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Surgery for Primary Vertebral Tumors: En Bloc versus Intralesional Resection

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Surgical techniques for the removal of spinal tumors have undergone tremendous advances over the past few decades, largely in step with segmental instrumentation, radical reconstruction, and combined surgical modalities. Aggressive vertebral column removal can be performed to allow "gross total" resection, with circumferential reconstruction achieved in most cases.

Intralesional resection can generally be defined as removal of the tumor, with violation of the tumor capsule and piecemeal removal of cancerous growth, with margins defined by the tumor itself. En bloc resection can be generally defined as complete removal of the tumor without violation of its capsule, and with clearly defined normal tissue as margins.

The decision of which technique to employ is of great importance, and much debate has ensued in the literature, given the differences in the degree of difficulty and complication rates between the two techniques. Additionally, en bloc resection is not always feasible without significant morbidity and risk, while intralesional resection would surely predispose to earlier recurrence. This article first reviews the classification systems used for primary vertebral tumors, which many use as a tool to determine the feasibility of resection, and second discusses the optimal role of en bloc and intralesional resection for primary vertebral tumors.

Classification system

In 1980, Enneking and colleagues [1,2] proposed an oncologic staging system defining the biologic behavior of primary tumors, in an effort to more effectively plan and evaluate surgical resection of limb tumors. In an effort to apply a similar system for the management of spine lesions, Enneking and colleagues [3] then created a classification scheme for primary tumors of the spine. The latter staging system divides benign tumors into three stages (S1, S2, S3) and localized malignant tumors into four stages (IA, IB, IIA, IIB). Two further stages include metastatic high-grade intra- and extra-compartmental malignant tumors (IIIA and IIIB, respectively) (Fig. 1). Multiple authors have applied the Enneking staging system to primary tumors of the spine; however, lack of clarification of resection-related terms, such as "intralesional," "marginal," "wide," and "radical" in such studies, has led to considerable confusion when planning management. Central to this problem is that, although techniques for en bloc or radical oncologic resection of spine tumors has been well established since the 1970s, application of common terminology and a universally accepted staging system dedicated to the surgical management had not yet evolved. Without an exact clarification

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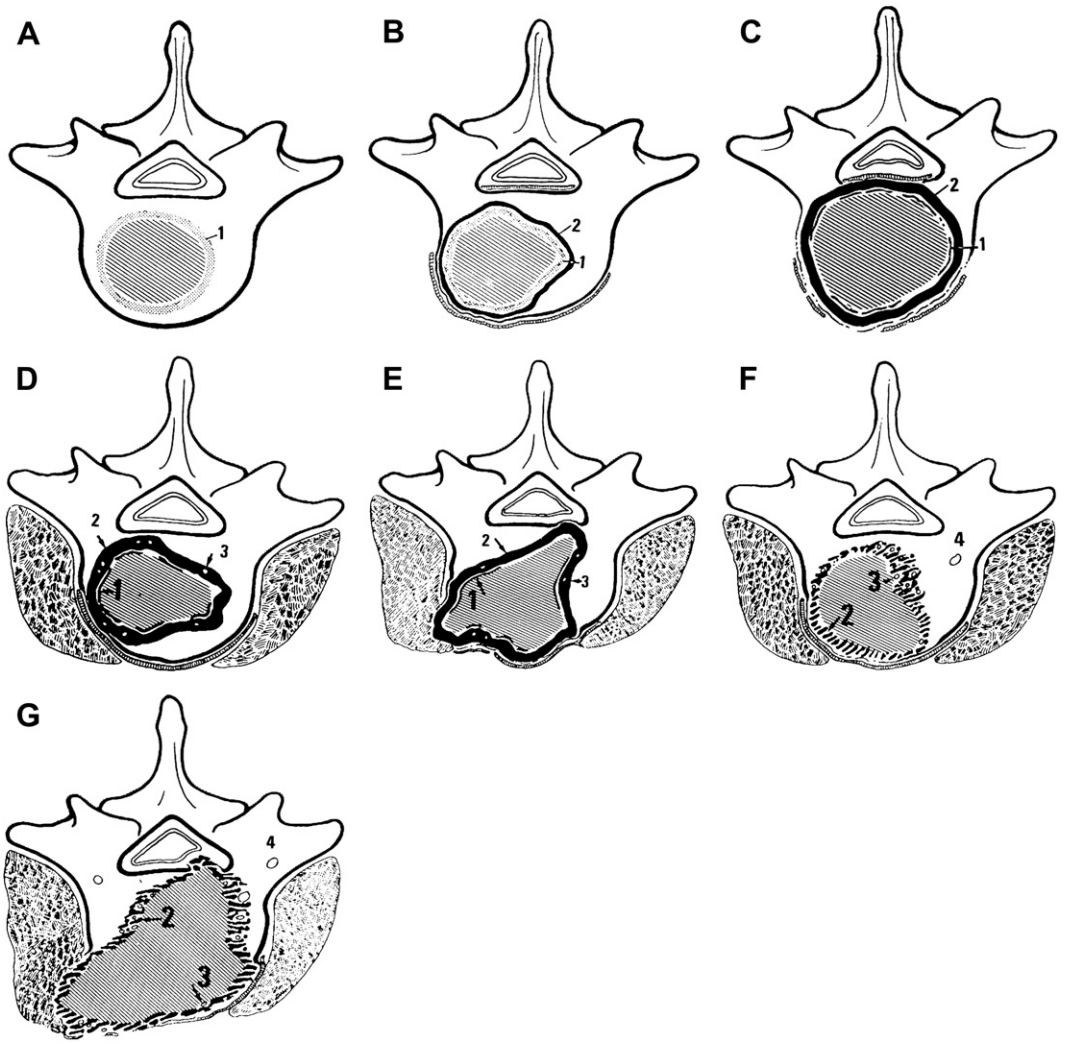

Fig. 1. (*A*) Inactive benign, encapsulated tumor. (*B*) Active benign, encapsulated tumor. (*C*) Aggressive benign tumor with expansion of capsule. (*D*) Encapsulated malignant tumor. (*E*) Malignant tumor with extra-skeletal expansion. (*F*) Encapsulated malignant tumor with multiple lesions. (*G*) Malignant tumor with extra-skeletal expansion and multiple lesions. (*From* Boriani S, Weinstein JN, Biagini R. Primary bone tumors of the spine. Terminology and surgical staging. Spine 1997;22:1036–44; with permission.)

of terms like ''radical'' or ''vertebrectomy,'' management and outcome of patients with spinal tumors was difficult to compare objectively.

In 1997, Weinstein, Boriani, and Biagini [4] created a terminology and staging system for primary tumors of the spine, now referred to as the WBB staging system. Specifically, using computed tomography, magnetic resonance imaging, and angiography, the effected vertebra is divided into 12 radiating zones (numbered 1 to 12 in a clockwise order) and into five layers (A to E, from the paravertebral extraosseous region to the dural involvement) in the transverse plane (Fig. 2). The longitudinal extent of the tumor is then further deduced by noting the number of spine segments involved. In this way, a more rigorous approach to surgical planning can be accomplished, as the surgeon plans on tumor resection via clearly delineated margins. In addition, the clock-face radiating zone system emphasizes the limitations in obtaining an en bloc excision because of the spinal cord lying in the longitudinal median axis of

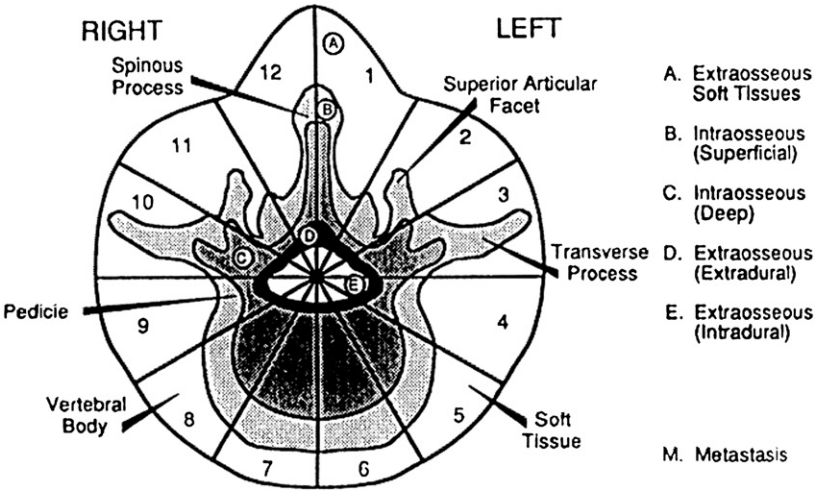

Fig. 2. WBB staging system for spine tumors. (*From* Boriani S, Weinstein JN, Biagini R. Primary bone tumors of the spine. Terminology and surgical staging. Spine 1997;22:1036–44; with permission.)

the vertebra. While respecting the boundaries of the spinal cord, the surgeon is able to resect wedge sections of the vertebra in a so-called "sagittal resection" for vertebral hemi-resection [5].

Using this staging system, Weinstein, Boriani, and Biagini went on to define three major methods for performing en bloc excisions in the thoracolumbar spine, and included the respective indications for each. "Vertebrectomy" is defined as en bloc excision of a tumor occurring in the vertebral body. Of note, an oncologically appropriate margin can be successfully achieved if at least one pedicle is free from tumor. A posterior approach then allows removal of the posterior elements and separation of the anterior surface of the dura from the posterior vertebral wall. An anterior approach may or may not be used, but is often necessitated if the tumor is growing outside the vertebra and soft tissue dissection is expected to be difficult (Fig. 3)."Sagittal resection" is defined as an en bloc excision of a tumor arising eccentrically in the vertebral body, pedicle, or transverse process. With this procedure, a posterior approach is required to remove the posterior healthy elements, and a combined posterior-anterior approach is needed to safely remove the specimen (Fig. 4). Finally, "posterior arch resection" is defined as an en bloc excision of a tumor arising in the arch but in neither pedicle. This procedure can be performed exclusively from a posterior approach (Fig. 5).

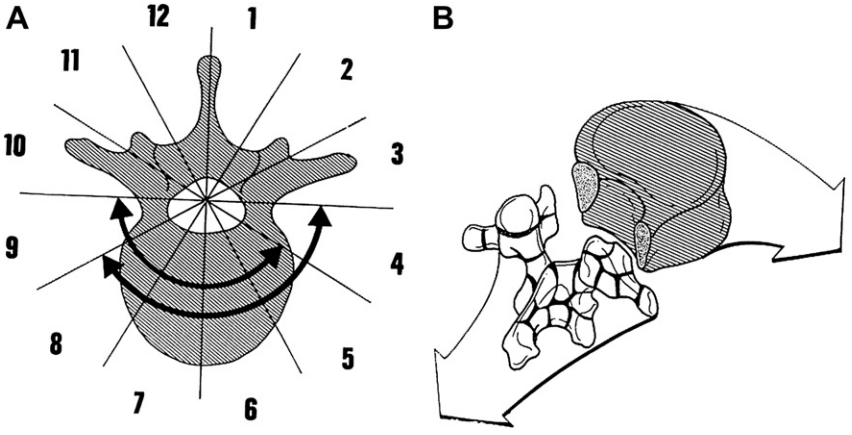

Fig. 3. (*A, B*) "Vertebrectomy" as defined by WBB. (*From* Boriani S, Weinstein JN, Biagini R. Primary bone tumors of the spine. Terminology and surgical staging. Spine 1997;22:1036–44; with permission.)

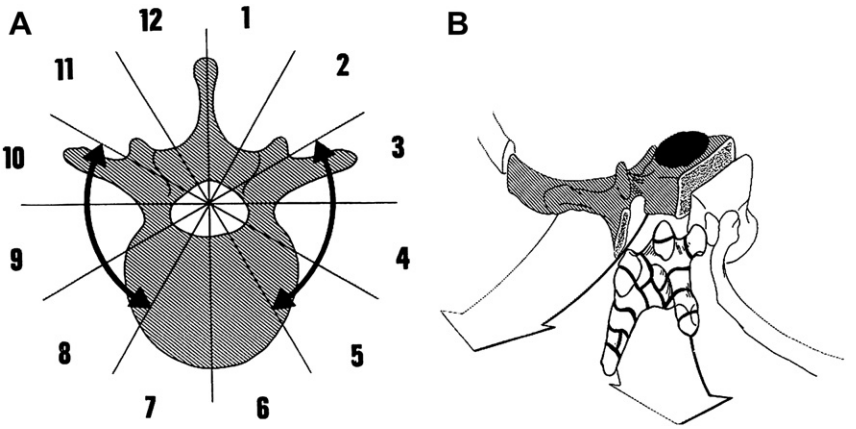

Fig. 4. (*A, B*) "Sagittal resection" as defined by WBB. (*From* Boriani S, Weinstein JN, Biagini R. Primary bone tumors of the spine. Terminology and surgical staging. Spine 1997;22:1036–44; with permission.)

Intralesional resection

Once the workhorse of spinal oncology surgery, intralesional resection is now used for metastatic disease or grade I, benign pathology (Table 1) [6–8]. Resection would employ standard spinal approaches for exposure, and use a combination of curettage, drilling, and piecemeal removal via rongeur. Intralesional resection is less technically demanding, requires less paravertebral exposure, and is a familiar method for spinal surgeons. The major drawback of intralesional resection is the gross violation of tumor margins in cases where complete oncologic removal is desired. However, when benign pathology is present, intralesional resection provides a simple, direct method of tumor removal, with optimal chances of tumor control or cure.

En bloc resection

En bloc resection for musculoskeletal tumors was conceived by Roy-Camille in 1982 [9], and complete or total en bloc spondylectomy for spinal tumors has been recently popularized by leading spinal surgeons in Japan, Europe, and the United States [10–15]. Though technically difficult to perform, the benefit of en bloc spondylectomy is preservation of the tumor margin, thus providing an oncologically complete resection. It is indicated most with malignant and locally aggressive tumors (Table 2). For these tumors,

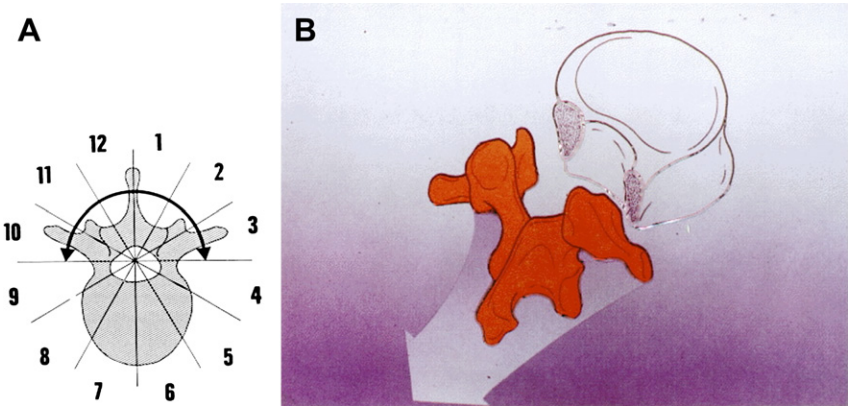

Fig. 5. (*A, B*) "Posterior arch resection" as defined by WBB. (*From* Boriani S, Weinstein JN, Biagini R. Primary bone tumors of the spine. Terminology and surgical staging. Spine 1997;22:1036–44; with permission.)

Table 1
Intralesional resection, acceptable

Pathology	Description
Benign tumors	Osteoid osteoma
	Osteoblastoma
	Chondroma
	Hemangioma
	Teratoma
Malignant tumors	Plasmacytoma
	Metastatic tumors
	Sarcoma (possibly)
Other pathology	Aneurysmal bone cyst
	Eosinophilic granuloma

complete removal without violation of the tumor margin leads to long-term progression-free survival and even possible cure.

Risks and obstacles

Major risks of en bloc spondylectomy include: (1) mechanical and vascular spinal cord injury, (2) injury to the major vascular structures (ie, aorta, vena cava), (3) possible tumor margin violation during resection, and (4) significant operative blood loss because of epidural venous bleeding [14].

Major obstacles to performing en bloc resection include massive size, location involving vital organs or essential functional elements (ie, neck, chest), and inability to provide reconstruction and stabilization or soft tissue coverage of defect. Epidural extension of a tumor has often presented a dilemma for surgeons who feel that true margins cannot be obtained in the presence of epidural spread without removal of the overlying dura [16]. Techniques which incorporate dural removal with en bloc spondylectomy have been reported [10,11,16], but are obviously high risk and challenging procedures, with unclear long range advantage. Other extreme solutions to these obstacles include hemicorporectomy (transection and removal of the lower half of the body) and hemi-pelvectomy (removal of one entire leg and half pelvis). Consideration of these options with the patient must be undertaken in multidisciplinary discussions of alternatives and options.

Table 2
En bloc resection preferred

Pathology	Description
Benign, locally aggressive	Chordoma
	Giant cell tumor
Malignant	Osteosarcoma
	Chondrosarcoma
	Solitary metastatic tumors (possibly)
	Sarcoma?

Recurrence rates and survival

The major advantage of en bloc spondylectomy is its ability to provide longer progression-free survival for locally aggressive and malignant tumors. It is well recognized that for benign aggressive tumors, such as chordoma, local recurrences occur frequently within 2 years after piecemeal resection [15,17,18]. Early recurrence and death affect more than half of patients, and 5-year survival is estimated at 50% to 70% with piecemeal resection with or without radiation [14,15,17]. Conversely, with en bloc excision, 5-year survival rates with benign aggressive pathology have been reported as high as 100% [10,14,17].

Patients with primary malignant spinal tumors are at extremely high risk of local recurrence, and less than half of patients survive beyond 5 years [4,6,19,20]. Recent evidence, though, suggests that with en bloc excision, recurrence can be delayed and 5-year survival can reach 60% to 70% [14]. Several investigators have also reported improved survival with en bloc resection over intralesional debulking of spinal metastases [14,21,22]; however, these results are likely caused by a selection bias, which favored patients with localized and controlled disease status for en bloc excision, while more advanced stage IV patients were selected for intralesional surgery.

Preoperative planning and complication avoidance

Access surgery

En bloc spondylectomy requires extensive paravertebral exposure and careful surgical planning. Detailed familiarity with vascular anatomy is paramount, as is an appreciation for regional anatomy of the neck, chest, abdomen, and pelvis. Extensive bleeding can occur from the epidural venous plexus, segmental arteries and veins, aorta, and vena cava or azygous vein. Transfusion is frequently required and should be planned on in advance. Embolization therapies should be considered in hypervascular tumors, or when sacrifice of a vessel is acceptable and would greatly increase the safety of surgery.

Injury to regional structures, such as the recurrent laryngeal nerve in the neck, the thoracic duct in the chest, and the ureter in the pelvis, can result in difficult-to-manage complications.

Assistance from vascular, thoracic, head and neck, and general surgeons is extremely helpful in gaining safe and adequate access to the region of interest.

Plastic surgery and tissue coverage

Because of the extensive nature of en bloc resections, soft tissue coverage for the resection cavity and surgical area is often problematic. A variety of muscle mobilization, tissue flap, and skin graft techniques can be employed by the plastic surgeon to provide adequate soft tissue coverage, not only in the resection cavity but to cover instrumentation constructs as well. Preoperative planning should include consideration of where vascularized tissue will come from to help cover the surgical defect and hardware, such that surgical incisions can be planned accordingly.

Adjunctive interventions

Though adjunct treatment is typically considered a postoperative intervention, chemotherapy and radiation therapy may have useful roles in preoperative treatment of tumors, depending on pathologic type and morphology. Osteosarcoma and other soft tissue sarcomas may be extremely large, involving vital organs and structures, making en bloc resection nearly impossible. Preoperative chemotherapy and radiation can shrink the tumor down to make the lesion more amenable to either en bloc or intralesional resection, thereby increasing the safety of surgery and decreasing the complexity of the case for the surgeon. For osteosarcoma, recent evidence shows that not only do tumors shrink in size, response to preoperative chemotherapy may also reduce risk of local recurrence following surgery, can help tailor postoperative chemotherapy protocols (based on degree of necrosis, and so forth), and even help prognosticate survival [23–25]. Input from medical oncologists and radiation oncologists should be obtained as soon as possible in a multidisciplinary setting.

Summary

The ability to perform an en bloc resection depends on tumor type, tumor anatomy, and risk of complications. However the decision to select en bloc resection or intralesional resection needs to be tailored to each individual patient and circumstance. Though complete resection with long-term progression-free survival is the goal, it is not always feasible nor advisable, depending on what the patient's expectations are and what the risk of complications may be. However, in cases with favorable circumstances and consensus agreement between physicians, surgeons, and patients, aggressive en bloc removal of spinal tumors can be extremely valuable and may offer the only chance at cure for otherwise devastating malignancies.

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