal cancer patients [5]. Some 10% of cancer patients develop symptomatic spinal secondaries [7–10]. Spinal metastases comprise the most frequently encountered spinal tumors and occur 20 times more often than primary neoplasms of the spine. It is estimated that approximately 18,000 new cases with spinal secondaries are diagnosed each year in North America [3–11].

Spinal metastasis develops in all age groups; the highest incidence occurs during midlife (40–65 years of age), corresponding to the period of increased cancer risk. A somewhat higher incidence of spinal metastasis in men compared with women parallels the incidence of prostatic versus breast carcinoma [12,13].

Cancers of the breast, prostate, and lung constitute the most common culpable primaries, reflecting the prevalence and tendency for these tumors to metastasize to bone [1,12,14–20].

### *Classification*

Spinal tumors are conveniently classified according to anatomic location (Table 1) [6,21–24]. Most symptomatic spinal metastases occur extradurally. Intradural extramedullary metastases (which usually represent tertiary spread from a cerebral secondary site) occur most frequently in the thoracolumbar region, where they are found entangled among the cauda equina nerve roots (Fig. 1) [24,25]. Intramedullary metastases are rare and occur most often in the cervical spinal cord [26,27].

## Pathophysiology

Secondary spinal tumors can arise in several ways:

1. The arterial system may deliver metastases to the vertebral bodies, where the tumor cells find an hospitable environment in the bone marrow; bony destruction and expansion of the tumor then cause compression of the dural sac, root sleeves, and their contents [4,28].
2. Batson's plexus may transmit metastasis through the valveless venous channels for deposition in the epidural space and where metastatic growth can compress and strangulate the dural sac and its contents [29,30].
3. Cerebrospinal fluid (CSF) can convey tumor cells (desquamated from cerebral secondaries), which then pass along the CSF pathway to become entangled among the roots of the cauda equina ("drop metastasis") [24,25].

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Table 1
Spinal metastases by anatomic location

| | ED | ID/EM | IM | Total cases |
|---|---|---|---|---|
| Rogers and Heard (1958) [25] | 94% | 6% | | 17 |
| Barron et al (1959) [7] | 98% | | 1.6% | 125 |
| Edelson et al (1972) [22] | 97% | | 3.4% | 175 |
| Perrin et al (1982) [24] | 94% | 5% | 0.5% | 200 |

*Abbreviations:* ED, extra dural; ID, intra dural; EM, extra medullary; IM, intra medullary.

4. Direct extension of paraspinal tumor may occur via venous channels to the epidural space and through the intervertebral foramina; this mechanism is typical for lymphoma and spinal metastasis in children [31–33].

Spinal metastases occur along the spinal column in approximate proportion to the bulk of the marrow-containing vertebral bodies [4,7]. Autopsy studies have demonstrated the lumbar spine to be most commonly involved, followed by the thoracic and cervical segments. Clinically, symptomatic spinal metastases are most often localized to the thoracic spine (with special predilection for the segments about T4 and T11), followed by the lumbar and cervical segments [34].

## Evaluation of patients

History, physical examination, and special tests are undertaken to establish a diagnosis and to provide the basis for assessing management options and formulating treatment strategies.


Fig. 1. Intradural extramedullary "drop metastases" in a patient with malignant melanoma metastatic to the brain.

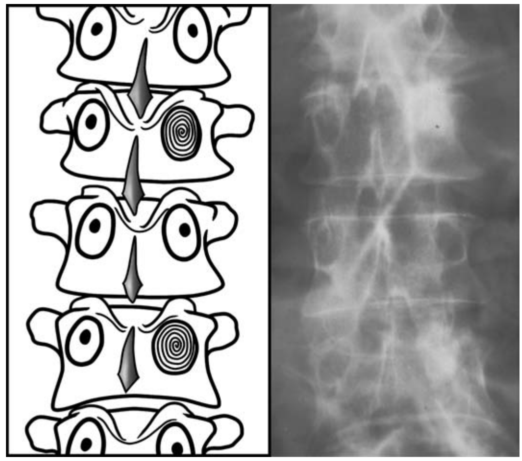

Fig. 2. Osteosclerotic metastases secondary to prostatic cancer.

Metastatic spinal tumor may be the initial manifestation of neoplastic disease in 10% or more of patients [34]. Once spinal secondaries become symptomatic, only 2% of patients have no known primary [18].

### History and physical examination

Symptomatic spinal metastases cause a well-recognized clinical syndrome beginning with local back or neck pain, followed by weakness, sensory loss, and sphincters dysfunction [14,16,21,23,24, 34,35]. Local back or neck pain is the earliest and most compelling manifestation in 90% of patients. Palpation or percussion over the posterior spinous process at an afflicted level often causes local tenderness. Radicular spread of pain indicates associated nerve root compromise. When the focal pain is aggravated by movement about the involved segment and is alleviated by immobility, spinal instability should be suspected. Pain that is burning, dysesthetic, intense and severe raises the probability that the patient harbors intradural extramedullary spinal metastasis [24]. The dura-

Table 2
Frequency of plain films findings[a]

| | Total cases |
|---|---|
| Winking owl | 77 |
| Paraspinal shadow | 19 |
| Compression | 32 |
| Pathologic dislocation | 13 |

[a] In 101 consecutive patients with symptomatic spinal metastases [38].

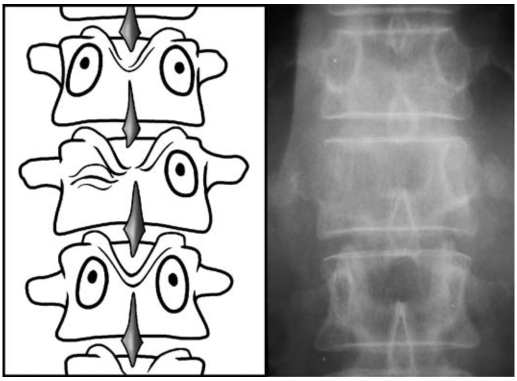

Fig. 3. Pedicle erosion "winking owl" sign, the most common plain film finding in patients with symptomatic spinal metastasis.

tion of pain is variable; pain may be present for weeks or months and is often initially attributed to "muscle spasm," back or neck "strain," or a "slipped disk"; definitive diagnosis is often delayed until more blatant manifestations of spinal cord and nerve root compromise are apparent [36]. It is axiomatic that *a cancer patient with new-onset back or neck pain harbors spinal metastasis until proven otherwise*.

Local back or neck pain is followed by weakness, numbness, and sphincter dysfunction. A Brown-Séquard syndrome is often found in patients with intramedullary spinal metastasis (one third of cases) and, less commonly, in patients with intradural extramedullary spinal secondaries [26,27,34,35].

The rate at which symptoms evolve is variable. The clinical course, however, is one of inevitable and relentless progression to complete and irreversible paralysis unless timely treatment is undertaken [14].

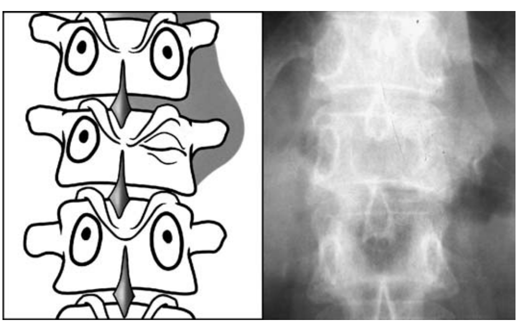

Fig. 4. Paraspinal soft tissue shadow adjacent to a "winking owl" sign.

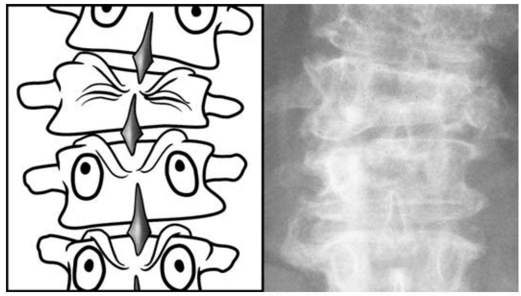

Fig. 5. Vertebral collapse.

*Special tests*

Radiologic investigations constitute the principal special tests that help to delineate the location, distribution, and extent of spinal metastases.

*Plain films*

Plain radiographs provide a useful screening test for spinal secondaries. The anteroposterior radiograph of the spine can be likened to a "totem of owls." Plain film abnormalities produce variations on this theme. Osteoblastic or osteosclerotic bony alteration may result from carcinoma of the breast or prostate (Fig. 2) [15,37]. Most metastasis-induced bony alteration involves osteolytic vertebral destruction, however. Typical plain film findings are documented in Table 2 [34,35,38]. Pedicle erosion is the most common plain film finding and results in a "winking owl" sign (and a "blinking owl" sign when the pedicle erosion occurs bilaterally) (Fig. 3). A paraspinal soft tissue shadow is often seen adjacent an involved vertebral segment (Fig. 4). More extensive bony destruction may produce vertebral collapse (Fig. 5). Loss of vertebral destruction can cause frank pathologic fracture dislocation, particularly in the cervical segments, where the dependent position of the head, wide range of neck movements, and lack of

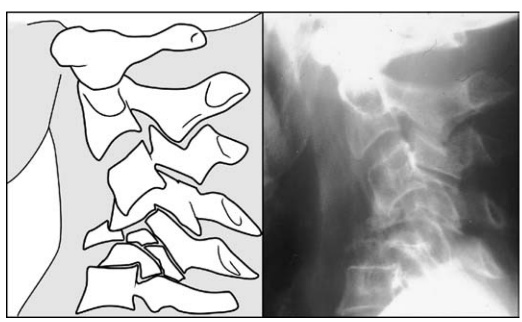

Fig. 6. Pathologic fracture dislocation.

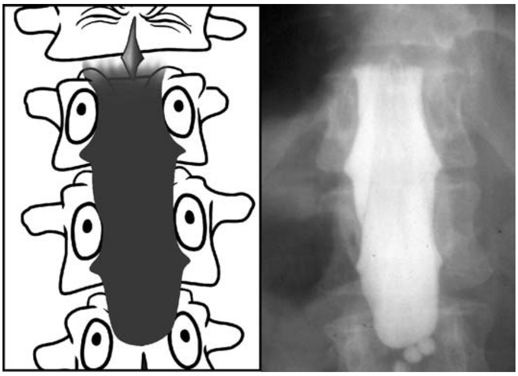

Fig. 7. Extradural metastasis causing complete "paint-brush" block to the flow of myelographic dye.

ribcage-supporting structures render the cervical spine more vulnerable to malaligning forces (Fig. 6).

*Bone scan*

Radiographic changes may not be discernable until 50% or more of the vertebral medullary space has been replaced [39]. Radioisotope bone scans may demonstrate evidence of spinal secondaries at an earlier stage than plain films [39–43]. Bone scans are, however, relatively nonspecific; positive uptake can result from spondylosis and infection as well as from spinal metastasis [39–44]. Nevertheless, a bone scan is useful to identify multiple sites of skeletal (including spinal) secondaries so as to assess the tumor burden.

*Myelography*

In the past, myelography has been the gold standard for localizing the level of spinal cord or nerve root compromise by demonstrating a block to the flow of contrast at an area of involvement [45]. Analysis of a myelographic block can de-

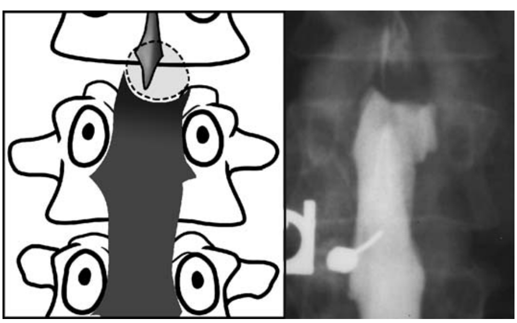

Fig. 8. Intradural extramedullary spinal metastasis producing a "meniscus" block.

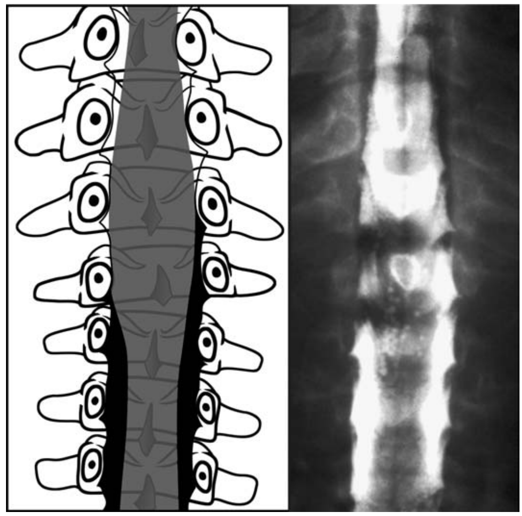

Fig. 9. Intramedullary spinal metastasis causing "fat cord" appearance.

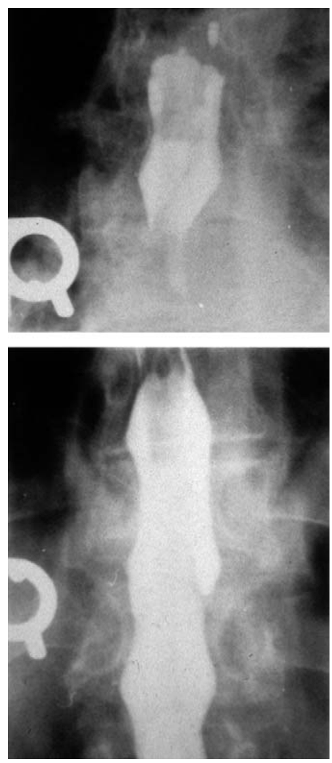

Fig. 10. Composite of lumbar and cisternal myelographic studies to delineate the extent of an extradural metastatic tumor.

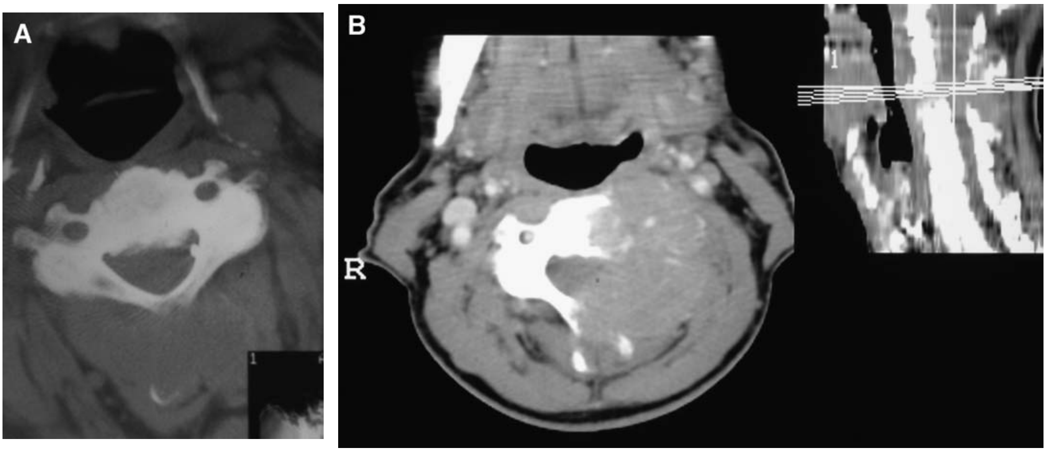


Fig. 11. (*A*) CT scan showing extradural tumor destroying posterior spinous process. (*B*) CT scan showing extradural metastasis destroying the lateral aspect of a cervical vertebra.

termine not only the level of involvement but the anatomic location of an offending lesion. An extradural lesion causing complete myelographic obstruction to myelographic dye produces a "paintbrush" block (Fig. 7), an intradural extramedullary lesion demonstrates a "meniscus" block (Fig. 8), and an intramedullary tumor is associated with a "fat cord" appearance (Fig. 9).

When a complete myelographic block is encountered cephalad to lumbar-administered contrast dye, a cisternal study may be necessary to accurately delineate the extent of the compressing lesion (Fig. 10) [46].

A myelographic study is optimized when it is followed by axial CT to demonstrate the area of interest in transverse sections.

Myelography remains a valuable imaging tool, particularly for patients who are unable (because of claustrophobia or lack of cooperation) or unfit (because of metal implants) to undergo MRI.

*Computerized tomography*

CT is helpful to delineate the degree and distribution of bony destruction caused by spinal metastases (Fig. 11) [47–49]. Plain CT lacks the sensitivity to distinguish soft tissue boundaries. The demonstration of dural sac and root sleeve displacements can be enhanced when CT is used in conjunction with myelography [48,49].

*MRI*

MRI has become the imaging modality of choice for spine pathologic changes, including metastatic tumors [50–54].

Some of the general MRI characteristics of spinal metastases include a convex posterior border of the vertebral body; abnormal signal intensity of the vertebral body, pedicle, or posterior elements; an epidural mass; a focal paraspinal mass; and other similar lesions at several levels along the spinal column [55]. Metastases appear as nonspecific foci of hypointense signal on T1-weighted images and are hyperintense, or bright, on T2-weighted images. Metastases enhance with gadolinium; however, normal bone marrow may also enhance, and metastases may merely appear


Fig. 12. MRI showing single isolated vertebral metastasis.

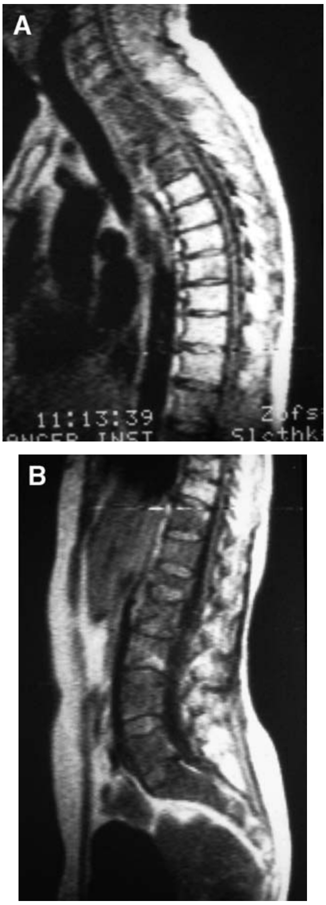


Fig. 13. MRI showing multiple adjacent levels of involvement: cervical (*A*) and lumbar (*B*).

isointense after contrast administration. Postcontrast fat-suppressed images help to differentiate metastases from bone marrow in this setting [55].

Epidural metastatic tumor masses sometimes display the "curtain sign," which helps to differentiate epidural tumor from epidural abscesses. The metastatic epidural tumor extends on either side of the median ligament of Trolard (joining the dura to the posterior longitudinal ligament) to form the appearance of curtains on postcontrast T1-weighted axial images. The inflammatory mediators and bacterial enzymes associated with epidural abscesses lyse this median ligament and thus eliminate the curtain sign [55].

Diffusion-weighted images can help to distinguish osteoporotic from metastatic vertebral fractures. Osteoporotic vertebral fractures are hypointense, whereas metastatic vertebral fractures are hyperintense [55,56].


Fig. 14. MRI showing multiple disparate levels of metastatic disease.

MRI allows imaging the length of the spine in sagittal sections to demonstrate single isolated (Fig. 12), multiple adjacent (Fig. 13), and multiple disparate (Fig. 14) levels of disease distribution [54]. MRI is particularly useful for displaying intradural extramedullary drop metastases. Transverse reconstructions provide details concerning the disposition and geometry of spinal secondaries, all of which is essential in deciding on management options (medical or surgical) and treatment strategies (anterior or posterior approach, with or without spinal reconstruction) [46,57–59].

*Angiography*

Spinal angiography should be part of the diagnostic evaluation in patients suspected of harboring metastases from thyroid or renal cell primaries [60–62]. Metastases from thyroid and renal cell cancers are notoriously vascular. Preoperative embolization may be a prudent part of the management strategy and, indeed, essential to avoid life-threatening blood loss if surgical intervention is contemplated (Fig. 15) [46,63].

*Percutaneous spine biopsy*

The acquisition of tissue to enable pathologic diagnosis is central to the investigation of any tumor. Percutaneous biopsy of the spine has evolved as a useful diagnostic technique since it was first introduced 70 years ago [64,65]. Improved imaging capabilities (CT fluoroscopy) and instrumentation (needle biopsy systems) provide the potential for percutaneous spine biopsy, with


Fig. 15. Spinal angiography before embolization (*A*) and after embolization (*B*).

an overall success rate of 80% to 95% (Fig. 16) [60–70]. This technique is indicated to establish a tissue diagnosis for a spinal lesion in a cancer patient, particularly when radiation therapy may be the initial treatment of choice, thereby obviating the necessity for surgical exploration. Percutaneous spine biopsy may help to distinguish between a metabolic and a neoplastic cause for pathologic fracture of the spine and to differentiate between an infective and a neoplastic process (also allowing aspiration of tissue sample for Gram stain and culture and sensitivity testing).

Percutaneous spine biopsy has become an important diagnostic tool and has been refined to the level of an outpatient procedure [71].

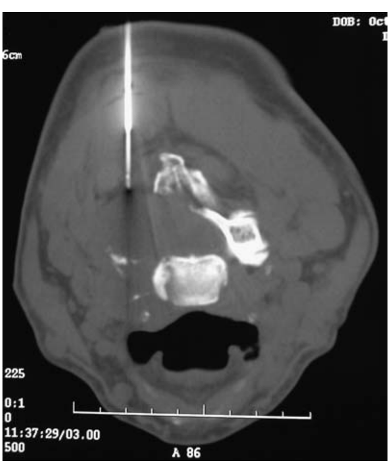


Fig. 16. Percutaneous image-guided spine biopsy.

## Summary

Spinal metastasis is the most commonly encountered tumor of the spine and represents an ominous extension of neoplastic disease. Symptomatic spinal metastases produce a characteristic clinical syndrome beginning with local back or neck pain. All too often, the significance of presenting pain is not appreciated and correct diagnosis is delayed until more blatant manifestations of spinal cord or nerve root dysfunction are manifest. Pain is followed by weakness, numbness, and sphincter dysfunction. The natural history is one of relentless progression to complete and irreversible paralysis unless timely treatment is undertaken.

Plain radiographs provide a simple and useful screening test. MRI is, however, the imaging method of choice, providing information concerning the level, location, and geometry of the spinal tumor as well as details concerning the bony integrity of the spine, particularly adjacent to a culpable tumor, all of which is essential to determine the management options and treatment strategies.

Percutaneous image-guided biopsy is a useful test to establish a tissue diagnosis.

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