Treatment and prognosis of neoplastic epidural spinal cord compression

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INTRODUCTION

Neoplastic epidural spinal cord compression (ESCC) is a common complication of cancer that can cause pain and potentially irreversible loss of neurologic function. The majority of cases arise from epidural extension of vertebral body metastases. Although the degree of thecal sac compression required for the designation of ESCC has been variably defined, we consider any radiologic evidence of indentation of the thecal sac to be evidence for ESCC.

The treatment and prognosis of ESCC are discussed here. The clinical features and diagnostic approach to patients with possible ESCC are discussed separately. (See "Clinical features and diagnosis of neoplastic epidural spinal cord compression".)

IMPORTANCE OF EARLY DETECTION

When patients present to medical attention with neurologic deficits potentially attributable to ESCC, clinicians should make every effort to assess and treat ESCC promptly in order to prevent further neurologic deterioration and to improve the probability of restoring ambulation [1].

Pretreatment neurologic status and duration of ambulatory loss are the most important prognostic factors for regaining ambulation after treatment of ESCC [1-11]. Patients with severe weakness (eg, unable to lift the limb against gravity) and those who have been nonambulatory

for longer than 48 hours before diagnosis are less likely to regain function with treatment than those who are diagnosed earlier [1]. (See 'Neurologic function' below.)

Patients with cancer, their caregivers, and clinicians should be educated about symptoms that warrant immediate evaluation, particularly otherwise unexplained back pain. Back pain is often the first symptom of ESCC and should be promptly evaluated in patients with cancer, especially when accompanied by neurologic signs or symptoms. (See "Clinical features and diagnosis of neoplastic epidural spinal cord compression", section on 'Diagnostic evaluation'.)

Fortunately, early recognition of ESCC at a stage in which therapy can be most effective is improving. In a 2010 study, 62 percent of patients who presented with ESCC were ambulatory at the time of diagnosis [12]. By contrast, only one-third of patients were ambulatory at the onset of therapy in older studies reviewing patients presenting through the late 1990s [11,13].

BASELINE ASSESSMENT

Patients with ESCC are heterogeneous, and treatment decisions must be individualized. Major considerations that inform both the urgency and selection of definitive treatment include the degree of neurologic compromise, the oncologic characteristics of the primary tumor (if known), the mechanical stability of the spine, and the systemic burden of cancer and medical comorbidities (the Neurologic, Oncologic, Mechanical, Systemic [NOMS] framework) [14].

Neurologic (high- versus low-grade ESCC) — A neurologic examination is required in all patients to assess for evidence of neurologic deficits attributable to tumor compression of the spinal cord and/or nerve roots. This information can be combined with magnetic resonance imaging (MRI)-based radiographic assessment to dichotomize patients into high- or low-grade ESCC [15].

- **High-grade ESCC** refers to patients with an ESCC radiologic grade of 2 or 3 (even if asymptomatic) (figure 1 and image 1). ESCC grade 2 refers to tumors that displace or compress the spinal cord, without circumferential tumor extension or obliteration of the cerebrospinal fluid (CSF) space. Grade 3 refers to tumors with circumferential epidural extension and/or that cause severe spinal cord compression with obliteration of the CSF space. Many of these patients have deficits attributable to spinal cord compression (ie, myelopathy) or nerve root compression (ie, radiculopathy).

- **Low-grade ESCC** refers to the remaining patients with ESCC radiologic grade 1 tumors (figure 1 and image 1). These are tumors with epidural extension without contact with the spinal cord or just spinal cord abutment without displacement. Patients with low-

grade ESCC may have symptoms of nerve root compression but do not have deficits attributable to spinal cord compression.

The degree of spinal cord compression influences the urgency of therapy, the selection of patients for surgical decompression, and the choice of radiation technique. (See 'Selection of definitive treatment' below.)

Oncologic (radiosensitivity of primary tumor) — The underlying primary tumor type helps to predict its sensitivity to systemic therapy and conventional external beam radiation therapy (cEBRT). For the purposes of ESCC, radiosensitivity to cEBRT in the dose ranges that are within spinal cord tolerance is a crucial characteristic and influences decisions about upfront surgery versus radiation therapy as well as the type of radiation used (ie, cEBRT versus stereotactic body radiation therapy [SBRT]).

Tumors such as lymphoma and multiple myeloma respond quickly and effectively to systemic therapy and/or cEBRT. Among solid tumors, a systematic literature review concluded that while prostate and breast cancer vertebral metastases readily respond to spine cEBRT, most other solid tumor spinal metastases exhibit variable or consistently poor local control (<30 percent) [16]. For the purposes of ESCC decision-making, tumors are therefore classified as "relatively radiosensitive" and "relatively radioresistant" based on their predicted responsiveness to cEBRT in the dose ranges that are within spinal cord tolerance (table 1).

Mechanical (spinal stability) — The mechanical stability of the spine should be assessed by clinical and radiographic criteria in all patients, as treatment of ESCC differs in patients with an unstable spine compared with a stable spine. Regardless of tumor histology and the degree of spinal cord compression, patients with mechanically unstable tumor-associated spinal fractures require surgical stabilization of the spine to relieve pain. (See 'Patients with spinal instability' below.)

Neoplastic spinal instability refers to a loss of spinal integrity as a result of a neoplastic process that is associated with movement-related pain, symptomatic or progressive deformity, and/or neural compromise under physiologic loads [17]. Regardless of the radiographic findings, the clinician should consider every patient with pain caused by movement to be unstable until proven otherwise. While neoplastic mechanical instability rarely results in neurologic deterioration, every effort should be made to refer patients with suspected mechanical instability for timely evaluation by a spine tumor surgeon to determine the optimal treatment plan, assess the need for surgical stabilization, and facilitate symptom palliation. Such patients should be immobilized (with bracing or bed rest) while awaiting further imaging and

neurosurgical assessment [18]. (See "Clinical features and diagnosis of neoplastic epidural spinal cord compression", section on 'Pain'.)

An expert consensus panel created the Spine Instability Neoplastic Score (SINS) to facilitate the diagnosis of spinal instability based on a combination of radiographic criteria and pain characteristics (table 2) [17]. According to this classification, patients with a score of 7 or higher are considered to be at risk for spinal instability and warrant surgical consultation. By consensus, the highest ranked factors predictive of spinal instability include:

- Subluxation/translation
- Presence of a de novo radiographic bone deformity
- Greater than 50 percent vertebral body collapse
- Bilateral facet destruction
- Movement-related pain (as opposed to tumor-related or biologic pain)
- Involvement of junctional segments of the spine (ie, occipitocervical, cervicothoracic, thoracolumbar, or lumbosacral)

The validity of the SINS was addressed in a cohort of 30 patients with spinal tumors that were classified as stable, potentially unstable, and unstable by members of the Spine Oncology Study Group (the same group that devised the classification scheme) [19]. The sensitivity and specificity rates of SINS for unstable or potentially unstable lesions were 96 and 80 percent, respectively. In addition, there was high inter- and intraobserver reliability in determining the three clinically relevant categories of stability.

Systemic (life expectancy) — The extent of systemic tumor burden, prior therapies, and medical comorbidities should be assessed in all patients, typically in consultation with medical oncology. A wide range of systemic variables are associated with worse clinical outcomes in patients undergoing surgery for ESCC, including older age (>60 years), male sex, very low or high body mass index, active smoking, medical comorbidities, hypoalbuminemia, low muscle mass, weakness and poor ambulation, low performance status, and high systemic disease burden [20]. Estimation of expected survival and the ability of the patient to safely undergo surgery play major roles in the individualized selection of an optimal treatment strategy.

In practice, rigid survival prediction systems or cutoffs should be avoided. Instead, the focus should be on whether a patient will have an opportunity to adequately recover from the indicated surgery and/or radiation in order to continue systemic therapy. Generally, patients may be considered for surgery as long as systemic progression does not appear to be rapid enough to prevent postoperative recovery and a reasonable systemic option is available for the postoperative period to attempt tumor control [14]. (See 'Overall survival' below.)

Several predictive survival models have been developed to facilitate decision-making regarding surgical mortality for patients with metastatic spine tumors. The New England Metastatic Spine Score and the Skeletal Oncology Research Group (SORG) nomograms have both been validated in the era of modern systemic therapies and are highly predictive of postoperative survival at three and 12 months [21,22]. A SORG-nomogram calculator is available online [21,23]. (See "Overview of therapeutic approaches for adult patients with bone metastasis from solid tumors", section on 'Predicting prognosis'.)

SYMPTOMATIC AND PREVENTIVE CARE

The goals of treatment for patients with ESCC include pain control, avoidance of complications, and the preservation or improvement of neurologic function and spinal mechanical stability utilizing treatments appropriate to the patient's burden of disease, life expectancy, values and preferences, and goals for care [24]. (See "Discussing goals of care".)

Symptomatic treatment of ESCC often begins prior to definitive therapy and continues throughout the treatment period.

Glucocorticoids — Glucocorticoid therapy is generally considered to be part of the standard regimen for symptomatic ESCC as a bridge to definitive treatment and for palliation of pain [25-27]. The dose and duration of therapy should be individualized in an effort to achieve maximal symptomatic benefit while minimizing side effects and toxicities.

Our approach, based on clinical experience, observational data, and a limited number of randomized trials in patients undergoing radiation therapy, is to tailor the dose according to ESCC severity and symptoms:

- For patients with neurologic deficits or pain associated with ESCC, we suggest high-dose glucocorticoid therapy. A typical dose is 10 mg dexamethasone intravenously followed by 16 mg daily orally in divided doses [28]. Once definitive treatment is underway, the dose can be tapered, for example by halving the total daily dose every three days.

  Very high-dose regimens (eg, dexamethasone 96 mg intravenously followed by 24 mg four times daily for 3 days and then tapered over 10 days) have been studied for patients with severe neurologic deficits (eg, paraparesis or paraplegia) but are not clearly superior and may be associated with increased toxicity [27,29].

- We do not routinely start glucocorticoids in patients with small epidural lesions and a normal neurologic examination. One small phase II trial showed that patients with back

pain but no myelopathy and less than 50 percent narrowing of the spinal canal by epidural tumor could successfully undergo radiation therapy without receiving glucocorticoids [30].

The ability of glucocorticoids to transiently improve neurologic function in patients with ESCC, presumably via anti-edema effects and/or oncolytic effects in steroid-responsive malignancies (eg, lymphoma), has long been recognized [31,32]. Only three small clinical trials have addressed the optimal initial dose and outcomes of glucocorticoids in ESCC [33-35]. A meta-analysis of the three studies concluded that the available data provided insufficient evidence as to the role of glucocorticoids and the appropriate initial dose [27]. When all three trials were considered, higher initial doses (eg, 96 mg of dexamethasone) were **not** associated with better outcomes, but they were associated with a higher incidence of serious adverse events (such as perforated gastric ulcer, psychosis, and death from infection). (See "Major adverse effects of systemic glucocorticoids".)

Of note, all of these trials evaluated the role of dexamethasone in the treatment of ESCC among patients who underwent radiation therapy and not surgery. Modern treatment of symptomatic ESCC frequently includes decompressive surgery. The role of glucocorticoids among patients undergoing surgical decompression has not been studied and can only be extrapolated from the radiotherapy trials [28].

Pain management and role of immobilization — Patients with ESCC are frequently in pain, occasionally limiting the ability to perform a thorough neurologic examination. Glucocorticoids usually improve the pain within several hours, but many patients require opioid analgesics to tolerate the physical examination and necessary diagnostic studies. (See "Cancer pain management with opioids: Optimizing analgesia" and "Cancer pain management: Role of adjuvant analgesics (coanalgesics)".)

There is generally no need to confine the patient to bed unless there is spinal instability. Patients are generally quite adept at avoiding maneuvers that trigger their pain, and there is no risk that movement will worsen the neurologic status unless the patient has a grossly unstable spine. Timely surgical evaluation by a spine tumor specialist should be arranged to expedite treatment. Patients with an unstable spine should be immobilized with bracing and/or bed rest until definitive surgical management. (See 'Mechanical (spinal stability)' above.)

Venous thromboembolism prophylaxis — Patients with advanced cancer are at increased risk for venous thromboembolism (VTE), and weakness and immobility associated with ESCC further increase the risk. In a series of over 230 consecutive patients requiring surgical treatment of spinal metastases who were screened with lower extremity Doppler ultrasonography, deep

venous thrombosis (DVT) was identified in 10 percent of all patients and in 24 percent of those who were nonambulatory [36].

Although the value of prophylaxis against VTE has not been studied specifically in patients with ESCC, short-term pharmacologic VTE prophylaxis with unfractionated heparin, low molecular weight heparin, or fondaparinux should be administered if the patient is immobilized due to the ESCC and there is no active bleeding or other contraindications to the use of anticoagulants. (See "Risk and prevention of venous thromboembolism in adults with cancer", section on 'Primary prevention'.)

If surgery is planned in the immediate future, anticoagulation should be withheld. If there are contraindications to the use of anticoagulants, such patients should be treated with mechanical prophylaxis, such as pneumatic venous compression devices or graduated compression stockings. (See "Prevention of venous thromboembolic disease in adult nonorthopedic surgical patients", section on 'With high bleeding risk: Mechanical methods'.)

Patients with VTE who have contraindications to anticoagulation, such as upcoming or recent surgery, may undergo placement of an inferior vena cava (IVC) filter, in an effort to reduce the short-term risk of pulmonary embolism. (See "Placement of vena cava filters and their complications".)

Urinary retention and constipation — Patients with ESCC and limited mobility are at risk for developing urinary retention, which may be diagnosed using post-void bladder scanning. Clinicians should have a high index of suspicion for urinary retention in patients with ESCC who endorse urinary hesitancy or new urinary incontinence, especially when accompanied by perineal numbness. Foley catheterization is indicated in patients with urinary retention. (See "Acute urinary retention", section on 'Bladder decompression'.)

Autonomic dysfunction from the spinal lesion, limited mobility, and opioid analgesics all can contribute to the development of constipation, ileus, and occasionally intestinal perforation, the symptoms of which may be masked by glucocorticoids [37]. Consequently, an aggressive prophylactic bowel regimen is indicated. (See "Prevention and management of side effects in patients receiving opioids for chronic pain", section on 'Opioid bowel dysfunction'.)

SELECTION OF DEFINITIVE TREATMENT

The choice of modality for definitive treatment of ESCC depends on many factors, including the relative radiosensitivity of the primary tumor (table 1), the extent or grade of spinal cord compression (figure 1 and image 1), and the presence or absence of spinal instability

(table 2). The Neurologic, Oncologic, Mechanical, Systemic (NOMS) paradigm facilitates the selection of optimal combination and sequencing of systemic therapy, radiation, and surgery for individual patients and provides an evidence-based and dynamic decision framework [14]. (See 'Baseline assessment' above.)

Patients with spinal instability — Spinal instability is an independent indication for surgical stabilization of the spine, regardless of ESCC grade and radiosensitivity of the primary tumor (algorithm 1). The assessment of spinal stability is based on clinical and radiographic criteria (table 2), as described above. (See 'Mechanical (spinal stability)' above.)

Pain from an unstable spine will not be relieved with radiotherapy, and there is a lack of evidence on whether spinal bracing is an effective technique for reducing pain [38]. In addition to pain considerations, a higher Spine Instability Neoplastic Score (SINS) also correlates with radiotherapy failure, as defined by the need for retreatment with more radiation, surgery, or conservative measures [39]. Conversely, surgical stabilization of higher SINS score lesions results in significant decrease in pain and improvement in health-related quality of life [40]. (See 'Mechanical (spinal stability)' above.)

Surgical stabilization of the spine can be accomplished either by surgery with spinal instrumentation (eg, pedicle screws) [41], performed at the time of surgical decompression in patients with other indications for surgery (eg, high-grade ESCC due to a radioresistant tumor), or by percutaneous cement injection into the vertebral body without (vertebroplasty) or with inflatable bone tamps (kyphoplasty) in patients who are suitable candidates for a radiation-alone approach (eg, patients without high-grade ESCC) [42]. (See 'Surgical decompression and spine stabilization' below and 'Role of vertebroplasty, kyphoplasty, and percutaneous spinal instrumentation' below.)

Radiosensitive tumors — Most patients with radiosensitive tumors (table 1) can be treated successfully with conventional external beam radiation therapy (cEBRT), regardless of the ESCC grade. Surgery can usually be avoided in these patients unless there is spinal instability, prior cEBRT to overlapping fields, or progression of tumor or neurologic deficit during radiation. (See 'Conventional external beam radiation therapy' below.)

Decisions must nonetheless be individualized, particularly in patients with neurologic deficits attributable to high-grade ESCC from solid tumors such as breast or prostate cancer. While these tumors generally respond well to cEBRT, response can take time, and surgery should at least be considered in patients with neurologic deficits to allow rapid decompression of the spinal cord. This is in contrast to tumors such as myeloma or lymphoma, which tend to respond rapidly to glucocorticoids (which have a lympholytic effect) plus cEBRT.

The appropriate dose and fractionation of cEBRT for definitive treatment vary according to the goal of treatment and life expectancy. Short-course radiation (eg, 8 Gy x 1) provides short-term palliation with minimal toxicity [43], whereas longer-course fractionated regimens with higher total doses provide more durable tumor control for those with a life expectancy of six months or more [44]. (See 'Dose and fractionation' below and "Radiation therapy for the management of painful bone metastases", section on 'Single-dose versus fractionated treatment'.)

Systemic therapy plays a role after definitive treatment of ESCC in most patients with radiosensitive tumors and is occasionally used in place of radiation in selected patients with highly chemosensitive tumors. (See 'Systemic therapy' below.)

Radioresistant tumors with low-grade ESCC — The approach to patients with low-grade ESCC due to radioresistant tumors has evolved with the advent of stereotactic body radiation therapy (SBRT) for spinal metastases. Where available and in the absence of spinal instability, SBRT is now the preferred approach for low-grade ESCC due to relatively radioresistant tumors (algorithm 1).

Previously, many of these patients were referred for surgical excision first rather than radiation therapy, since local control rates for patients with relatively radioresistant tumors treated with cEBRT were historically poor [2,45]. This is due to the limitations of cEBRT in delivering the higher tumoricidal radiation doses that are needed for radioresistant tumors without high risk of spinal cord or adjacent organ toxicity.

However, durable local control of radioresistant tumors can be achieved safely with SBRT in patients with low-grade ESCC, with effective pain control and without the need for surgery. SBRT allows for high doses of radiation to be delivered in one or several fractions to a highly localized field, with avoidance of potentially toxic doses to the spinal cord and other critical structures. (See 'Stereotactic body radiotherapy' below.)

If SBRT is not available, options include cEBRT or surgical excision followed by cEBRT. (See 'Maximal surgical excision plus cEBRT' below.)

Radioresistant tumors with high-grade ESCC — Most patients with radioresistant tumors and high-grade ESCC require surgical decompression and stabilization prior to radiation therapy in order to achieve maximal pain relief, neurologic recovery, and local tumor control [46,47]. (See 'Surgical decompression and spine stabilization' below.)

Postoperatively, all patients require radiation therapy to treat residual disease with the goal of maintaining local tumor control and preventing further neurologic compromise from tumor regrowth. When available, we suggest postoperative SBRT rather than cEBRT due to the

radioresistant nature of the primary tumor and the ability of SBRT to safely deliver high-dose radiation while sparing the spinal cord (algorithm 1). (See 'Separation surgery plus SBRT' below and 'Maximal surgical excision plus cEBRT' below.)

Even though surgery provides the best chance for neurologic recovery and symptom control, some patients are not candidates for surgery based on factors such as extensive and heavily pretreated metastatic disease, lack of further systemic options for cancer therapy, and very short expected survival. For these patients, glucocorticoids and short-course cEBRT are the primary palliative therapies. SBRT alone is generally not used in the setting of high-grade ESCC; however, selected nonsurgical patients with grade 2 ESCC may be candidates for SBRT using a hypofractionated regimen. (See 'Conventional external beam radiation therapy' below and 'Stereotactic body radiotherapy' below.)

Patients with unknown or synchronous primary — Patients presenting with ESCC without a preexisting cancer diagnosis require a full radiographic staging evaluation, screening for relevant tumor markers, if applicable, and a tumor core biopsy for histologic confirmation of the diagnosis [48]. The biopsy may be obtained from the spinal tumor or the most readily accessible site in cases of disseminated disease. Histologic diagnosis plays a paramount role in determination of the need for surgery and in selection of systemic and/or radiation therapy. However, if a patient presents with a significant or progressive neurologic deficit due to ESCC, neurologic presentation takes precedence over the need for accurate diagnosis and staging, and the patient should undergo urgent surgical decompression of the spinal cord. Tissue can be sent for histologic analysis at the time of decompression, and a formal staging evaluation can be undertaken postoperatively.

Patients with multilevel involvement — Cancer patients frequently present with multilevel tumor spinal involvement. In such cases, the symptomatic spinal tumor(s) take precedence in treatment prioritization. All spinal levels with ESCC usually require radiation therapy, with the exception of tumors that are highly responsive to systemic therapy. (See 'Systemic therapy' below.)

For patients deemed to require decompression at one or more spinal levels, multilevel tumor involvement affects the extent and technique of surgical stabilization, since the stability of the instrumentation may be impaired in spines with diffuse tumor infiltration.

Patients with prior in-field radiation — Patients with tumor recurrence or progression in previously irradiated areas generally require SBRT, regardless of tumor histology. Reirradiation using SBRT generally results in good local control [49]. Previously irradiated tumors causing high-grade ESCC usually require surgical decompression prior to SBRT, in order to permit

optimal delivery of SBRT to the entire tumor volume without delivering excessive radiation dose to the adjacent spinal cord. Intraoperative brachytherapy may be used in select cases in order to facilitate postoperative SBRT and to optimize dosimetry [50]. (See 'Management of recurrent ESCC' below.)

SPECIFIC MODALITIES

Conventional external beam radiation therapy — Conventional external beam radiation therapy (cEBRT) is appropriate definitive therapy for ESCC in patients who have relatively radiosensitive tumors and for palliation of pain in patients with very short expected survival (eg, three months or less). cEBRT can also be administered following surgical decompression, although stereotactic body radiotherapy (SBRT) is preferred for radioresistant tumors. (See 'Maximal surgical excision plus cEBRT' below.)

Response to treatment — cEBRT is effective for palliation of pain and local tumor control in radiosensitive histologies (table 1) [16,51]. Approximately 70 percent of patients have an improvement in pain, and one-half of those without spinal instability experience resolution of back pain following cEBRT [2,16,51,52]. Local control rates are over 75 percent, and cerebrospinal fluid (CSF) flow is restored in approximately 80 percent of patients who have evidence of complete subarachnoid block on pretreatment myelography [4,16,53].

Even in patients with high-grade ESCC due to radiosensitive tumors, cEBRT using a variety of dose and fractionation schedules improves ambulatory status and provides durable local tumor control and pain relief [2,54,55]. This was illustrated by a prospective study in which 255 out of 275 consecutive patients with ESCC were treated with glucocorticoids and cEBRT, while surgery was reserved for the remaining 20 selected cases in which there was diagnostic uncertainty or a need for spine stabilization [2]. Among 124 patients with lymphoma, myeloma, breast cancer, or prostate cancer, 82 percent of patients achieved recovery or preservation of walking ability with a median response duration of 11 months. Two-thirds of nonambulatory patients with breast cancer regained ambulation.

cEBRT is generally very well tolerated. When extensive segments of the spine are irradiated, bone marrow suppression and gastrointestinal toxicity may complicate treatment.

Dose and fractionation — The optimal dose and schedule of cEBRT for treatment of ESCC is debated, and treatment decisions should be individualized. A variety of cEBRT schedules have been used, ranging from single large fractions (eg, 8 Gy) to protracted courses (eg, 30 to 40 Gy divided in 10 to 20 fractions).

The available data, which include several small randomized trials conducted primarily in patients with solid tumors and a relatively short estimated life expectancy (eg, three to six months or less), indicate that shorter courses of cEBRT (delivered in 5 fractions or less) afford similar palliation compared with more protracted courses (10 fractions or longer) in this group [51,54,56-59]. Among the short-course options, a single, large fraction (8 Gy x 1) can be offered as a convenient palliative option in patients with a very short life expectancy (three months or less), whereas a multifraction short course (eg, 4 Gy x 5) offers similar to slightly better ambulatory outcomes [43,55,58,60]. The largest trial to date compared 8 Gy x 1 with 4 Gy x 5 in 686 patients with ESCC from a solid tumor [55]. At eight weeks and with 50 percent of patients still alive and evaluable for the primary outcome, the proportion of patients who were ambulatory was 69.3 percent after 8 Gy x 1 and 72.7 percent after 4 Gy x 5. This result did not meet the criterion for noninferiority for the primary outcome (ambulatory at eight weeks). As systemic therapy evolves and patient survival improves, the role for single-fraction 8 Gy treatment may be diminishing, but this palliative dose can still be useful for patients with very short expected survival or hospice-bound patients.

There is less certainty about the effectiveness of a short versus protracted course of cEBRT in patients with ESCC who have a more prolonged estimated life expectancy (eg, six months or longer). This includes patients with a prolonged natural history of disease leading up to the ESCC event; oligometastatic disease without visceral involvement; slow progression of motor deficits; histologic diagnosis of myeloma, lymphoma, prostate cancer, or breast cancer; and those who are receiving radiation after surgical decompression. For these patients, a more protracted course of cEBRT (eg, 30 to 40 Gy divided in 10 to 20 fractions) is suggested in order to achieve better long-term local control [56,57,61,62].

Treatment field — The cEBRT portal covers the width of the vertebral body and all areas of paravertebral tumor extension with margin, is centered on the spine, and typically extends one vertebral body above and one below the epidural metastasis.

The necessity of including the adjacent vertebrae in the radiation treatment volume has been questioned, given the low rates of local failure (<5 percent) in adjacent nonirradiated vertebral bodies in patients with isolated spinal metastases (without ESCC [63]). However, disadvantages of treating with just a margin on the disease (as opposed to one vertebral body above and below) include the difficulty in matching radiation fields if recurrences occur adjacent to the prior radiated field, the requirement of daily imaging when delivering cEBRT with tighter margins, and the uncertainty of microscopic extent of disease once it has entered the epidural space.

Stereotactic body radiotherapy — SBRT provides an effective alternative to cEBRT in patients with radioresistant or recurrent spinal metastases that are diagnosed early, before high-grade ESCC has developed.

Technique — The effectiveness of cEBRT is limited by the proximity of the spinal cord, which is intolerant of high-dose radiation. SBRT is a modern radiation strategy that uses sophisticated radiation delivery technology (eg, image-guided intensity-modulated radiation therapy) to deliver a precisely targeted high dose of radiation to a tumor in a single or small number of fractions while minimizing radiation to adjacent normal tissue. For spinal metastases, this targeting allows precise delivery of high doses of radiation to tumors separated by 2 to 3 millimeters from the spinal cord. (See "Radiation therapy techniques in cancer treatment", section on 'Stereotactic radiation therapy techniques'.)

While the biologically effective doses of radiation delivered by cEBRT are effective for the treatment of relatively radiosensitive neoplasms such as lymphoma and breast cancer, they are less useful for relatively radioresistant tumors [16]. The ability to deliver high doses of radiation safely with SBRT overcomes the relative radioresistance of tumors such as melanoma and renal cell carcinoma.

Response to treatment — SBRT gives excellent pain relief and local tumor control in patients with spinal metastases from relatively radioresistant neoplasms.

In the absence of high-grade ESCC, there is a large body of evidence that SBRT is a viable noninvasive treatment option for spinal metastases both with and without malignant epidural disease [64-70]. In large series of up to nearly 700 patients with spinal metastases treated with SBRT, actuarial rates of local control at one year are approximately 90 percent and are similar across a range of tumor histologies and in patients with and without low-grade ESCC [64-69].

The use of SBRT alone in patients with high-grade ESCC is largely investigational, and no prospective studies have examined safety and efficacy outcomes in this setting. Many patients with high-grade ESCC lack sufficient separation between tumor and spinal cord for safe delivery of therapeutic doses of SBRT and are generally only appropriate for SBRT if they have undergone surgical decompression first. (See 'Separation surgery plus SBRT' below.)

For patients with less severe (ie, ESCC grade 2) high-grade ESCC who cannot undergo surgery, SBRT alone using a hypofractionated regimen (eg, three fractions) is being explored and may be an option in selected patients [71]. In a retrospective review of 29 such patients with relatively radioresistant tumors, hypofractionated SBRT (mostly delivered as 27 Gy in three fractions) was well tolerated and associated with low locoregional failure rates (approximately 10 and 20

percent at one and two years, respectively) [71]. There were no acute complications, and the cumulative incidence of progressive disease requiring open surgery was 14.5 percent [71].

Dose and fractionation — Relatively high doses of SBRT must be used to overcome tumor resistance to radiation and achieve optimal results. Typically, spine SBRT is delivered as 16 to 24 Gy in a single fraction, 24 Gy in two fractions, 27 to 30 Gy in three fractions, or 50 Gy in five fractions.

In patients with a favorable prognosis and relatively radioresistant tumors, higher doses are needed to achieve optimal local control. In a series of 657 patients with 811 spinal metastases treated with single-fraction SBRT, patients treated with high-dose SBRT (22.4 Gy to at least 95 percent of planned treatment volume) had local failure risk of 0.4 percent at 12 months, 1.6 percent at 24 months, and 2.1 percent at 48 months [64]. This local control was significantly better compared with lower single-fraction SBRT doses, independent of tumor histology and tumor volume.

Risks and toxicities — The risk of vertebral compression fracture after SBRT is as high as 40 percent [72-75]. Risk factors for fracture include use of single doses >20 Gy, preexisting fracture or spinal deformity, and lytic (rather than sclerotic) bone lesions. (See "Radiation therapy for the management of painful bone metastases", section on 'Stereotactic radiation therapy'.)

Other SBRT-related toxicities are usually mild and may include esophagitis, mucositis, dysphagia, diarrhea, paresthesia, transient laryngitis, and transient radiculitis [65,76]. Radiation-induced spinal cord injury appears to be very rare, affecting only 6 of 1075 patients in one multicenter series [77]. (See "Complications of spinal cord irradiation", section on 'Late radiation-induced myelopathy'.)

Surgical decompression and spine stabilization — Surgery is the preferred approach for patients with an unstable spine (table 2) and for high-grade ESCC due to relatively radioresistant tumors (algorithm 1) [13,52].

The two primary goals of surgery in patients with neoplastic ESCC are:

- Preservation or restoration of mechanical stability to effectively manage movement-induced pain
- Circumferential decompression of the spinal cord to preserve neurologic function and allow delivery of adequate doses of radiation to the entire tumor volume while avoiding toxicity to the spinal cord

Separation surgery plus SBRT — The combined strategy of surgery and postoperative SBRT provides durable local control and diminishes the need for extensive tumor excision and prolonged postoperative recovery. Since SBRT provides local control irrespective of tumor volume, the surgical goal shifts from maximal tumor volume reduction to providing adequate separation between the tumor and the spinal cord ("separation surgery") in order to permit optimal SBRT dosimetry to the entire tumor volume without delivering excessive radiation dose to the adjacent spinal cord [47].

- **Separation surgery** – Separation surgery requires excision of the epidural tumor to ensure circumferential spinal cord decompression and is most readily accomplished using the posterior approach through a laminectomy, facetectomy, and the transpedicular approach to the circumferential epidural space [41]. Posterior segmental fixation is accomplished using screw-rod systems, including pedicle screws in the thoracic and lumbar spine and lateral mass screws in the cervical spine. For patients with extensive vertebral body destruction, anterior reconstruction can be accomplished using either bone grafts or bone cement [46,78-81]. In a single-center series of 186 patients treated with separation surgery plus SBRT, the one-year local recurrence risk was under 10 percent after high-dose single-fraction or hypofractionated SBRT [47]. While gross total excision of the vertebral body or paraspinal metastatic tumor may be undertaken, it confers no local control advantage in the setting of effective postoperative SBRT and exposes patients to increased risk of morbidity.

- **Postoperative SBRT** – Postoperative SBRT provides better local control than cEBRT, particularly for relatively radioresistant tumors. A systematic review that included 11 studies totaling 426 patients treated by various surgical approaches followed by SBRT for spine metastases concluded that the crude local control rate at last follow-up was 89 percent (range 70 to 100 percent); 92 to 100 percent had durable pain response, and post-treatment ambulatory status, in the studies that reported it, was 100 percent [82]. Absent any direct comparisons, the authors compared these results with those of six published reports (including a randomized trial [46]) of surgical decompression plus cEBRT. Crude local control rates ranged from 4 to 79 percent, and ambulatory rates (in the series reporting this endpoint) were 80 to 87 percent. In the few series that specified tumor control outcome by histology, local control rates for radioresistant primaries ranged from 60 to 100 percent after SBRT, compared with roughly 41 percent of patients treated with cEBRT (range 0 to 72 percent).

Maximal surgical excision plus cEBRT — For patients with high-grade ESCC and/or spinal instability from relatively radioresistant tumors who do not have access to SBRT, surgery aims

to completely or maximally excise the tumor, since radioresistant tumors have poor responsiveness to cEBRT alone. A more protracted course of cEBRT (eg, 30 Gy over 10 days) is typically used postoperatively to reduce the risk of local recurrence. Compared with separation surgery, maximal tumor resection often requires both anterior and posterior decompression and stabilization.

The benefit of surgical decompression followed by cEBRT was shown in a randomized trial that compared direct circumferential surgical decompression followed by cEBRT (30 Gy over 10 days, starting within 14 days of surgery) with the same radiation therapy alone in 101 patients with symptomatic metastatic ESCC caused by solid tumor metastases [46]. Enrolled patients had a known cancer diagnosis (patients with lymphoma or a primary spine tumor were excluded), had a single level of cord compression, and could not have been paraplegic for more than 48 hours. Both groups received the same initial dose of glucocorticoids (dexamethasone 100 mg initially, then 24 mg every six hours) and either began radiation or underwent surgery within 24 hours of presentation.

The study was stopped after a planned interim analysis, which showed that patients treated with surgery followed by cEBRT had a significantly higher ambulatory rate (84 versus 57 percent) and retained the ability to walk significantly longer than those treated with cEBRT alone (median 122 versus 13 days). In addition, 10 of 16 patients who were initially unable to walk regained the ability to ambulate after surgery, compared with 3 of 16 treated with cEBRT alone. Three of 10 patients who failed to respond to cEBRT regained the ability to walk after salvage surgery. The use of glucocorticoids and opioid analgesics was also reduced in those treated surgically.

A later unplanned subgroup analysis from this trial also suggested an important interaction between age and treatment [83]. Preservation of ambulation was significantly prolonged in surgically treated patients under the age of 65, but not in older individuals. This association has not been found in other analyses [84].

Embolization of highly vascular tumors is occasionally used as an adjunct to make surgery safer, through reduction in intraoperative blood loss.

Role of vertebroplasty, kyphoplasty, and percutaneous spinal instrumentation — Patients with painful compression fractures due to metastatic disease without high-grade ESCC or retropulsion of bone fragments into the spinal canal benefit from minimally invasive techniques such as percutaneous vertebroplasty and kyphoplasty, as an adjunct to radiation therapy [85]. Patients with spinal instability associated with high-grade ESCC or retropulsion of bone

fragments are not candidates for this approach due to the risk of exacerbating spinal cord compression.

Both techniques involve cement injection into the fractured vertebral body through a needle, with kyphoplasty using an expandable balloon in order to create a cavity for cement injection and vertebroplasty using direct injection without cavity creation. A prospective trial that randomized patients with painful metastatic compression fractures to undergo kyphoplasty or nonoperative management showed that kyphoplasty resulted in much earlier and larger improvement in mobility and decrease in pain [86]. There are no trials directly comparing vertebroplasty with kyphoplasty. (See "Osteoporotic thoracolumbar vertebral compression fractures: Clinical manifestations and treatment", section on 'Vertebral augmentation procedures (vertebroplasty and kyphoplasty)'.)

For patients with fractures extending into the pedicles, patients with extensive lytic destruction of the vertebral body osseous cortex, and patients with high-grade ESCC who do not require surgical decompression, the use of percutaneously placed spinal instrumentation provides safe and reliable stabilization with consistent pain relief [87]. Such minimally invasive instrumented stabilization provides a safe alternative to cement augmentation for patients with more complex vertebral structures.

Systemic therapy — There are no intrinsic reasons why chemotherapy or other forms of systemic antitumor treatment cannot be used to treat ESCC. Among patients with a highly chemosensitive malignancy and ESCC, chemotherapy is an attractive option because it can also treat tumor deposits elsewhere in the body. However, most patients with ESCC have a tumor that is not highly chemosensitive. Additionally, systemic therapy may require several days or weeks to take effect, and patients with ESCC generally require more expeditious tumor treatment, necessitating local therapy such as radiation and/or surgery.

Tumors in which chemotherapy has been used in selected cases to successfully treat ESCC include Hodgkin lymphoma [88], non-Hodgkin lymphoma [89], neuroblastoma [90], germ cell neoplasms [91], and breast cancer [92]. There are also case reports of patients with prostate cancer and breast cancer deriving benefit from hormonal manipulation [92,93].

PROGNOSIS

Overall survival — The median survival in large historical series following the diagnosis of ESCC is approximately six months [2,5,94,95]. Modern series describing treatment outcomes of patients with ESCC report longer survival, with many patients surviving several years after

treatment [12,96]. Such prolonged survival supports the need for durable local control and surgical constructs that provide stabilization on the scale of years rather than months.

The outcome is better in ambulatory patients [2,5,97], and approximately one-half of patients surviving one year are still ambulatory at that time [6]. The median survival for patients ambulatory prior to radiation therapy is 8 to 10 months compared with 2 to 4 months for those who are nonambulatory [2,98,99]. For those who remain nonambulatory at the conclusion of radiation, the median survival is only one month [2].

The prognosis is better in patients with hematologic malignancies, breast cancer, or prostate cancer, and significantly worse with lung cancer [2,94,96,97]. Studies suggest a median survival of 9 to 10 months for breast and prostate cancer, lymphoma, and multiple myeloma compared with three to four months for lung cancer. In patients with breast cancer, hormone receptor-negative tumors, particularly those lacking human epidermal growth factor receptor 2 (HER2) overexpression (ie, triple-negative tumors), are associated with worse survival compared with hormone receptor-positive tumors [100].

Modest improvement in postoperative survival has been observed for patients with colon, lung, breast, and kidney metastases in the modern era [71]. While the presence of targetable mutations generally confers a survival advantage for patients with cancer in general, such mutations lose prognostic significance when surgery is performed in the setting of cancer progression after targeted therapy was initiated [101].

Neurologic function — Pretreatment neurologic function is the strongest predictor of post-treatment neurologic function [2-4]. In most series, 67 to 82 percent of patients who are ambulatory when treated remain ambulatory at the conclusion of therapy [2,12,51,102]. Approximately one-third of patients who are nonambulatory because of paraparesis regain the ability to walk with treatment, as do 2 to 6 percent of those who are paraplegic; higher rates are reported in series with predominantly radiosensitive neoplasms [2].

The likelihood of being ambulatory after treatment is higher among patients whose motor deficits developed more slowly (over longer than two weeks versus less than one week prior to therapy) [103], and in nonambulatory patients, among those whose treatment is begun less than 12 hours after loss of ambulation [104]. Among patients who require a urinary catheter before therapy, 20 to 40 percent will become catheter free [3,5].

The underlying tumor type is also a major predictor of neurologic response to conventional external beam radiation therapy (cEBRT), which allows for patients with radiosensitive tumors to be treated effectively with cEBRT, even when there is evidence of high-grade ESCC. Patients who are paraparetic or even paraplegic have a much better chance of recovery if they have a tumor

such as lymphoma, myeloma, seminoma, small cell lung cancer (SCLC), breast cancer, prostate cancer, or ovarian cancer [2,16,45,105]. Patients with one of these histologies are also less likely to suffer local relapse of their epidural disease [45,106].

Disease extent also influences outcomes. Complete subarachnoid block produced by the tumor is a poor prognostic sign [4,107].

MANAGEMENT OF RECURRENT ESCC

Following primary treatment for ESCC, patients are at risk for recurrent ESCC [7,106,108,109]. Recurrence can occur at the same initial level or at a remote level. The rate of recurrence depends on multiple factors including the tumor type, the initial treatment modality, and the dose and fractionation of radiation.

The main options for retreatment are stereotactic body radiotherapy (SBRT), a second course of conventional external beam radiation therapy (cEBRT), and surgery [66,110-115]. Similar to a first occurrence of ESCC, treatment decisions are individualized based on consideration of neurologic, oncologic, mechanical, and systemic factors, in addition to any local therapies previously delivered at the involved level(s). (See 'Baseline assessment' above.)

Many patients who fail prior cEBRT may be eligible for SBRT. The benefit of SBRT in this setting was demonstrated in a report of 500 spinal metastases in 393 patients, the vast majority (69 percent) of whom were treated with high-dose SBRT for radiographic tumor progression after cEBRT [66]. Long-term tumor control was achieved in 88 percent.

Observational data suggest that a second course of cEBRT can be given reasonably safely to patients with no other satisfactory options [43,51,111,116,117]. The importance of ambulatory status at the time of reirradiation on motor function was shown in an analysis of data from two randomized trials of hypofractionated cEBRT for initial treatment [43,51]; 24 patients had an in-field recurrence, of whom 12 underwent reirradiation [116]. None of the five nonambulatory patients regained the ability to walk, while six of seven ambulatory patients retained ambulation. The median survival after reirradiation was five months, and the median duration of response was 4.5 months.

Although reirradiation may result in a cumulative dose exceeding the reported radiation tolerance of the spinal cord (45 Gy in 2 Gy fractions), radiation myelopathy in this setting is an infrequent occurrence [111,112,117]. This may be attributable to repair of sublethal radiation damage between courses [118] or the generally short survival of patients receiving repeat irradiation (median, five months) compared with the latency of radiation myelopathy. In

addition, some radiation oncologists have argued that spinal cord tolerance has been defined too conservatively and may be closer to 60 Gy in 2 Gy fractions [119]. (See "Complications of spinal cord irradiation".)

In carefully selected patients, a second decompressive surgery may be considered. In a series of 39 patients who underwent reoperation because of tumor recurrence causing high-grade ESCC, 65 percent remained ambulatory until death or last follow-up, and functional status was maintained or improved in 97 percent [120]. However, a high complication rate is often observed in patients undergoing resection and stabilization after prior cEBRT. In a series of 110 patients undergoing aggressive tumor resection for ESCC following cEBRT, 47 of whom had failed to respond to prior irradiation and 44 percent of whom were nonambulatory, postoperative complications occurred in 48 percent and were related statistically to age over 65 years, prior treatment, and presence of paraparesis [81].

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Neoplastic epidural spinal cord compression" and "Society guideline links: Cancer pain" and "Society guideline links: Management of bone metastases in solid tumors".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5^{th} to 6^{th} grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10^{th} to 12^{th} grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topics (see "Patient education: Cauda equina syndrome (The Basics)" and "Patient education: Bone metastases (The Basics)")

SUMMARY AND RECOMMENDATIONS

- **Definition** – Neoplastic epidural spinal cord compression (ESCC) is a common complication of cancer that can cause pain and potentially irreversible loss of neurologic function. We consider any radiologic evidence of indentation of the thecal sac to be evidence for ESCC (figure 1 and image 1). (See 'Introduction' above.)

- **Glucocorticoids** – For patients with neurologic deficits or pain associated with ESCC, we suggest high-dose glucocorticoid therapy (**Grade 2C**). A typical dose is 10 mg dexamethasone intravenously followed by 16 mg daily orally in divided doses. (See 'Glucocorticoids' above.)

- **Baseline assessment** – The urgency and selection of definitive treatment are informed by the degree of neurologic compromise (figure 1 and image 1), the oncologic characteristics of the primary tumor (if known) (table 1), the mechanical stability of the spine (table 2), and the systemic burden of cancer and medical comorbidities. (See 'Baseline assessment' above and 'Selection of definitive treatment' above.)

- **Patients with spinal instability** – For patients with spinal instability due to ESCC, spine stabilization is generally required before proceeding with radiation therapy. Stabilization can be accomplished by external brace application, by open or percutaneous instrumented stabilization, or by percutaneous cement vertebral repair in patients who are suitable candidates for a radiation-alone approach. (See 'Patients with spinal instability' above and 'Surgical decompression and spine stabilization' above.)

- **All other patients** – In the absence of spinal instability, our approach to definitive treatment is as follows (algorithm 1):

  - **Previously untreated radiosensitive tumor, regardless of ESCC grade** – We suggest conventional external beam radiation therapy (cEBRT) rather than surgery plus radiation (**Grade 2C**). Surgery may allow for more rapid decompression of the spinal cord in some cases and can be considered in patients with solid tumors such as breast and prostate cancer who have neurologic deficits from high-grade ESCC. (See 'Radiosensitive tumors' above.)

  - **Low-grade ESCC (grade 1) due to a relatively radioresistant tumor** – We suggest stereotactic body radiation therapy (SBRT) rather than cEBRT (**Grade 2C**). If SBRT is not available, options include cEBRT or surgical excision followed by cEBRT. (See 'Radioresistant tumors with low-grade ESCC' above.)

- **High-grade ESCC (grade 2 or 3) due to a relatively radioresistant tumor** – We suggest surgical decompression and stabilization followed by radiation therapy rather than radiation alone (**Grade 2B**). When surgery is not pursued due to factors such as extensive and heavily pretreated systemic disease and very short expected survival, symptom palliation can usually be achieved with glucocorticoids and short-course cEBRT or, for selected patients with grade 2 disease, SBRT using a hypofractionated regimen. (See 'Radioresistant tumors with high-grade ESCC' above.)

- **Surgical technique** – For most patients who undergo surgery for ESCC, we suggest separation surgery with postoperative SBRT rather than maximal surgical excision with postoperative cEBRT (**Grade 2C**). Both techniques provide effective local control and palliation, and our preference for separation surgery is based on shorter anesthesia time and lower risk of surgical morbidity. (See 'Surgical decompression and spine stabilization' above.)

- **cEBRT technique** – When patients are selected for cEBRT, the dose and schedule of radiation should be individualized. Shorter courses of cEBRT provide short-term palliation, while longer courses provide more durable local tumor control. (See 'Dose and fractionation' above.)

  - **Patients with short expected survival (≤3 to 6 months)** – We suggest a short course of cEBRT (eg, 5 fractions or less) instead of a more protracted treatment schedule (**Grade 2B**). A single, large fraction (8 Gy x 1) can be offered as a convenient palliative option in patients with a very short life expectancy (≤3 months), whereas a multifraction short course (eg, 4 Gy x 5) offers similar to slightly better ambulatory outcomes.

  - **Patients with more favorable prognosis** – For patients with a more favorable prognosis, such as those with oligometastatic disease, a histologic diagnosis of myeloma or lymphoma, or those who are receiving radiation after maximal surgical excision, we suggest a more protracted course of cEBRT (eg, 30 Gy in 10 fractions) (**Grade 2C**).

- **SBRT technique** – Relatively high doses of SBRT must be used to overcome tumor resistance to radiation and achieve optimal results. Typically, spine SBRT is delivered as 16 to 24 Gy in a single fraction, 24 Gy in two fractions, or 27 to 30 Gy in three fractions. (See 'Stereotactic body radiotherapy' above.)

- **Recurrent ESCC** – Management of recurrent ESCC is individualized according to patient characteristics and prior treatments received. Many patients who fail prior cEBRT may be eligible for SBRT. (See 'Management of recurrent ESCC' above.)

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REFERENCES

1. Laufer I, Zuckerman SL, Bird JE, et al. Predicting Neurologic Recovery after Surgery in Patients with Deficits Secondary to MESCC: Systematic Review. Spine (Phila Pa 1976) 2016; 41 Suppl 20:S224.
2. Maranzano E, Latini P. Effectiveness of radiation therapy without surgery in metastatic spinal cord compression: final results from a prospective trial. Int J Radiat Oncol Biol Phys 1995; 32:959.
3. Bach F, Larsen BH, Rohde K, et al. Metastatic spinal cord compression. Occurrence, symptoms, clinical presentations and prognosis in 398 patients with spinal cord compression. Acta Neurochir (Wien) 1990; 107:37.
4. Helweg-Larsen S, Johnsen A, Boesen J, Sørensen PS. Radiologic features compared to clinical findings in a prospective study of 153 patients with metastatic spinal cord compression treated by radiotherapy. Acta Neurochir (Wien) 1997; 139:105.
5. Maranzano E, Latini P, Beneventi S, et al. Comparison of two different radiotherapy schedules for spinal cord compression in prostate cancer. Tumori 1998; 84:472.
6. Kim RY, Spencer SA, Meredith RF, et al. Extradural spinal cord compression: analysis of factors determining functional prognosis--prospective study. Radiology 1990; 176:279.
7. Greenberg HS, Kim JH, Posner JB. Epidural spinal cord compression from metastatic tumor: results with a new treatment protocol. Ann Neurol 1980; 8:361.
8. Maranzano E, Latini P, Checcaglini F, et al. Radiation therapy of spinal cord compression caused by breast cancer: report of a prospective trial. Int J Radiat Oncol Biol Phys 1992; 24:301.
9. Maranzano E, Latini P, Checcaglini F, et al. Radiation therapy in metastatic spinal cord compression. A prospective analysis of 105 consecutive patients. Cancer 1991; 67:1311.
10. Martenson JA Jr, Evans RG, Lie MR, et al. Treatment outcome and complications in patients treated for malignant epidural spinal cord compression (SCC). J Neurooncol 1985; 3:77.

11. Husband DJ. Malignant spinal cord compression: prospective study of delays in referral and treatment. BMJ 1998; 317:18.
12. Rades D, Huttenlocher S, Dunst J, et al. Matched pair analysis comparing surgery followed by radiotherapy and radiotherapy alone for metastatic spinal cord compression. J Clin Oncol 2010; 28:3597.
13. Findlay GF. Adverse effects of the management of malignant spinal cord compression. J Neurol Neurosurg Psychiatry 1984; 47:761.
14. Laufer I, Rubin DG, Lis E, et al. The NOMS framework: approach to the treatment of spinal metastatic tumors. Oncologist 2013; 18:744.
15. Bilsky MH, Laufer I, Fourney DR, et al. Reliability analysis of the epidural spinal cord compression scale. J Neurosurg Spine 2010; 13:324.
16. Gerszten PC, Mendel E, Yamada Y. Radiotherapy and radiosurgery for metastatic spine disease: what are the options, indications, and outcomes? Spine (Phila Pa 1976) 2009; 34:S78.
17. Fisher CG, DiPaola CP, Ryken TC, et al. A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. Spine (Phila Pa 1976) 2010; 35:E1221.
18. Hawkins JE, Dworzynski K, Haden N, Guideline committee. Spinal metastases and metastatic spinal cord compression: summary of updated NICE guidance. BMJ 2023; 383:1973.
19. Fourney DR, Frangou EM, Ryken TC, et al. Spinal instability neoplastic score: an analysis of reliability and validity from the spine oncology study group. J Clin Oncol 2011; 29:3072.
20. MacLean MA, Touchette CJ, Georgiopoulos M, et al. Systemic considerations for the surgical treatment of spinal metastatic disease: a scoping literature review. Lancet Oncol 2022; 23:e321.
21. Paulino Pereira NR, Mclaughlin L, Janssen SJ, et al. The SORG nomogram accurately predicts 3- and 12-months survival for operable spine metastatic disease: External validation. J Surg Oncol 2017; 115:1019.
22. Massaad E, Hadzipasic M, Alvarez-Breckenridge C, et al. Predicting tumor-specific survival in patients with spinal metastatic renal cell carcinoma: which scoring system is most accurate? J Neurosurg Spine 2020; :1.
23. Spine Oncology Research Group nomogram. https://www.sorg-ai.com/spine (Accessed on March 01, 2021).

24. Lawton AJ, Lee KA, Cheville AL, et al. Assessment and Management of Patients With Metastatic Spinal Cord Compression: A Multidisciplinary Review. J Clin Oncol 2019; 37:61.
25. Loblaw DA, Perry J, Chambers A, Laperriere NJ. Systematic review of the diagnosis and management of malignant extradural spinal cord compression: the Cancer Care Ontario Practice Guidelines Initiative's Neuro-Oncology Disease Site Group. J Clin Oncol 2005; 23:2028.
26. Loblaw DA, Mitera G, Ford M, Laperriere NJ. A 2011 updated systematic review and clinical practice guideline for the management of malignant extradural spinal cord compression. Int J Radiat Oncol Biol Phys 2012; 84:312.
27. George R, Jeba J, Ramkumar G, et al. Interventions for the treatment of metastatic extradural spinal cord compression in adults. Cochrane Database Syst Rev 2015; :CD006716.
28. Kumar A, Weber MH, Gokaslan Z, et al. Metastatic Spinal Cord Compression and Steroid Treatment: A Systematic Review. Clin Spine Surg 2017; 30:156.
29. Heimdal K, Hirschberg H, Slettebø H, et al. High incidence of serious side effects of high-dose dexamethasone treatment in patients with epidural spinal cord compression. J Neurooncol 1992; 12:141.
30. Maranzano E, Latini P, Beneventi S, et al. Radiotherapy without steroids in selected metastatic spinal cord compression patients. A phase II trial. Am J Clin Oncol 1996; 19:179.
31. Ushio Y, Posner R, Kim JH, et al. Treatment of experimental spinal cord compression caused by extradural neoplasms. J Neurosurg 1977; 47:380.
32. Delattre JY, Arbit E, Rosenblum MK, et al. High dose versus low dose dexamethasone in experimental epidural spinal cord compression. Neurosurgery 1988; 22:1005.
33. Sørensen S, Helweg-Larsen S, Mouridsen H, Hansen HH. Effect of high-dose dexamethasone in carcinomatous metastatic spinal cord compression treated with radiotherapy: a randomised trial. Eur J Cancer 1994; 30A:22.
34. Vecht CJ, Haaxma-Reiche H, van Putten WL, et al. Initial bolus of conventional versus high-dose dexamethasone in metastatic spinal cord compression. Neurology 1989; 39:1255.
35. Graham PH, Capp A, Delaney G, et al. A pilot randomised comparison of dexamethasone 96 mg vs 16 mg per day for malignant spinal-cord compression treated by radiotherapy: TROG 01.05 Superdex study. Clin Oncol (R Coll Radiol) 2006; 18:70.
36. Zacharia BE, Kahn S, Bander ED, et al. Incidence and risk factors for preoperative deep venous thrombosis in 314 consecutive patients undergoing surgery for spinal metastasis. J Neurosurg Spine 2017; 27:189.

37. Fadul CE, Lemann W, Thaler HT, Posner JB. Perforation of the gastrointestinal tract in patients receiving steroids for neurologic disease. Neurology 1988; 38:348.
38. Lee SH, Cox KM, Grant R, et al. Patient positioning (mobilisation) and bracing for pain relief and spinal stability in metastatic spinal cord compression in adults. Cochrane Database Syst Rev 2012; :CD007609.
39. Huisman M, van der Velden JM, van Vulpen M, et al. Spinal instability as defined by the spinal instability neoplastic score is associated with radiotherapy failure in metastatic spinal disease. Spine J 2014; 14:2835.
40. Hussain I, Barzilai O, Reiner AS, et al. Patient-reported outcomes after surgical stabilization of spinal tumors: symptom-based validation of the Spinal Instability Neoplastic Score (SINS) and surgery. Spine J 2018; 18:261.
41. Wang JC, Boland P, Mitra N, et al. Single-stage posterolateral transpedicular approach for resection of epidural metastatic spine tumors involving the vertebral body with circumferential reconstruction: results in 140 patients. Invited submission from the Joint Section Meeting on Disorders of the Spine and Peripheral Nerves, March 2004. J Neurosurg Spine 2004; 1:287.
42. Mendel E, Bourekas E, Gerszten P, Golan JD. Percutaneous techniques in the treatment of spine tumors: what are the diagnostic and therapeutic indications and outcomes? Spine (Phila Pa 1976) 2009; 34:S93.
43. Maranzano E, Trippa F, Casale M, et al. 8Gy single-dose radiotherapy is effective in metastatic spinal cord compression: results of a phase III randomized multicentre Italian trial. Radiother Oncol 2009; 93:174.
44. Rades D, Fehlauer F, Schulte R, et al. Prognostic factors for local control and survival after radiotherapy of metastatic spinal cord compression. J Clin Oncol 2006; 24:3388.
45. Katagiri H, Takahashi M, Inagaki J, et al. Clinical results of nonsurgical treatment for spinal metastases. Int J Radiat Oncol Biol Phys 1998; 42:1127.
46. Patchell RA, Tibbs PA, Regine WF, et al. Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: a randomised trial. Lancet 2005; 366:643.
47. Laufer I, Iorgulescu JB, Chapman T, et al. Local disease control for spinal metastases following "separation surgery" and adjuvant hypofractionated or high-dose single-fraction stereotactic radiosurgery: outcome analysis in 186 patients. J Neurosurg Spine 2013; 18:207.

48. Schiff D, O'Neill BP, Suman VJ. Spinal epidural metastasis as the initial manifestation of malignancy: clinical features and diagnostic approach. Neurology 1997; 49:452.
49. Myrehaug S, Sahgal A, Hayashi M, et al. Reirradiation spine stereotactic body radiation therapy for spinal metastases: systematic review. J Neurosurg Spine 2017; 27:428.
50. Folkert MR, Bilsky MH, Cohen GN, et al. Local recurrence outcomes using the ^{32}P intraoperative brachytherapy plaque in the management of malignant lesions of the spine involving the dura. Brachytherapy 2015; 14:202.
51. Maranzano E, Bellavita R, Rossi R, et al. Short-course versus split-course radiotherapy in metastatic spinal cord compression: results of a phase III, randomized, multicenter trial. J Clin Oncol 2005; 23:3358.
52. Young RF, Post EM, King GA. Treatment of spinal epidural metastases. Randomized prospective comparison of laminectomy and radiotherapy. J Neurosurg 1980; 53:741.
53. Zelefsky MJ, Scher HI, Krol G, et al. Spinal epidural tumor in patients with prostate cancer. Clinical and radiographic predictors of response to radiation therapy. Cancer 1992; 70:2319.
54. Rades D, Šegedin B, Conde-Moreno AJ, et al. Radiotherapy With 4 Gy × 5 Versus 3 Gy × 10 for Metastatic Epidural Spinal Cord Compression: Final Results of the SCORE-2 Trial (ARO 2009/01). J Clin Oncol 2016; 34:597.
55. Hoskin PJ, Hopkins K, Misra V, et al. Effect of Single-Fraction vs Multifraction Radiotherapy on Ambulatory Status Among Patients With Spinal Canal Compression From Metastatic Cancer: The SCORAD Randomized Clinical Trial. JAMA 2019; 322:2084.
56. Rades D, Lange M, Veninga T, et al. Preliminary results of spinal cord compression recurrence evaluation (score-1) study comparing short-course versus long-course radiotherapy for local control of malignant epidural spinal cord compression. Int J Radiat Oncol Biol Phys 2009; 73:228.
57. Rades D, Stalpers LJ, Veninga T, et al. Evaluation of five radiation schedules and prognostic factors for metastatic spinal cord compression. J Clin Oncol 2005; 23:3366.
58. Rades D, Huttenlocher S, Šegedin B, et al. Single-Fraction Versus 5-Fraction Radiation Therapy for Metastatic Epidural Spinal Cord Compression in Patients With Limited Survival Prognoses: Results of a Matched-Pair Analysis. Int J Radiat Oncol Biol Phys 2015; 93:368.
59. Rades D, Šegedin B, Conde-Moreno AJ, et al. Patient-Reported Outcomes-Secondary Analysis of the SCORE-2 Trial Comparing 4 Gy × 5 to 3 Gy × 10 for Metastatic Epidural Spinal Cord Compression. Int J Radiat Oncol Biol Phys 2019; 105:760.
60. Lee KA, Dunne M, Small C, et al. (ICORG 05-03): prospective randomized non-inferiority phase III trial comparing two radiation schedules in malignant spinal cord compression

(not proceeding with surgical decompression); the quality of life analysis. Acta Oncol 2018; 57:965.

61. Rades D, Hoskin PJ, Stalpers LJ, et al. Short-course radiotherapy is not optimal for spinal cord compression due to myeloma. Int J Radiat Oncol Biol Phys 2006; 64:1452.
62. Rades D, Veninga T, Stalpers LJ, et al. Outcome after radiotherapy alone for metastatic spinal cord compression in patients with oligometastases. J Clin Oncol 2007; 25:50.
63. Klish DS, Grossman P, Allen PK, et al. Irradiation of spinal metastases: should we continue to include one uninvolved vertebral body above and below in the radiation field? Int J Radiat Oncol Biol Phys 2011; 81:1495.
64. Yamada Y, Katsoulakis E, Laufer I, et al. The impact of histology and delivered dose on local control of spinal metastases treated with stereotactic radiosurgery. Neurosurg Focus 2017; 42:E6.
65. Yamada Y, Bilsky MH, Lovelock DM, et al. High-dose, single-fraction image-guided intensity-modulated radiotherapy for metastatic spinal lesions. Int J Radiat Oncol Biol Phys 2008; 71:484.
66. Gerszten PC, Burton SA, Ozhasoglu C, Welch WC. Radiosurgery for spinal metastases: clinical experience in 500 cases from a single institution. Spine (Phila Pa 1976) 2007; 32:193.
67. Ryu S, Fang Yin F, Rock J, et al. Image-guided and intensity-modulated radiosurgery for patients with spinal metastasis. Cancer 2003; 97:2013.
68. Gerszten PC, Burton SA, Ozhasoglu C, et al. Stereotactic radiosurgery for spinal metastases from renal cell carcinoma. J Neurosurg Spine 2005; 3:288.
69. Chang EL, Shiu AS, Mendel E, et al. Phase I/II study of stereotactic body radiotherapy for spinal metastasis and its pattern of failure. J Neurosurg Spine 2007; 7:151.
70. Guckenberger M, Mantel F, Sweeney RA, et al. Long-Term Results of Dose-Intensified Fractionated Stereotactic Body Radiation Therapy (SBRT) for Painful Spinal Metastases. Int J Radiat Oncol Biol Phys 2021; 110:348.
71. Rothrock RJ, Li Y, Lis E, et al. Hypofractionated spinal stereotactic body radiation therapy for high-grade epidural disease. J Neurosurg Spine 2020; :1.
72. Sahgal A, Atenafu EG, Chao S, et al. Vertebral compression fracture after spine stereotactic body radiotherapy: a multi-institutional analysis with a focus on radiation dose and the spinal instability neoplastic score. J Clin Oncol 2013; 31:3426.
73. Cunha MV, Al-Omair A, Atenafu EG, et al. Vertebral compression fracture (VCF) after spine stereotactic body radiation therapy (SBRT): analysis of predictive factors. Int J Radiat Oncol Biol Phys 2012; 84:e343.

74. Thibault I, Al-Omair A, Masucci GL, et al. Spine stereotactic body radiotherapy for renal cell cancer spinal metastases: analysis of outcomes and risk of vertebral compression fracture. J Neurosurg Spine 2014; 21:711.
75. Sahgal A, Whyne CM, Ma L, et al. Vertebral compression fracture after stereotactic body radiotherapy for spinal metastases. Lancet Oncol 2013; 14:e310.
76. Benzil DL, Saboori M, Mogilner AY, et al. Safety and efficacy of stereotactic radiosurgery for tumors of the spine. J Neurosurg 2004; 101 Suppl 3:413.
77. Gibbs IC, Patil C, Gerszten PC, et al. Delayed radiation-induced myelopathy after spinal radiosurgery. Neurosurgery 2009; 64:A67.
78. Sioutos PJ, Arbit E, Meshulam CF, Galicich JH. Spinal metastases from solid tumors. Analysis of factors affecting survival. Cancer 1995; 76:1453.
79. Siegal T, Siegal T, Robin G, et al. Anterior decompression of the spine for metastatic epidural cord compression: a promising avenue of therapy? Ann Neurol 1982; 11:28.
80. Harrington KD. Anterior decompression and stabilization of the spine as a treatment for vertebral collapse and spinal cord compression from metastatic malignancy. Clin Orthop Relat Res 1988; :177.
81. Sundaresan N, Sachdev VP, Holland JF, et al. Surgical treatment of spinal cord compression from epidural metastasis. J Clin Oncol 1995; 13:2330.
82. Redmond KJ, Lo SS, Fisher C, Sahgal A. Postoperative Stereotactic Body Radiation Therapy (SBRT) for Spine Metastases: A Critical Review to Guide Practice. Int J Radiat Oncol Biol Phys 2016; 95:1414.
83. Chi JH, Gokaslan Z, McCormick P, et al. Selecting treatment for patients with malignant epidural spinal cord compression-does age matter?: results from a randomized clinical trial. Spine (Phila Pa 1976) 2009; 34:431.
84. Rades D, Rudat V, Veninga T, et al. A score predicting posttreatment ambulatory status in patients irradiated for metastatic spinal cord compression. Int J Radiat Oncol Biol Phys 2008; 72:905.
85. Lutz S, Balboni T, Jones J, et al. Palliative radiation therapy for bone metastases: Update of an ASTRO Evidence-Based Guideline. Pract Radiat Oncol 2017; 7:4.
86. Berenson J, Pflugmacher R, Jarzem P, et al. Balloon kyphoplasty versus non-surgical fracture management for treatment of painful vertebral body compression fractures in patients with cancer: a multicentre, randomised controlled trial. Lancet Oncol 2011; 12:225.
87. Moussazadeh N, Rubin DG, McLaughlin L, et al. Short-segment percutaneous pedicle screw fixation with cement augmentation for tumor-induced spinal instability. Spine J 2015;

15:1609.

88. Burch PA, Grossman SA. Treatment of epidural cord compressions from Hodgkin's disease with chemotherapy. A report of two cases and a review of the literature. Am J Med 1988; 84:555.
89. Wong ET, Portlock CS, O'Brien JP, DeAngelis LM. Chemosensitive epidural spinal cord disease in non-Hodgkins lymphoma. Neurology 1996; 46:1543.
90. Hayes FA, Thompson EI, Hvizdala E, et al. Chemotherapy as an alternative to laminectomy and radiation in the management of epidural tumor. J Pediatr 1984; 104:221.
91. Grommes C, Bosl GJ, DeAngelis LM. Treatment of epidural spinal cord involvement from germ cell tumors with chemotherapy. Cancer 2011; 117:1911.
92. Boogerd W, van der Sande JJ, Kröger R, et al. Effective systemic therapy for spinal epidural metastases from breast carcinoma. Eur J Cancer Clin Oncol 1989; 25:149.
93. Sasagawa I, Gotoh H, Miyabayashi H, et al. Hormonal treatment of symptomatic spinal cord compression in advanced prostatic cancer. Int Urol Nephrol 1991; 23:351.
94. Schiff D, O'Neill BP, Wang CH, O'Fallon JR. Neuroimaging and treatment implications of patients with multiple epidural spinal metastases. Cancer 1998; 83:1593.
95. Sørensen S, Børgesen SE, Rohde K, et al. Metastatic epidural spinal cord compression. Results of treatment and survival. Cancer 1990; 65:1502.
96. Fehlings MG, Nater A, Tetreault L, et al. Survival and Clinical Outcomes in Surgically Treated Patients With Metastatic Epidural Spinal Cord Compression: Results of the Prospective Multicenter AOSpine Study. J Clin Oncol 2016; 34:268.
97. Rades D, Veninga T, Stalpers LJ, et al. Prognostic factors predicting functional outcomes, recurrence-free survival, and overall survival after radiotherapy for metastatic spinal cord compression in breast cancer patients. Int J Radiat Oncol Biol Phys 2006; 64:182.
98. Huang J, Jatoi A. Morbidity and mortality in patients with cancer who become nonambulatory after spinal cord compression: a case series on end-of-life care. J Palliat Med 2009; 12:219.
99. Savage P, Sharkey R, Kua T, et al. Malignant spinal cord compression: NICE guidance, improvements and challenges. QJM 2014; 107:277.
100. Wang M, Jensen AB, Morgen SS, et al. Survival analysis of breast cancer subtypes in patients with spinal metastases. Spine (Phila Pa 1976) 2014; 39:1620.
101. Chakravarthy VB, Schachner B, Amin AG, et al. The Impact of Targetable Mutations on Clinical Outcomes of Metastatic Epidural Spinal Cord Compression in Patients With Non-

Small-Cell Lung Cancer Treated With Hybrid Therapy (Surgery Followed by Stereotactic Body Radiation Therapy). Neurosurgery 2023; 92:557.

102. Rades D, Walz J, Stalpers LJ, et al. Short-course radiotherapy (RT) for metastatic spinal cord compression (MSCC) due to renal cell carcinoma: results of a retrospective multi-center study. Eur Urol 2006; 49:846.
103. Rades D, Heidenreich F, Karstens JH. Final results of a prospective study of the prognostic value of the time to develop motor deficits before irradiation in metastatic spinal cord compression. Int J Radiat Oncol Biol Phys 2002; 53:975.
104. Zaidat OO, Ruff RL. Treatment of spinal epidural metastasis improves patient survival and functional state. Neurology 2002; 58:1360.
105. Helweg-Larsen S, Rasmusson B, Sørensen PS. Recovery of gait after radiotherapy in paralytic patients with metastatic epidural spinal cord compression. Neurology 1990; 40:1234.
106. Gilbert RW, Kim JH, Posner JB. Epidural spinal cord compression from metastatic tumor: diagnosis and treatment. Ann Neurol 1978; 3:40.
107. Tomita T, Galicich JH, Sundaresan N. Radiation therapy for spinal epidural metastases with complete block. Acta Radiol Oncol 1983; 22:135.
108. Loeffler JS, Glicksman AS, Tefft M, Gelch M. Treatment of spinal cord compression: a retrospective analysis. Med Pediatr Oncol 1983; 11:347.
109. van der Sande JJ, Boogerd W, Kröger R, Kappelle AC. Recurrent spinal epidural metastases: a prospective study with a complete follow up. J Neurol Neurosurg Psychiatry 1999; 66:623.
110. Schiff D, Shaw EG, Cascino TL. Outcome after spinal reirradiation for malignant epidural spinal cord compression. Ann Neurol 1995; 37:583.
111. Rades D, Rudat V, Veninga T, et al. Prognostic factors for functional outcome and survival after reirradiation for in-field recurrences of metastatic spinal cord compression. Cancer 2008; 113:1090.
112. Wright JL, Lovelock DM, Bilsky MH, et al. Clinical outcomes after reirradiation of paraspinal tumors. Am J Clin Oncol 2006; 29:495.
113. Nieder C, Grosu AL, Andratschke NH, Molls M. Proposal of human spinal cord reirradiation dose based on collection of data from 40 patients. Int J Radiat Oncol Biol Phys 2005; 61:851.
114. Milker-Zabel S, Zabel A, Thilmann C, et al. Clinical results of retreatment of vertebral bone metastases by stereotactic conformal radiotherapy and intensity-modulated radiotherapy. Int J Radiat Oncol Biol Phys 2003; 55:162.

115. Garg AK, Wang XS, Shiu AS, et al. Prospective evaluation of spinal reirradiation by using stereotactic body radiation therapy: The University of Texas MD Anderson Cancer Center experience. Cancer 2011; 117:3509.

116. Maranzano E, Trippa F, Casale M, et al. Reirradiation of metastatic spinal cord compression: definitive results of two randomized trials. Radiother Oncol 2011; 98:234.

117. Wallace ND, Dunne MT, McArdle O, et al. Efficacy and toxicity of primary re-irradiation for malignant spinal cord compression based on radiobiological modelling: a phase II clinical trial. Br J Cancer 2023; 128:576.

118. Ang KK, Price RE, Stephens LC, et al. The tolerance of primate spinal cord to re-irradiation. Int J Radiat Oncol Biol Phys 1993; 25:459.

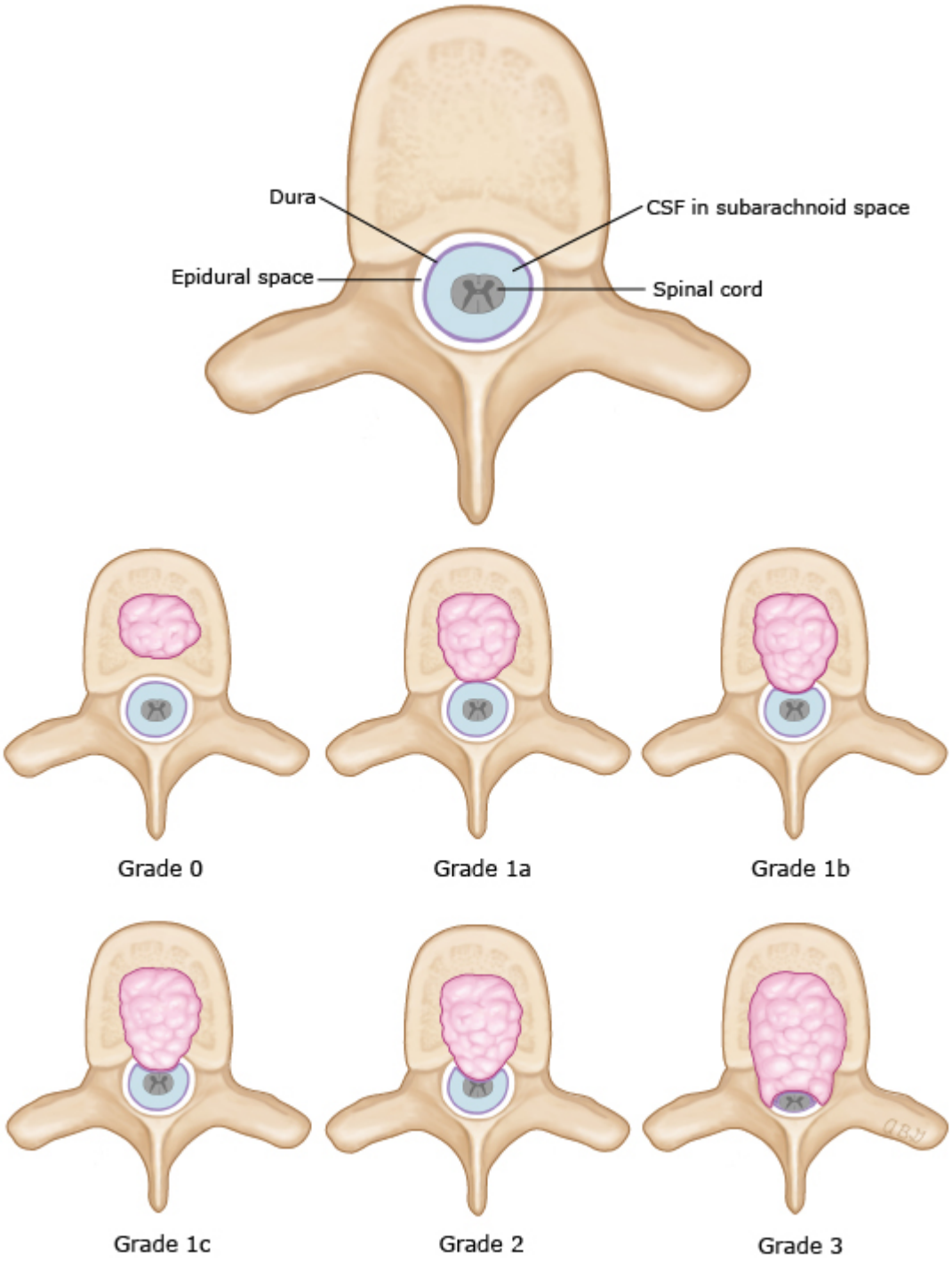
119. Schultheiss TE, Stephens LC. Invited review: permanent radiation myelopathy. Br J Radiol 1992; 65:737.

120. Laufer I, Hanover A, Lis E, et al. Repeat decompression surgery for recurrent spinal metastases. J Neurosurg Spine 2010; 13:109.

Topic 2820 Version 52.0

GRAPHICS

Schematic representation of the ESCC grading scale



Grade 0 – Tumor confined to bone.

Grade 1a – Tumor with epidural extension, without displacement of thecal sac.

Grade 1b – Tumor with epidural extension and displacement of thecal sac but no contact with the spinal cord.

Grade 1c – Tumor with epidural extension and spinal cord abutment, without displacement.

Grade 2 – Tumor that displaces or compresses the spinal cord, without circumferential tumor extension or obliteration of the CSF space.

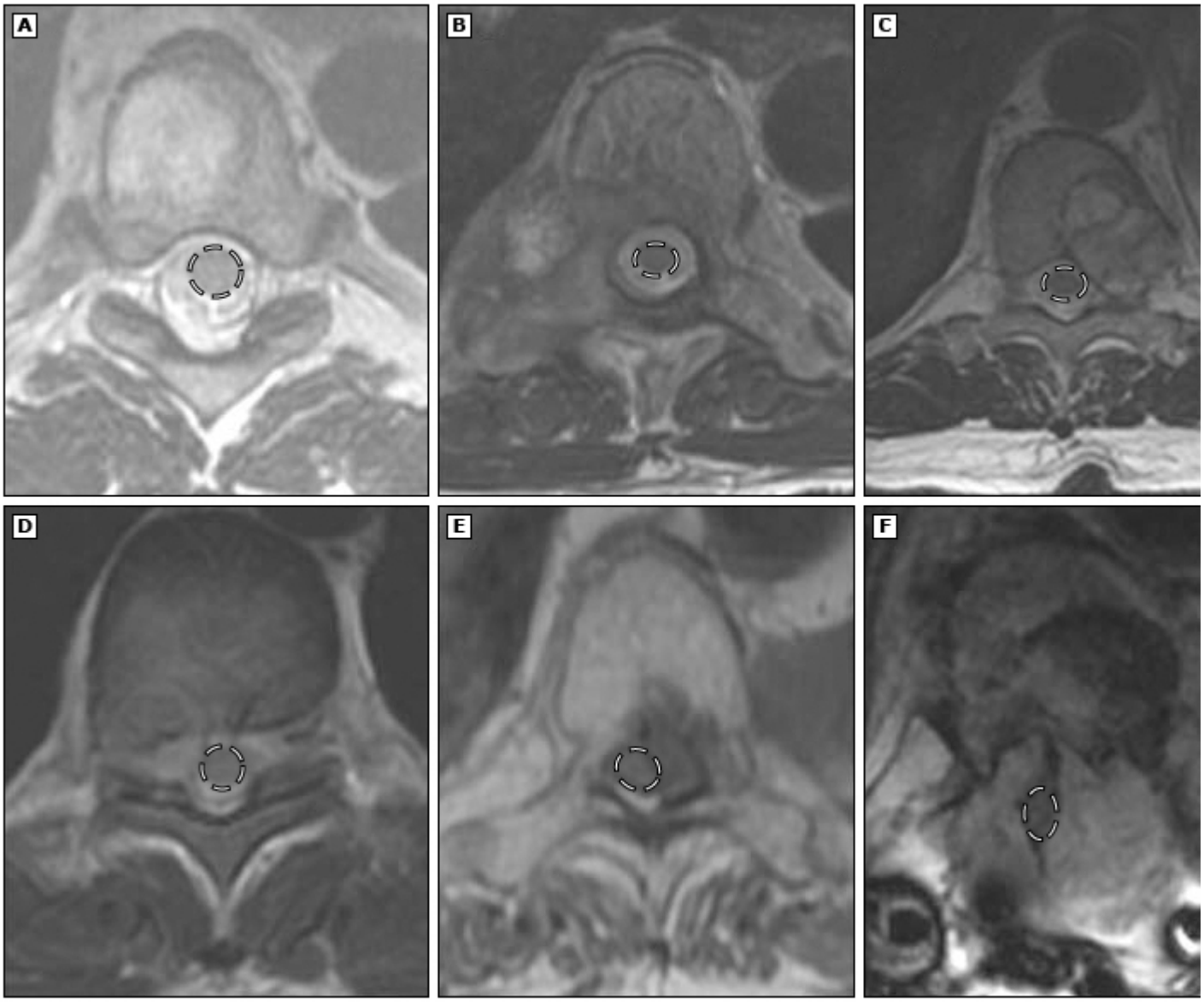
Grade 3 – Tumor with circumferential epidural extension and/or that causes severe spinal cord compression with obliteration of the CSF space.

ESCC: epidural spinal cord compression; CSF: cerebrospinal fluid.

Modified from: Bilsky MH, Laufer I, Fourney DR, et al. Reliability analysis of the epidural spinal cord compression scale. J Neurosurg Spine 2010; 13:324.

Graphic 119111 Version 2.0

ESCC grading



Axial T2-weighted MR images representing progressive grades of ESCC. The spinal cord is encircled in white in each image.

(A) Grade 0 – Tumor confined to bone (not considered ESCC).

(B) Grade 1a – Tumor with epidural extension, without displacement of thecal sac.

(C) Grade 1b – Epidural tumor with thecal sac compression but no cord contact.

(D) Grade 1c – Epidural tumor with thecal sac compression and cord contact without compression.

(E) Grade 2 – Tumor that displaces or compresses the spinal cord, without circumferential tumor extension or obliteration of the CSF space.

(F) Grade 3 – Tumor with circumferential epidural extension and/or that causes severe spinal cord compression with obliteration of the CSF space.

ESCC: epidural spinal cord compression; MR: magnetic resonance; CSF: cerebrospinal fluid.

Graphic 119112 Version 3.0

Relative radiosensitivity of neoplasms for the purposes of ESCC decision-making*

Radiosensitive tumors	Radioresistant tumors
▪ Lymphoma ▪ Myeloma ▪ Small cell lung cancer ▪ Germ cell tumors ▪ Prostate cancer ▪ Breast cancer	▪ Melanoma ▪ Renal cell carcinoma ▪ Non-small cell lung cancer ▪ Gastrointestinal cancers ▪ Sarcoma

ESCC: epidural spinal cord compression; NOMS: Neoplasm, Oncologic, Mechanical, Systemic; cEBRT: conventional external beam radiation therapy.

* For the purposes of ESCC decision-making as part of the NOMS framework, tumors are classified as "relatively radiosensitive" and "relatively radioresistant" based on their predicted responsiveness to cEBRT in the dose ranges that are within spinal cord tolerance.

Graphic 119129 Version 2.0

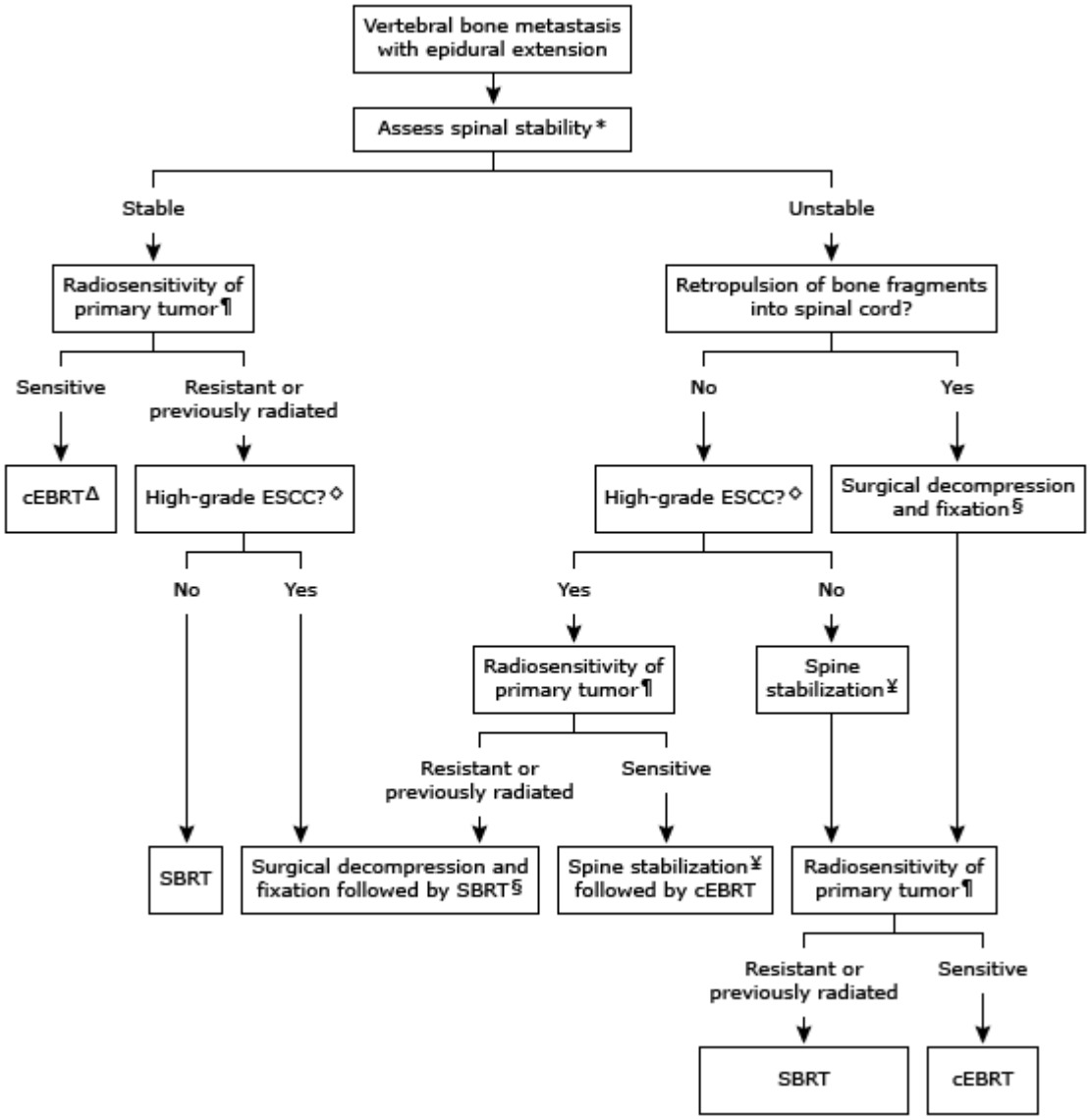
Classification system for Spine Instability Neoplastic Score (SINS)

Component scores for clinical and radiographic findings	Score
Spine location	
Junctional (occiput-C2, C7-T2, T11-L1, L5-S1)	3
Mobile spine (C3-C6, L2-L4)	2
Semi-rigid (T3-T10)	1
Rigid (S2-S5)	0
Pain relief with recumbence (lying down) or pain with movement/loading of the spine	
Yes	3
No (occasional pain but not mechanical)	1
Pain-free lesion	0
Bone lesion quality	
Lytic	2
Mixed lytic/blastic	1
Blastic	0
Radiographic spinal alignment	
Subluxation/translation present	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Vertebral body collapse	
>50% collapse	3
<50% collapse	2
No collapse with >50% body involved	1
None of the above	0
Posterolateral involvement of spinal elements (facet, pedicle, or costovertebral joint fracture or replacement with tumor)	
Bilateral	3
Unilateral	1
None of the above	0

The SINS score is generated by adding all of the scores from the six individual components (minimal score is 0, maximal score is 18)		
Score	**Classification**	**Action**
0 to 6	Stable spine	
7 to 12	Indeterminant	Possible impending instability, warrants surgical consultation
13 to 18	Instability	Warrants surgical consultation

Graphic 80396 Version 3.0

Suggested algorithm for the management of epidural spinal cord compression (ESCC)



cEBRT: conventional external beam radiation therapy; SBRT: stereotactic body radiation therapy.

* Spine stability is primarily determined by imaging. Spine Instability Neoplastic Score (SINS) scores ≥7 are generally considered to indicate high risk for spinal instability and warrant surgical consultation; pain caused by movement suggests spinal instability unless proven otherwise. Refer to UpToDate topics on ESCC for further details.

¶ Examples of relatively radioresistant neoplasms for the purposes of ESCC decision-making include melanoma, renal cell carcinoma, non-small cell lung cancer, sarcoma, and gastrointestinal malignancies; relatively radiosensitive neoplasms include lymphoma, myeloma, small cell lung cancer, germ cell tumors, breast cancer, prostate cancer, and ovarian cancer.

Δ Although solid tumors such as breast and prostate cancer generally respond well to cEBRT, response can take time, and surgery should at least be considered in those patients with neurologic deficits due to high-grade ESCC to allow rapid decompression of the spinal cord.

◇ High-grade ESCC refers to patients with an ESCC radiologic grade of 2 or 3, even if asymptomatic. Grade 2 ESCC tumors displace or compress the spinal cord, without circumferential epidural extension or obliteration of the cerebrospinal fluid (CSF) space; grade 3 ESCC tumors cause severe spinal cord compression with obliteration of the CSF space. Many patients with high-grade ESCC have deficits attributable to spinal cord compression (ie, myelopathy) or nerve root compression (ie, radiculopathy).

§ Patients who are not suitable candidates for surgery or who decline surgery may be treated by cEBRT, preceded by noninvasive stabilization if spine is unstable. Selected patients with grade 2 ESCC may be candidates for hypofractionated SBRT.

¥ Stabilization options include percutaneous cement augmentation, percutaneous pedicle screw instrumentation, and open instrumentation.

Graphic 60269 Version 8.0

Contributor Disclosures

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