Review Article

Metastatic Disease in the Thoracic and Lumbar Spine: Evaluation and Management

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Abstract

Spinal metastases are found in most patients who die of cancer. The number of patients with symptomatic spinal metastases likely will increase as therapy for the primary disease improves and as cardiovascular mortality decreases. Understanding the epidemiology of metastatic spine disease and its presentation is essential to developing a diagnostic strategy. Treatment may involve chemotherapy, corticosteroids, radiotherapy, surgery, and/or percutaneous procedures (eg, vertebroplasty, kyphoplasty). A rational treatment plan can help improve quality of life, preserve neurologic function, and prolong survival.

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Spinal metastases can present as a progression of known cancer or as a primary malignancy. They are a source of considerable morbidity in patients with disseminated malignancies. Early diagnosis is essential in reducing pain, improving or preserving neurologic function, and maximizing quality of life.[1] Spinal metastases are categorized as intradural or extradural. Extradural lesions account for 90% to 95% of spinal metastases.[2,3] Careful physical examination and imaging studies (eg, radiography, CT, MRI) aid in making the diagnosis. Treatment must be individualized to each patient and may include nonsurgical or palliative measures (eg, corticosteroids, radiotherapy) or interventional treatments (eg, surgery, vertebroplasty, kyphoplasty).

Epidemiology

Cancer is the second leading cause of death in the United States, with >550,000 cancer-related deaths each year.[4] Prolonged survival in patients with metastatic disease as the result of new treatment modalities will likely result in increased incidence of spinal metastases.

The skeletal system is the third most common organ affected by metastatic cancer, after the lungs and the liver. As many as 70% of patients who die of cancer have been shown on autopsy to have spinal metastases, and ≤14% exhibit clinically symptomatic disease before death. In the United States, >20,000 patients present with metastatic epidural spinal cord compression annually.[5,6]

Breast, prostate, lung, renal, and hematopoietic tumors are most likely to metastasize to the spine. The thoracic spine is most commonly involved in metastatic disease, possibly because it contains the greatest volume of bone marrow for receiving metastatic deposits.[7]

Presentation

Pain is the most common symptom in approximately 90% of patients

Table 1

Neurologic Impairment Scales[9,10]

Scale	Grade	Deficit Below the Level of the Lesion
ASIA	A	Complete: no motor or sensory function
	B	Incomplete: sensory function but no motor function
	C	Incomplete: some motor function; most muscle groups grade <3
	D	Incomplete: some motor function; most muscle groups grade ≥3
	E	Normal motor and sensory function
Frankel	A	Complete motor and sensory loss
	B	Complete motor loss; incomplete sensory loss
	C	Sensory function useless; some motor function; no functional strength
	D	Sensory function useful; weak but useful motor function
	E	Normal motor and sensory function

ASIA = American Spinal Injury Association

with metastatic spine disease.[8] Pain is often poorly characterized, and it may be difficult to distinguish from more typical causes of back pain. However, progressive and unrelenting pain that is nonmechanical in nature and is present at night is strongly indicative of malignant etiology.

Neurologic signs and symptoms are frequently present, but they rarely precede axial pain. Eccentrically located tumors may cause rapid onset of radiculopathy, and neural compression resulting from epidural extension or fracture can produce myelopathy or cauda equina syndrome. Few patients initially present with frank quadriplegia or paraplegia, but many demonstrate subtle objective neurologic deficit that can be measured with the American Spinal Injury Association (ASIA) impairment scale or the Frankel scale[9,10] (Table 1). The median Frankel score in patients with metastatic spine lesions is D (ie, decreased sensory function and decreased but useful motor function).[11] These early neurologic deficits are often mistakenly attributed to other causes (eg, medication side effects), which delays recognition and treatment.

Compression fractures are common in patients with metastatic disease of the spine, and patient history and/or imaging studies typically are indicative of the presence of a malignant lesion. For example, unrecognized cancer is rare in patients who undergo kyphoplasty with biopsy for presumed osteoporotic fracture. In our experience, metastatic disease involving the thoracic and lumbar spine rarely presents with frankly displaced fractures, whereas lesions in the cervical spine are more likely to present with such fracture.

Diagnostic Approach

Patients who present with spinal metastases have either known metastatic disease, history of malignancy without prior metastases, or no prior diagnosis of cancer. In patients with established metastatic disease who present with typical imaging findings, treatment generally proceeds without biopsy unless histologic evaluation is expected to affect treatment decisions.

The patient with a history of nonmetastatic cancer who presents with spinal metastases requires further evaluation prior to treatment. Repeat oncologic staging studies are needed, including CT scan of the chest, abdomen, and pelvis as well as a total body scan (eg, bone, positron emission tomography). Typically, biopsy is done to confirm the initial metastasis. Staging studies often reveal other lesions that are technically easier and safer to biopsy than vertebral lesions. For the patient with cancer, the initial diagnosis of metastatic disease carries significant treatment, prognostic, and emotional weight. Although restaging and biopsy may seem tedious to the patient, they are essential in determining a treatment plan.

Patients with no prior diagnosis of cancer may present with vertebral lesions. Spinal metastases are the initial manifestation of malignancy in approximately 20% of patients who present with vertebral metastases.[12] The most common histologies that present in this manner are carcinoma of unknown origin, carcinoma of the lung, multiple myeloma, and lymphoma. An established diagnostic strategy is required for these patients. In a prospective study, biopsy alone failed to identify the primary tumor in two thirds of patients with these histologies.[13] Using a protocol that included history and physical examination, routine laboratory studies, technetium Tc-99m phosphonate whole-body bone scintigraphy, and plain radiography as well as CT of the chest, abdomen, and pelvis, Rougraff et al[13] identified the primary site of disease in 85% of patients who presented with skeletal metastatic disease of unknown origin. The addition of biopsy identified the diagnosis in an additional 8% of patients. Many patients without a prior cancer diagnosis who present in this manner do not require biopsy. For those who do require biopsy, it

may be possible to obtain a specimen at a site that is safer for the patient than the spine. Proper evaluation is needed before performing biopsy of any lesion.

Image-guided biopsy has supplanted open surgical biopsy as the first-line invasive tool for the evaluation of patients with spinal lesions. Image-guided biopsy using a large-bore needle can be safely performed in an outpatient setting with sedation or light anesthesia in conjunction with sparing use of local anesthesia. Overall accuracy with CT-guided biopsy of spinal lesions has been reported to approach 89%, with better accuracy in lytic lesions than in sclerotic lesions (93% versus 76%, respectively).[14] Antibiotics should be withheld before biopsy, and a tissue sample should be tested for standard and atypical cultures because of the increased risk of osteomyelitis in cancer patients on immunosuppressive chemotherapy.

Physical Examination

A detailed examination of the spine and neurologic system is required, along with a global assessment of the patient's health status. A standardized evaluation of pain, neurologic impairment, and performance status is needed, as well. The surgeon should focus first on the presence of clinical deformity. Kyphosis is the most common. It is typically the result of mild compression fractures and decreased ambulation. Coronal plane deformities and fixed deformities are rare. The presence of deformity influences the assessment of spinal stability and the levels of instrumentation should surgical intervention be required.

A detailed neurologic examination and radiologic evaluation of the entire neural axis is required. Nearly 15% of patients have clinically significant noncontiguous metastases,[15] and an unknown number may have undiagnosed intracranial lesions. Careful assessment of motor strength, sensory levels, proprioception, and reflexes is critical in guiding initial management. These findings are used later in the evaluation of the level of response or deterioration during treatment. New or abnormal clinical findings (eg, weakness, sensory loss, hyperreflexia, pathologic reflexes) may reveal previously undiagnosed lesions at other levels.

Careful examination also yields valuable information regarding clinically significant instability. This is important because the patient with spinal instability may require surgical stabilization. In contrast to traumatic injuries, in which spinal instability generally can be assessed using radiographic studies alone, oncologic spinal instability is assessed based on clinical and radiographic findings.[7,16] The radiographic criteria for traumatic injury (eg, degree of focal kyphosis, fracture pattern, degree of subluxation) are not necessarily applicable to pathologic fracture; however, the extent and location of bony destruction demonstrated radiographically contribute to the assessment of spinal stability.

Taneichi et al[7] reported that patients with thoracic spinal lesions involving 50% to 60% of the vertebral body and patients with costovertebral joint destruction and involvement of 25% to 30% of the vertebral body were at risk for impending collapse. Patients with lumbar spinal lesions involving 35% to 40% of the vertebral body and those with posterior element and/or pedicle destruction as well as involvement of 20% to 25% of the vertebral body were also at risk of impending collapse. In addition to radiographic findings, pain—or, more importantly, neurologic signs and symptoms—that increases with axial or rotational loading is suggestive of mechanical insufficiency and local instability. Intractable mechanical pain is a strong indication for surgery in many patients with cancer.

Assessment of overall health status and burden of disease is important in selecting a treatment modality. A careful approach to treatment is required for persons with cachexia, decubitus ulcers or compromised skin resulting from radiation therapy, and impaired pulmonary status resulting from lung metastases, hepatomegaly, or malignant ascites.

The last step in the physical examination involves objective assessment of pain, neurologic status, and performance status. These assessment scores inform research, treatment decisions, and subsequent follow-up. A multidisciplinary approach is required in the assessment of performance status. Pain can be quickly assessed using the visual analog scale. Neurologic status is quantified with either the ASIA or the Frankel scale (Table 1). Performance status is a measure of disease burden on overall patient activities. This can be assessed with the Eastern Cooperative Oncology Group scale or the Karnofsky Performance Scale[17,18] (Table 2). Many palliative chemotherapy regimens require a minimum performance status. Aggressive treatment of spinal metastases often improves performance status scores to a level at which the patient qualifies for further adjuvant treatment.

Imaging

Standing and/or weight-bearing radiographs of the spine provide an accurate assessment of spinal alignment and stability as well as pathologic fracture and surgical

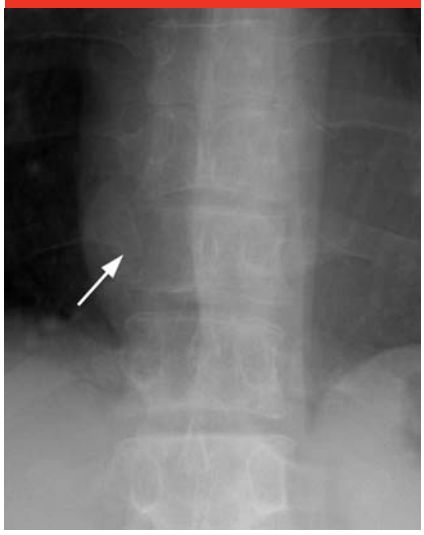
Table 2

Measurement of Performance Status

Scale	Grade	Description
ECOG	0	Fully active: able to carry on all predisease activities without restriction
	1	Restricted in strenuous activity; ambulatory; able to perform light work
	2	Ambulatory; able to perform self care; unable to work; bedridden ≤50% of the time
	3	Limited self care; bedridden ≥50% of the time
	4	Completely disabled; incapable of self care; bedridden
Karnofsky	100%	Normal, with no complaints or signs of disease
	90%	Capable of normal activity with few signs or symptoms of disease
	80%	Normal activity with some difficulty, some signs or symptoms of disease
	70%	Self care; incapable of normal activity and work
	60%	Requires some help but can fulfill most personal requirements
	50%	Requires frequent help and medical care
	40%	Disabled; specialized care needed
	30%	Severely disabled; hospital admission indicated; death is not imminent
	20%	Very ill; urgent hospital admission and treatment required
	10%	Moribund with rapidly progressive fatal disease processes

ECOG = Eastern Cooperative Oncology Group

Figure 1



AP radiograph demonstrating the so-called winking owl sign (arrow), which is indicative of pediculolysis resulting from metastatic carcinoma.

anatomy. Serial radiographs are used to assess disease progression (eg, changes in alignment, progression of osteolysis). Radiographs are not sufficiently sensitive to detect metastatic disease, however. Overlying visceral structures impair interpretation, and lesions cannot reliably be detected on lateral radiographs until ≥30% to 50% of trabecular bone has been destroyed.[19] Pediculolysis (ie, winking owl sign) is highly suggestive of tumor (Figure 1). However, most radiographic findings are nonspecific in determining malignancy.

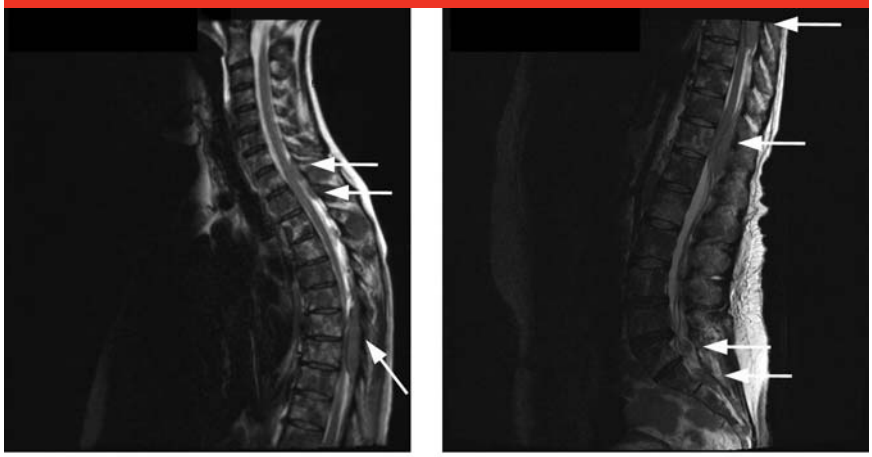
Although advances in CT technology have led to increased speed and greater detail, CT lacks the sensitivity required to detect metastatic lesions in the spine. A recent study showed sensitivity to be only 66% and diagnostic accuracy to be 89%.[20] CT provides the greatest bony anatomic detail. In conjunction with myelography, it allows visualization of neural compression. CT is a valuable adjunct study, particularly in patients unable to undergo MRI.

MRI provides the greatest sensitivity and specificity in the detection of spinal metastases (98.5% versus 98.9%, respectively), with an overall accuracy of 98.7%.[20] MRI provides excellent detail regarding extraosseous extent of disease, neural compression, leptomeningeal disease, and involvement of adjacent levels.

Tumors are most commonly located in the vertebral bodies. Seventy percent of tumors are located in the thoracic spine, a number that is roughly equal to the volume of the thoracic vertebrae as a percentage of the total spine.[7] Direct invasion from contiguous primary tumors is associated with some malignancies (eg, Pancoast, apical lung). The Batson vertebral venous plexus, a valveless network with contributions from the pelvic and intercostal veins, may permit the spread of cells from primary tumors and contribute to the propensity of metastases in the spine.

A magnetic resonance image of the entire spine should be obtained. Nearly 15% of patients have clinically significant lesions at noncontiguous sites[15] (Figure 2). Although focused radiographic studies offer cost and time savings, the risk of missed pathology is substantial. Sagittal and axial T1- and T2-weighted fat-saturated or short tau inversion recovery (STIR) sequences should be obtained. Tumors present as hypointense to normal marrow on T1-weighted images and hyperintense on T2-weighted images. Adjacent edema and cerebrospinal fluid can be seen on T2-weighted images. Tumor may not be adequately visualized on T2-weighted fast spin-echo MRI.

Figure 2



A B

Sagittal T2-weighted magnetic resonance image demonstrating metastatic epidural spinal cord compression in the thoracic (**A**) and lumbar (**B**) spine. The arrows indicate discontiguous sites of epidural compression.

Table 3

Mean Survival by Tumor Histology in Patients Treated for Metastatic Spine Disease[23]

Histology	Survival (mo)
Thyroid	26
Breast	19
Prostate	18
Rectal	18
Renal	10
Lung	6
Unidentified carcinoma	5

STIR sequences show enhanced contrast between hypointense lipid marrow and hyperintense tumor, which compensates for decreased tumor visualization on fast spin-echo MRI. Although STIR sequences are sensitive, they provide poor anatomic detail.[21] Gadolinium enhancement is not required to define intraosseous tumors, but it is helpful in the evaluation of soft tissue, epidural extension, and the spinal cord. Contrast should be given only after standard images have been obtained.

Prognosis

Traditional teaching has been that patients undergoing surgery for spine metastases should have an anticipated life expectancy of ≥3 months beyond surgery and those undergoing radiation treatment should have an anticipated survival of >1 month beyond radiotherapy.[22] Although more liberal criteria are often applied in clinical settings, these time frames are chosen because patient benefit from surgical procedures is not immediate.

Patient survival is influenced by many factors, including primary tumor histology, overall burden of disease, neurologic status, and performance status. Mean survival rates in patients who are treated for metastatic spine tumors that arise from common histologies are shown in Table 3.[23] Considerable variation exists between patients with the same histology. Clinician assessment alone is inadequate in predicting survival in patients with osseous metastases.[24] Several scoring systems have been developed to guide treatment of patients with spinal metastases.

In 1990, Tokuhashi et al[25] presented a scoring algorithm to guide surgical management of spinal metastases. Tomita et al[26] later proposed a similar scoring system as part of a new surgical management strategy. Tokuhashi et al[23] recently revised their scoring system to incorporate performance status, number of extraspinal bone metastases and vertebral metastases, presence of metastases in major organs, tumor histology, and neurologic deficit (Table 4, Figure 3, Table 5). This system was based on a retrospective review and has not been externally validated. However, we have found the revised system to be helpful in guiding treatment decisions, and we believe that it may be efficiently applied in the clinical setting. Other scoring systems have been developed. However, a recent analysis reported inaccuracies in all seven preoperative scoring systems studied.[27]

Management

Spinal metastases may be managed with medical therapy, radiation therapy, and/or surgical treatment. The approach must be individualized based on tumor histology, overall fitness or performance status, tumor burden, and neurologic status (Figure 4). Rapid progression is common in patients who present with neurologic deficits. Thirty percent of patients who present with weakness progress to paraplegia within 1 week.[28] The likelihood of regaining neurologic function is poor when paraplegia has been present for ≥24 hours, particularly in patients with rapid progression of symptoms.

Medical Therapy

Chemotherapy is the mainstay of treatment for persons with metastatic disease. However, because of its delayed efficacy, chemotherapy

Table 4

Scoring System for the Prognosis of Metastatic Spine Tumors

Characteristic	Score
General condition (performance status)	
Poor (PS 10%–40%)	0
Moderate (PS 50%–70%)	1
Good (PS 80%–100%)	2
No. of extraspinal bone metastases foci	
≥3	0
1–2	1
0	2
No. of metastases in the vertebral body	
≥3	0
2	1
1	2
Metastases to the major internal organs	
Unremovable	0
Removable	1
No metastases	2
Primary site of the cancer	
Lung, osteosarcoma, stomach, bladder, esophagus, pancreas	0
Liver, gallbladder, unidentified	1
Other	2
Kidney, uterus	3
Rectum	4
Thyroid, breast, prostate, carcinoid tumor	5
Palsy	
Complete (Frankel A, B)	0
Incomplete (Frankel C, D)	1
None (Frankel E)	2

Criteria of predicted prognosis: Total score (TS) 0–8 = <6 mo, TS 9–11 = 6 mo–1 yr, TS 12–15 = ≥1 yr
PS = Karnofsky Performance Status
Adapted with permission from Tokuhashi Y, Matsuzaki B, Oda H, Oshima M, Ryu J: A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. *Spine* 2005;30:2186-2191.

should be used as an adjuvant rather than a primary treatment in most persons with symptomatic vertebral metastases. Exceptions to this include highly chemosensitive tumors, such as lymphoma, neuroblastoma, and seminoma.

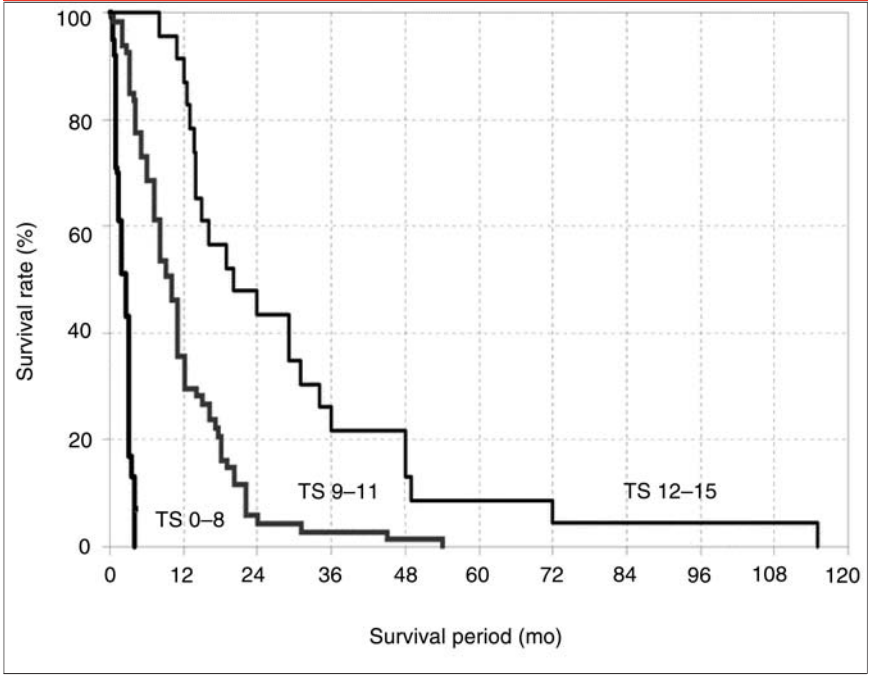
Corticosteroids are commonly used in the management of spinal metastases. Corticosteroid treatment is believed to reduce vasogenic edema, stabilize liposomal membranes, and decrease local inflammation, and it is known to have a direct tumorolytic effect in some histologies (eg, multiple myeloma, lymphoma). Published evidence on corticosteroid use is limited and suggests that only limited short-term improvement in ambulatory status is achieved.[29] Patients are often continued on steroids long-term for pain control; however, neurologic benefit is typically seen in the first 10 to 14 days of treatment. In the event of a new diagnosis of malignancy, steroid treatment should be withheld until a biopsy is obtained. The tumorolytic effect of steroids can produce a false-negative biopsy, particularly in the case of hematologic malignancies.

Radiotherapy

Although recent data have sparked renewed enthusiasm for aggressive surgical management of spinal metastases, radiation therapy is administered to all patients except for the few with exquisitely chemosensitive tumors and those who are undergoing en bloc excision.[16,30] The degree of radiosensitivity varies by tumor type. Lymphoma, myeloma, and seminoma are highly radiosensitive; breast and prostate tumors have intermediate sensitivity; and most other solid organ malignancies are relatively radioresistant. Spinal cord tolerance varies depending on the dosing regimen, for example, 45 to 50 Gy for 1.80-Gy fractions but only 30 to 33 Gy for 3.0-Gy fractions.

The efficacy of radiotherapy for the management of metastatic disease was established in a prospective trial in which 71% of patients experienced pain relief and 76% of patients preserved or regained ambulatory status.[15] However, these results were highly dependent on tumor histology. Patients with favorable histologies (eg, multiple myeloma, breast carcinoma, prostate carcinomas) had a durable clinical response (≤10 to 16 months), whereas those with unfavorable histologies (eg, renal cell carcinoma, hepatocellular carcinoma) experienced rapid failure (≤1 to 3 months). Other authors have reported similar results.[31] The ideal radiation treatment protocol is not clearly defined,[32] although 30 Gy in 10 fractions is a common treatment algorithm.

Figure 3



Kaplan-Meier curves representing estimated survival following treatment for spinal metastases. TS = total score. (Adapted with permission from Tokuhashi Y, Matsuzaki B, Oda H, Oshima M, Ryu J: A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. *Spine* 2005;30:2186-2191.)

Table 5

Treatment Strategy for Spinal Metastases[23]

Total Score	Predicted Prognosis (mo)	Treatment
0–8	<6	Nonsurgical or palliative surgery
9–11	6–12	Palliative surgery; excisional surgery is rarely indicated for a single lesion with no metastases to the major internal organs
12–15	≥12	Excisional surgery

Surgery

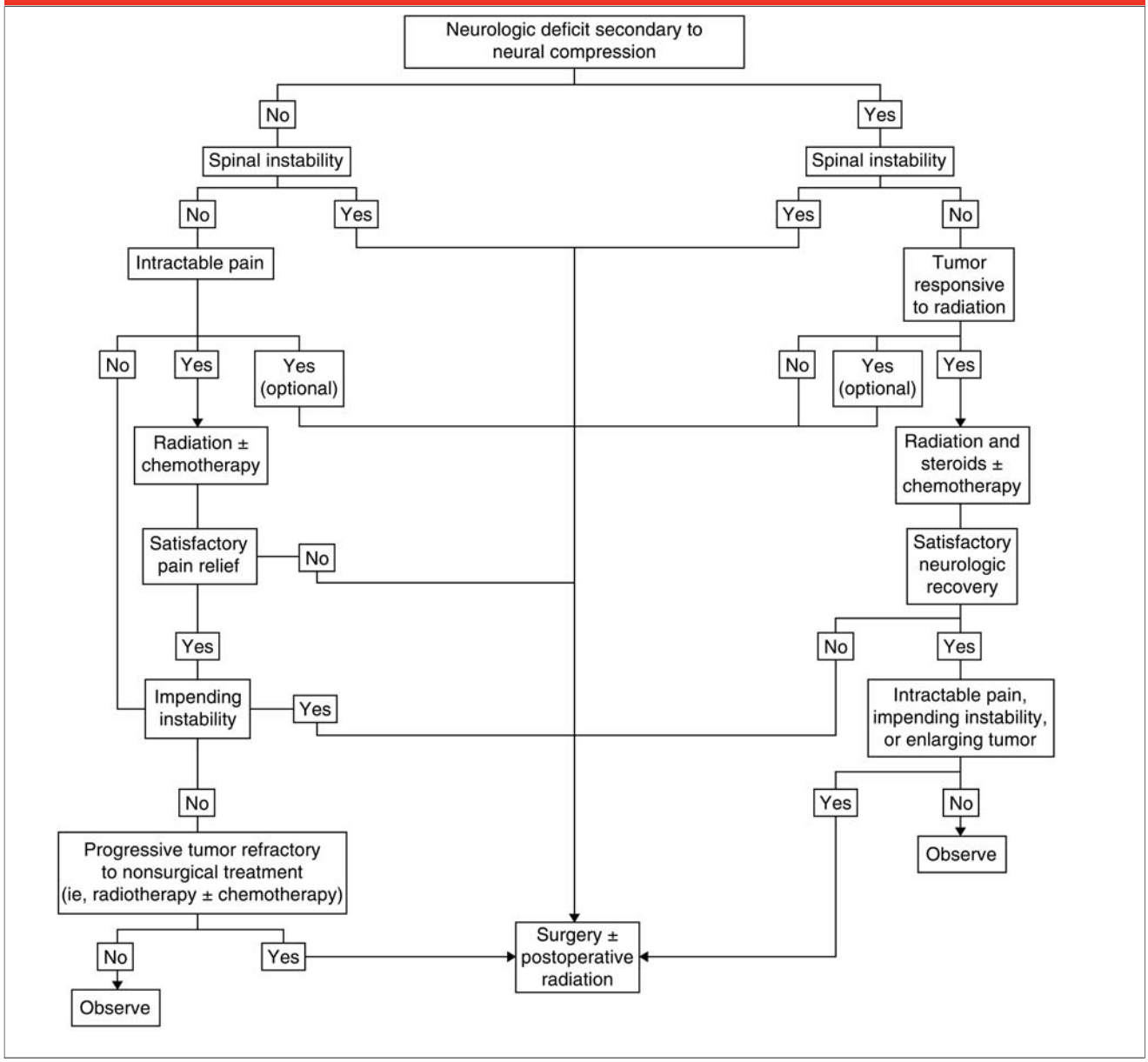
Surgical management of spinal metastases is considered for four primary indications: neurologic compression; spinal instability, including pathologic fracture; unrelenting pain; and in cases in which a histologic diagnosis must be established.

Historically, posterior laminectomy was used to manage spinal metastases. Most metastatic lesions are anteriorly based, however, so at best these procedures provided indirect neural decompression. Additionally, they caused iatrogenic instability as a result of the removal of the only healthy bony structures at the involved level or levels. Because of the poor results and clinical deterioration frequently associated with these procedures, radiation therapy became a first-line treatment for most patients.[8] However, advances in imaging, surgical technique, and segmental instrumentation systems enabled the development of direct decompressive surgery with concurrent spinal stabilization. Outcomes with direct decompressive surgery are equal or superior to those with traditional radiotherapy in properly selected patients.[33]

Patchell et al[11] sparked renewed enthusiasm in surgery as first-line treatment of metastatic disease. In their prospective randomized multicenter trial, outcomes with decompressive surgery followed by radiotherapy were shown to be superior to those following radiotherapy alone. In this study, 50 patients were treated with surgery followed by radiotherapy, and 51 were treated with radiotherapy alone. Average survival was 126 days with surgical treatment plus radiotherapy versus 100 days with radiotherapy alone ($P = 0.033$). Neurologic function, which was assessed using the ASIA and Frankel scales, was maintained for an average of 566 days in the surgical group compared with an average of 72 days in the radiotherapy-only group ($P = 0.001$ and $P = 0.0006$, respectively). Continence was maintained for a significantly longer period in surgically treated patients compared with patients treated with radiotherapy alone (average, 156 versus 17 days, respectively; $P = 0.016$). Surgically treated patients retained the ability to walk for a significantly longer period than did those treated with radiotherapy alone (median, 122 days versus 13 days, respectively; $P = 0.003$). Significantly more surgical patients than radiotherapy-only patients regained the ability to walk (62% versus 19%, respectively; $P = 0.01$).

Although this study excluded patients with highly radiosensitive tumors and cauda equina lesions, it provides excellent evidence in sup-

Figure 4



Treatment algorithm for metastatic lesions of the spine. In decreasing order of importance, the indications for surgical management of metastatic spine disease include neurologic deficit secondary to neural compression, spinal instability, intractable pain, impending fracture and/or instability, and progressive tumor refractory to nonsurgical treatment (ie, radiotherapy ± chemotherapy). (Adapted with permission from Walker MP, Yaszemski MJ, Kim CW, Talac R, Currier BL: Metastatic disease of the spine: Evaluation and treatment. *Clin Orthop Relat Res* 2003;[415S]:S165-S175.)

port of early surgical intervention in patients with neurologic signs or symptoms of metastatic disease. These results were recently replicated in a large multicenter observational study.[34] Notably, patients in the study by Patchell et al[11] who were first treated with radiotherapy and who then crossed over to the surgical treatment arm had inferior clinical outcomes. Thus, if surgery is considered, it is best performed before radiotherapy treatment is administered.

Spinal surgical staging systems map the extent of local disease. They should not be confused with oncologic staging systems, which are used to determine the total metastatic burden. In the Weinstein-Boriani-Biagini classification, an axial view of the spine in a clock-face projection is used to identify local tumor extent, areas to be resected, and fixation

points.[35] This system is excellent for planning en bloc excision of primary malignancies and solitary metastases; however, it is less applicable to common metastatic scenarios with multiple diseased levels. The staging system developed by Tomita et al[26] accommodates lesions at multiple levels and is more applicable to the typical patient with spinal metastases.

Anterior tumor location does not necessarily dictate an anterior approach for surgical decompression. Resection must be carefully tailored to each patient. Pulmonary compromise resulting from lung metastases or general deconditioning often precludes the use of anterior thoracotomy or a thoracoabdominal approach. The posterolateral transpedicular approach has been shown to be safe and effective in spinal cord decompression and stabilization of diseased segments, and it avoids the morbidity (particularly pulmonary) associated with thoracotomy[36] (Figure 5). Although a tumor often presses dorsally from the vertebral body to the spinal cord, the posterior longitudinal ligament provides an excellent anatomic barrier to clear local disease and decompress neural elements.

Management of metastatic disease is fundamentally palliative. Long-term survival is well documented in carefully selected patients who undergo aggressive en bloc resection; however, patients are rarely cured. Most patients who are treated surgically for metastatic disease undergo intralesional tumor resection to provide neurologic decompression, local stabilization, and gross total resection. Subsequent radiotherapy is employed to minimize the risk of local recurrence. Fixation is selected to provide immediate stability and to avoid the morbidity associated with orthoses. Bony fusion is unlikely in these patients; thus, we favor efficient instrumented stabilization. We avoid extensive decortication and bone grafting because it weakens the remaining bone and increases blood loss in an environment in which bony fusion is unlikely.

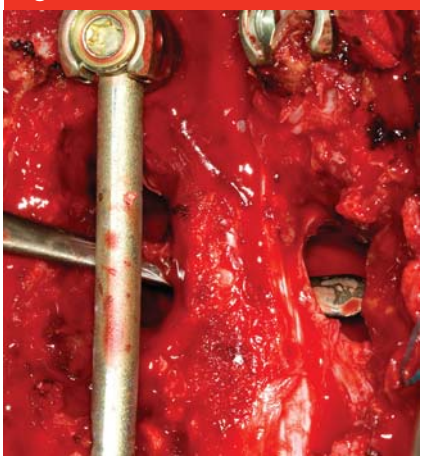
En bloc resection in carefully selected patients has been proposed.[26,37] These procedures are technically demanding and are associated with a high rate of morbidity. En bloc excision obviates the need for supplemental radiotherapy to achieve local control in the patient with insensitive tumors or in whom no further radiotherapy treatment options exist. Additionally, en bloc resection may result in disease-free status in the patient with a solitary metastasis. We reserve these aggressive procedures for patients with solitary metastases following a long disease-free interval.

Preoperative medical optimization and attention to preoperative nutritional status may reduce surgical complications. Perioperative and postoperative nutritional supplementation should be used in patients who are malnourished preoperatively (eg, low albumin level, low prealbumin serum level). We often add nutritional shakes to a patient's diet when he or she is able to tolerate oral food intake perioperatively, and we recommend either total or partial parenteral nutrition immediately postoperatively, especially in the patient who may not be able to tolerate oral intake within 1 to 2 days of surgery. Preoperative embolization may be liberally employed to minimize bleeding.[38] Preoperative radiotherapy and/or neurologic deficit place patients at higher risk of surgical complications.[39] Careful surgical technique, attention to nutritional status, and the liberal use of local wound flaps (eg, trapezial, gluteal) can decrease wound complications.

Vertebroplasty and kyphoplasty are commonly used to achieve pain relief following osteoporotic vertebral compression fracture. These closely related procedures also can be used to manage spinal metastases, particularly spinal plasmacytoma and multiple myeloma.[40] Pain relief is the main objective of vertebroplasty and kyphoplasty in this setting. These procedures are not indicated as a primary treatment in patients with neurologic dysfunction caused by epidural compression of the neural elements or gross instability.[40,41]

Fourney et al[42] reported marked or complete pain relief in 84% of patients following vertebroplasty or kyphoplasty and no symptomatic improvement in 9%. No patient was worse off following the procedure, and neither symptomatic complications nor death was reported. Asymptomatic cement extravasation was noted in 9.2% of cases. Dudeney et al[43] reported significant improvement in functional outcome scores following kyphoplasty. No

Figure 5



Intraoperative photograph demonstrating circumferential decompression of the spinal cord through a posterior approach. A stabilizing rod must remain in place on one side of the spinal cord at all times during decompression to guard against spinal subluxation.

major complications were reported. Asymptomatic cement leakage occurred in 4% of patients. Others have reported similar findings.[44,45] Vertebroplasty following radiotherapy appears to be effective in managing persistent pain, with no complications.[46]

Vertebroplasty and kyphoplasty are contraindicated in certain circumstances. Poor candidates for these procedures include patients with ≥75% loss of vertebral body height, ≥20% spinal canal compromise due to epidural disease, posterior vertebral body cortex violation, more than three levels requiring treatment, radiculopathy, and/or uncorrected coagulopathy.[47-50] In persons with these contraindications, vertebroplasty or kyphoplasty will likely result in a higher rate of complications than is seen in patients without these contraindications (39% versus 11%, respectively).[47]

Treatment Strategy

Treatment must be individualized. Patients who present with asymptomatic lesions are good candidates for local disease control with systemic treatment and/or radiotherapy, as are those who present with pain but without extended extraosseous disease and who are not at risk of impending fracture. Bracing may be used to alleviate pain and prevent fracture during the course of radiotherapy. Vertebroplasty and kyphoplasty are also used to palliate local symptoms. Close observation for local progression is required. Surgery may be necessary to protect against fracture. These patients should be followed closely for the appearance of new metastases elsewhere in the spine.

Many patients present with pain and evidence of compressive neurologic deficit or impending pathologic fracture. Rapid treatment with corticosteroids and radiotherapy can yield excellent results in the management of exquisitely radiosensitive tumors (eg, lymphoma, multiple myeloma). Vertebroplasty or kyphoplasty can be used to supplement these modalities. However, many patients present with symptoms caused by neurologic compression or impending or completed pathologic fracture related to solid organ metastases that are poorly responsive to radiotherapy. These patients should be considered for urgent surgical intervention. In the patient who is expected to survive for >3 months and who is able to tolerate surgery, we recommend surgical decompression and stabilization in the setting of neurologic deficit secondary to neural compression. We also recommend surgery for spinal instability, especially in patients with concomitant neurologic deficit secondary to neural compression. Finally, we strongly consider surgery in patients with progressive symptoms, impending fracture, or inadequate pain relief following radiotherapy and/or chemotherapy. A treatment algorithm is presented in Figure 4.[51] According to Bilsky and Smith,[52] patients with

> high-grade epidural spinal cord compression (N) from radioresistant disease (O) or [who] demonstrate mechanical instability (M) are offered surgery if they can tolerate it from a systemic (S) standpoint.

The NOMS algorithm assesses neurologic, oncologic, mechanical, and systemic indications for surgery.[52]

Summary

Decreased cardiovascular mortality and improved cancer therapy may result in an increased incidence of metastatic spinal disease. Although the prognosis of these patients remains guarded at best, careful surgical management in conjunction with medical and radiation oncology care has great potential to improve quality of life and prolong survival in this challenging patient population. Recent studies highlight the benefits of carefully considered surgical management.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, reference 11 is a level I study. References 13, 15, and 29 are level II studies. References 14, 20, 21, 32, and 33 are level III studies. References 7, 12, 16, 19, 23-27, 31, 34, 36, and 38-49 are level IV studies. References 1-3, 5, 6, 8, 28, 35, and 50-52 are level V expert opinion.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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