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Comprehensive Management of Symptomatic and Aggressive Vertebral Hemangiomas

Frank L. Acosta, Jr, MD[a,*], Nader Sanai, MD[a], John H. Chi, MD, MPH[b], Christopher F. Dowd, MD[c], Cynthia Chin, MD[c], Tarik Tihan, MD[d], Dean Chou, MD[a], Philip R. Weinstein, MD[a], Christopher P. Ames, MD[a]

[a]*Department of Neurological Surgery, University of California, San Francisco, R505 Parnassus Avenue, Room M-779, San Francisco, CA 94143-0112, USA*
[b]*Department of Neurological Surgery, Johns Hopkins University, Meyer 7-109 Neurosurgery, 600 North Wolfe Street, Baltimore, MD 21287, USA*
[c]*Department of Radiology, University of California, San Francisco, 505 Parnassus Avenue, San Francisco, CA 94143-0112, USA*
[d]*Department of Pathology, University of California, San Francisco, 505 Parnassus Avenue, San Francisco, CA 94143-0112, USA*

Vertebral hemangiomas are relatively common, benign dysplasias or vascular tumors affecting the vertebral column. They account for approximately 2% to 3% of all spinal tumors and occur with an estimated incidence of 10% to 12% in the population based on large autopsy series and reviews of plain spine radiographs [1–5]. These lesions are usually asymptomatic and often present as incidental findings on plain radiographs [4] and on MRI. Rarely, they may enlarge and cause pain or neurological deficit because of spinal cord compression, vertebral body or arch expansion, or pathologic fracture [5–7]. Radiation therapy or decompressive surgery with or without postoperative radiation has been the traditional means for treating lesions causing spinal pain or spinal cord compression and neurological deficit. However, surgery is often associated with massive hemorrhage from these highly vascular tumors [4,5,7–12]. Moreover, in a small subset of patients, these lesions behave more aggressively and lead to complete circumferential vertebral involvement, including anterior and posterior elements. In these cases, more conservative surgical strategies, such as canal decompression, even with stabilization, do not always result in a permanent cure, despite the reportedly benign nature of this neoplasm. Preoperative transarterial embolization of vessels feeding the hemangioma has been shown to decrease intraoperative blood loss and associated morbidity. These advances in embolization and surgical strategies for spondylectomy and reconstruction have made possible the complete removal and reconstruction of all involved vertebral segments with minimal morbidity [13–18]. Conversely, management of painful lesions has traditionally relied on medical management with analgesics or treatment by radiation therapy [4,19]. Percutaneous vertebroplasty is a relatively new technique that has been used to treat lesions causing pain without neurological deficit [13,16,20–26]. Transarterial particulate embolization or ethanol injection have also recently been reported to be effective in some cases in relieving pain or reversing neurological deficit [4,13,16,23,27–37].

This article focuses on the comprehensive management of symptomatic and aggressive vertebral hemangiomas based upon our experience at

* Corresponding author.
E-mail address: acostaf@post.harvard.edu (F.L. Acosta).

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the University of California, San Francisco, with 22 patients over a 23-year period with an average follow-up period of 65 months (range 2–240 months).

Diagnostic evaluation

The diagnostic evaluation should include plain radiographs and CT scans demonstrating the classical ''honeycombing,'' or vertically oriented vertebral lucencies separated by thickened trabecular bone, indicative of a vertebral hemangioma (Fig. 1). MRI can be used to characterize the degree of soft tissue extension, fat content, and/or spinal cord compression (Fig. 2). Finally, before decompression or vertebrectomy, spinal angiography is performed for preoperative embolization when the above studies suggest the presence of large feeding or draining vessels (Fig. 3).

Pathology

The histologic appearance of hemangiomas consists of benign vascular proliferation with normal capillary and venous structure [11,38,39]. Two types have been described: cavernous and capillary. The most common type of vertebral hemangioma is the cavernous type, which is characterized by large sinusoidal spaces lined by a single layer of epithelium. Only smaller vascular channels distinguish the capillary type of vertebral hemangioma from the cavernous type.

Experience at the University of California, San Francisco

Table 1 summarizes the results of patients managed surgically. Sixteen patients underwent surgery for symptomatic vertebral hemangioma. Fifteen of these patients presented with a neurological deficit and 1 presented with pain as the chief complaint. Six patients presenting with neurological deficit and 1 patient presenting with pain underwent decompressive laminectomy. The remaining 9 patients presenting with neurological deficits with or without pain underwent intralesional spondylectomy for hemangioma resection, followed by anterior column reconstruction with an expandable cage or fibular allograft. All 9 of these patients had evidence of circumferential vertebral involvement with extraosseous tumor extension causing cord compression (Fig. 4). Ten patients (1 laminectomy case and 9 vertebrectomy cases) underwent preoperative embolization. In all cases, preoperative embolization reduced expected intraoperative blood loss. The mean estimated blood loss for patients undergoing vertebrectomy was 400 mL. One patient (#8) presenting with painful myelopathy underwent two palliative transarterial embolizations without pain relief and required a third embolization procedure followed by vertebrectomy for definitive treatment of pain symptoms. Thirteen of 15 patients experienced complete resolution of both neurologic and pain symptoms after initial surgical treatment. One patient (#9) had recurrent myelopathy after initial decompression and required a second

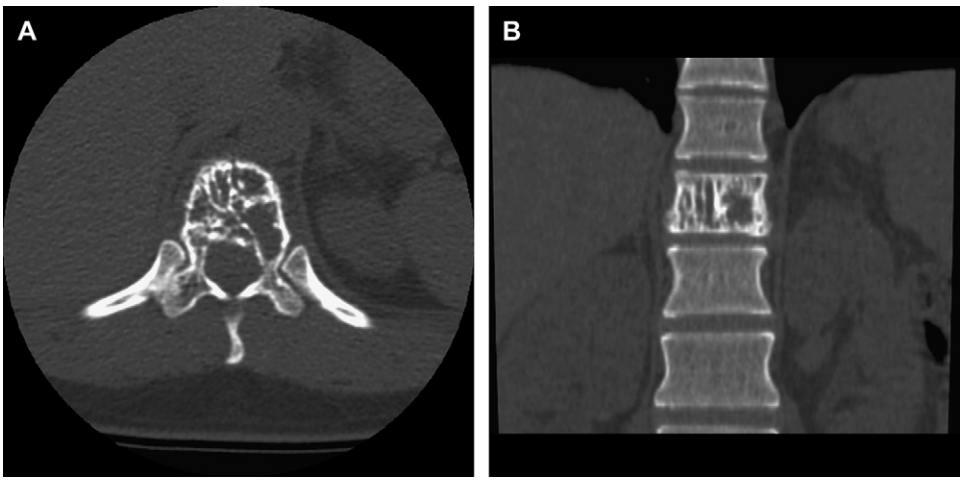

Fig. 1. Axial (*A*) and coronal (*B*) CT reconstruction of a verterbral hemangioma demonstrating the classic ''honeycombing'' pattern.

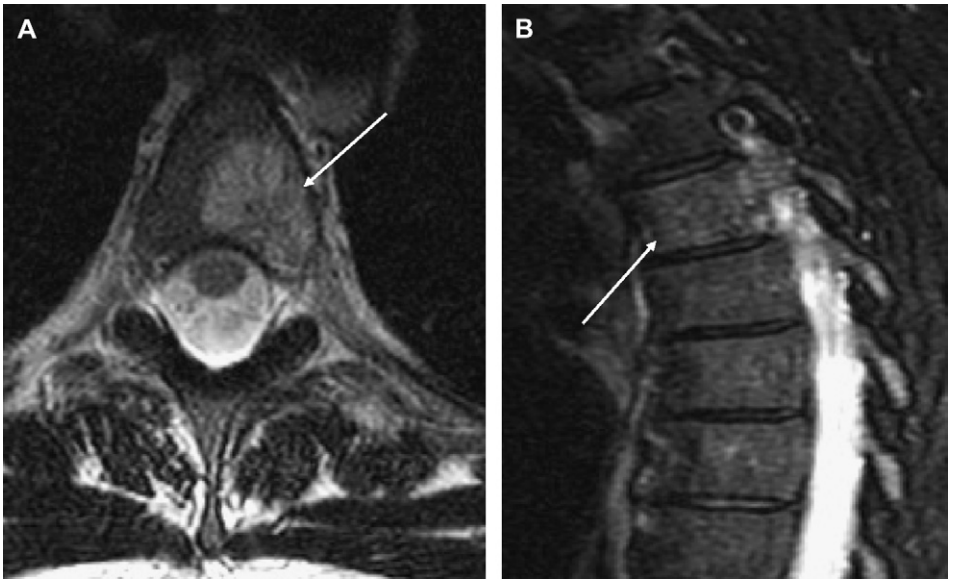

Fig. 2. Axial fast spin echo T2-weighted MRI performed without fat saturation (*A*) shows a hemangioma (*arrow*) markedly increased in signal representing both the adipocyte, edema and vascular content. Note this hemangioma extends into the pedicle. Sagittal fast spin echo T2 sequence with fat saturation (*B*) demonstrates mild increased signal corresponding to the vascular and water content (*arrow*). This patient with severe back pain went on to have successful transarterial embolization.

decompressive operation without embolization. In the second patient (#11), who did not undergo preoperative embolization, excessive bleeding limited initial surgical treatment was limited to decompressive laminectomy. Recurrent tumor growth necessitated reoperation for vertebrectomy and fusion made feasible by preoperative embolization (Fig. 5). None of the patients undergoing vertebrectomy has experienced recurrent or new symptoms to date.

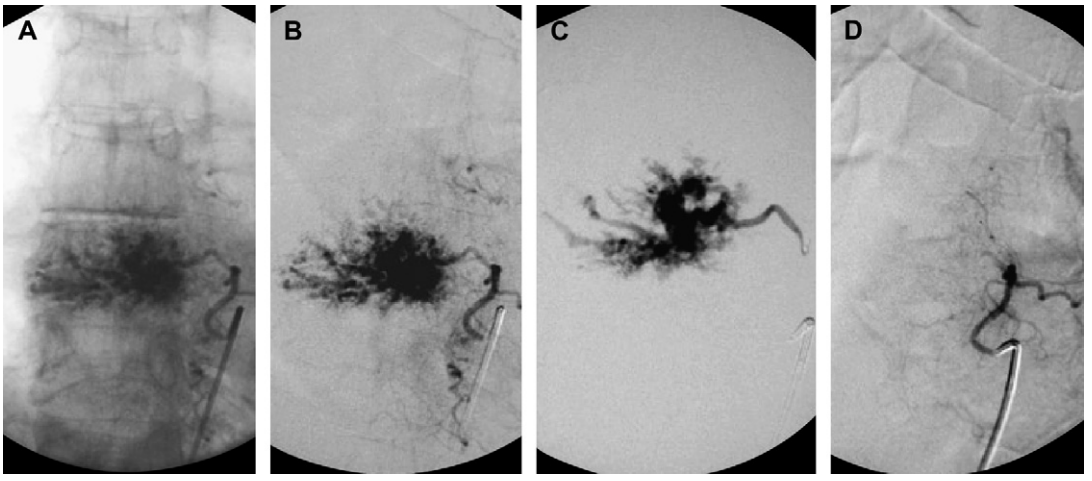

Fig. 3. Anteroposterior spot views from a spinal angiogram via the left T8 intercostal artery show a prominent vascular stain (*A* and *B*) with large venous pools predominantly within the left T8 vertebra. The stain is not visualized after microcatheterization and embolization performed with 250 to 350 μm polyvinyl acetate particles (*C*). (*D*) Postembolization angiogram shows no residual vascular supply.

Table 1
Patients with symptomatic vertebral hemangioma

Patient no.	Age (y)	Sex	Presenting symptom	Vertebral level	Initial treatment	Follow-up (mo)	Time to recurrence (mo)	Outcome at last follow-up
#1	70	F	Pain	L2	TA	21	-	Asymptomatic
#2	78	F	Radiculomyelopathy	L5	Surgical	156	-	Asymptomatic
#3	45	F	Pain	T4	TA	10	-	Asymptomatic
#4	31	F	Pain	T9	VP	77	-	Back pain
#5	27	M	Pain	T10	TA	183	-	Asymptomatic
#6	83	F	Pain	T10	Surgical	156	-	Asymptomatic
#7	54	M	Pain	T7	VP	52	-	Back pain
#8	72	F	Pain, myelopathy	T5	TA	240	29	Asymptomatic[a]
#9	44	M	Radiculomyelopathy	T11, 12	Surgical	144	132	Asymptomatic
#10	56	M	Pain	T8	VP	22	-	Asymptomatic
#11	66	F	Radiculomyelopathy	T8	Surgical	44	34	Asymptomatic
#12	26	F	Radiculomyelopathy	T11	Surgical	2	-	Asymptomatic
#13	32	F	Pain	L3	Surgical	88	-	Asymptomatic
#14	29	M	Pain	L1	VP	6	-	Asymptomatic
#15	83	F	Radiculomyelopathy	T7	Surgical	79	-	Asymptomatic
#16	47	F	Radiculomyelopathy	T7	Surgical	13	-	Asymptomatic
#17	50	M	Radiculomyelopathy	T10	Surgical	12	-	Asymptomatic
#18	68	F	Radiculomyelopathy	T8	Surgical	24	-	Asymptomatic
#19	24	F	Pain, myelopathy	T11	Surgical	18	-	Asymptomatic
#20	24	F	Radiculomyelopathy	T10	Surgical	36	-	Asymptomatic
#21	65	F	Radiculomyelopathy	T4	Surgical	18	-	Asymptomatic
#22	27	M	Radiculomyelopathy		Surgical	29	-	Asymptomatic

Abbreviations: F, female; M, male; TA, transarterial embolization; VP, vertebroplasty; -, no recurrence.
[a] With regard to back pain. Chronic myelopathy was unchanged.

Table 2 summarizes the results of patients treated endovascularly. Four patients underwent initial treatment with transarterial embolization. Pain was the presenting symptom in three patients, while one patient presented with pain and myelopathy. All procedures were deemed anatomically "successful" in terms of obliterating the feeding vessel. The patient presenting with

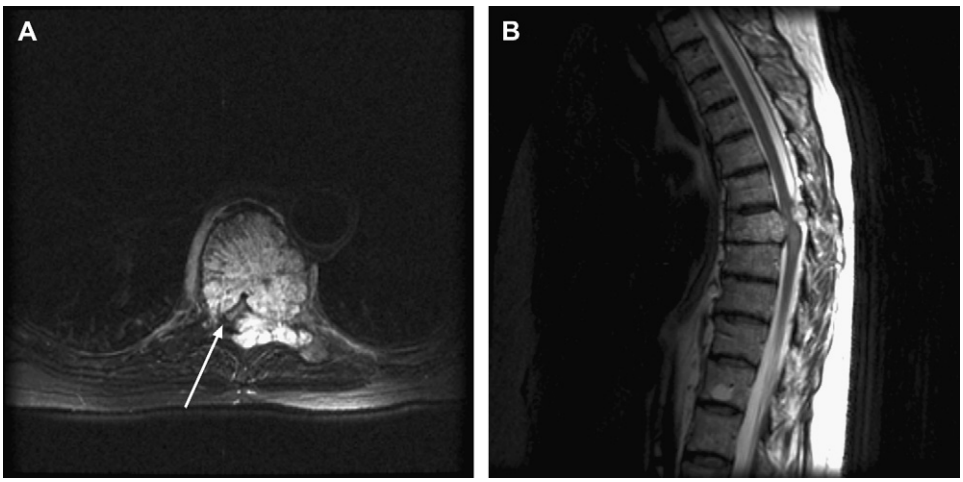

Fig. 4. Axial (*A*) and sagittal (*B*) T2-weighted MRI through a T8 hemangioma shows extension into both pedicles, the left lamina and transverse process, and the left T8 rib. The associated vertebral body expansion and epidural extension results in severe circumferential cord compression with abnormal cord signal (*arrow*).

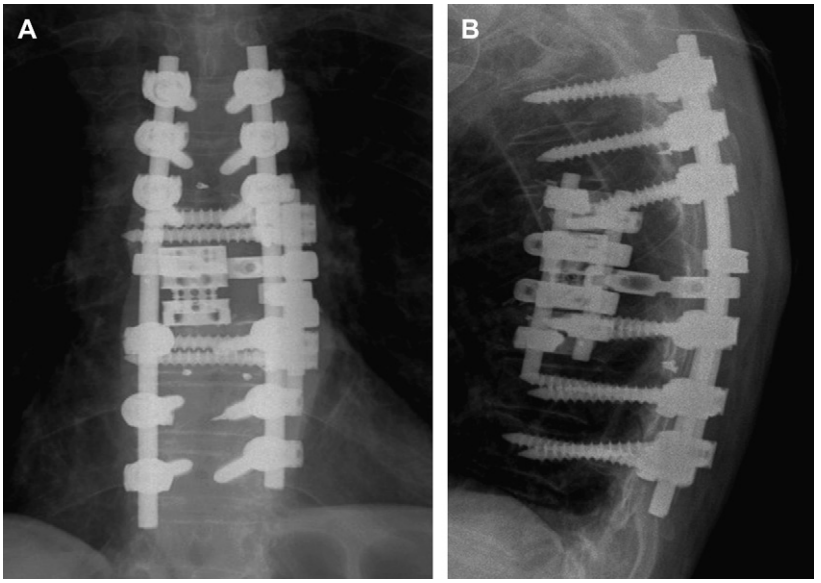

Fig. 5. Anteroposterior (*A*) and lateral (*B*) radiographs after T8 corpectomy with implant of an expandable interbody cage, T7–T9 lateral fusion plate, and T5–T11pedicle screws and rods. This patient's initial surgery (without preoperative embolization) was limited by excessive blood loss to a decompressive laminectomy. Extensive posterior fixation was performed to prevent progression of a marked preoperative kyphotic deformity in this patient.

painful myelopathy (#8) underwent two "successful" transarterial embolizations for palliation of pain symptoms without relief. A third embolization procedure followed by vertebrectomy was required for definitive pain relief. In one patient (#4) presenting with pain only from a thoracic hemangioma, initial attempts at transarterial embolization were aborted because there were bilateral spinal arteries at the level of the hemangioma. A successful vertebroplasty was performed soon thereafter.

Percutaneous vertebroplasty became a treatment option at our institution for symptomatic vertebral hemangiomas beginning in 1998. Four patients were treated with percutaneous polymethylmethacrylate (PMMA) vertebroplasty (Fig. 6). All of these patients presented with a chief complaint of pain and had intraosseous lesions without neurological deficit. Three patients had improvement in pain after the initial vertebroplasty without any further treatment. Two of these patients had complete resolution of pain at final follow-up. One patient (#4) who initially had improvement in back pain after vertebroplasty complained of mild back pain at last follow-up.

Comprehensive management

Most vertebral hemangiomas are asymptomatic lesions discovered incidentally on screening radiographs or CT scans [4,11,13,40]. Occasionally these

Table 2
Results of endovascular embolization according to presenting symptom (N = 4)

Presenting symptoms	Number of patients	Embolization		Recurrent symptoms
		Successful	Unsuccessful	
Pain	3	3	0	0
Neurologic deficit and pain[a]	1	1	0	1[b]

Successful/unsuccessful with respect to embolization of the feeding vessel.

[a] Transarterial embolization performed in this setting was for palliative purposes only.

[b] This patient had another subsequent embolization with persistent back pain and later underwent corpectomy (with preoperative embolization) without recurrent pain symptoms.

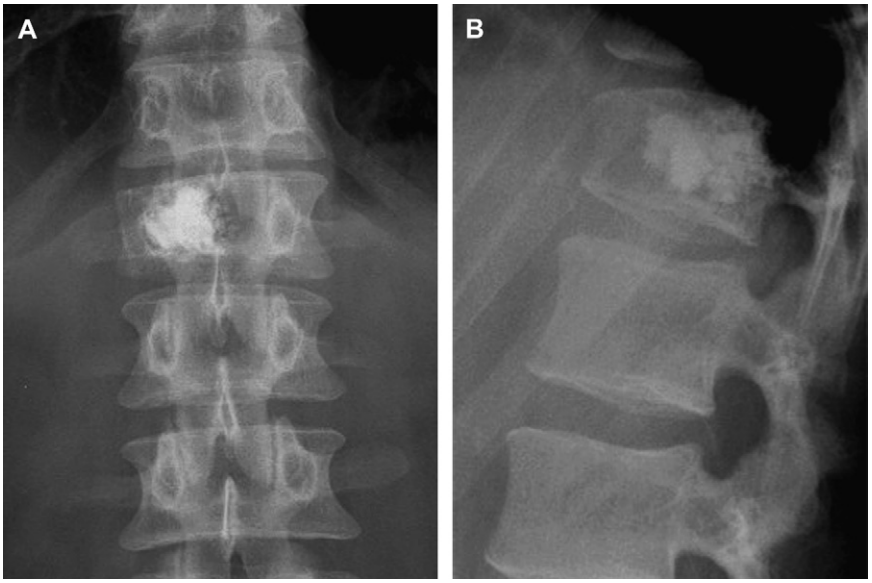

Fig. 6. Anteroposterior (*A*) and lateral (*B*) radiographs show the PMMA within the right L1 vertebral body status after vertebroplasty/kyphoplasty. There is an associated mild compression fracture of the right L1 vertebral body.

lesions may become symptomatic by causing neural arch expansion, vertebral body enlargement, or direct compression of the thecal sac and/or nerve roots by epidural tissue expansion or hemorrhage [3,41]. Symptomatic vertebral hemangiomas have been treated with surgery, transarterial embolization, direct ethanol injection, and vertebroplasty, each with varying degrees of success (Table 3) [6,9,14,16,20,26–28,37,42].

Our experience with 16 cases of symptomatic vertebral hemangioma treated by selecting surgical decompression and/or resection with stabilization, percutaneous vertebroplasty, or transarterial embolization, indicates that each of these modalities can be effective when applied to a particular subset of patients (Fig. 7).

Surgical management

It is generally agreed that surgical decompression should be undertaken if significant or progressive neurological deficit is present [4,7,43]. The choice of surgical procedure and surgical approach (anterior versus posterior) is determined by the location of the hemangioma and by the rate of neurological decline [4,6,7,44,45]. Emergency decompression with laminectomy should be performed in all cases of rapid and progressive neurological deficit [4,6,13,43]. Some investigators have reported cure rates of 70% to 80% using laminectomy alone to treat lesions involving only the posterior elements without soft tissue extension [3–6,43,46,47]. In our series, six patients initially underwent decompressive laminectomy for progressive pain or neurological deficit. All had vertebral body involvement with varying degrees of infiltration of the posterior elements and no evidence of extraosseous tumor. Two patients required reoperation for recurrent tumor growth, while one patient underwent Cyberknife radiosurgery for residual T7 vertebral body tumor extending into the mediastinum. All other laminectomy patients had complete recovery of pain or neurologic function without further surgical or radiation treatment. In our experience, tumors without extravertebral extension do not have a significant destabilizing effect on the structural integrity of the involved vertebrae. To date, we have had no cases of late instability in patients treated with laminectomy alone for these types of tumors. Thus, we have found that decompressive laminectomy alone is useful for treating progressive neurological decline from neural canal stenosis due to osseous tumor growth involving the vertebral body and/or posterior elements, with only a minority of patients requiring a second surgical procedure for recurrent tumor growth. Radiation therapy was used in one postoperative patient to prevent progression of extravertebral tumor growth.

Table 3
Summary of the management and outcome of patients with symptomatic vertebral hemangioma

			Presenting symptoms (number of patients)		Treatment				Outcome			
Investigators	Year	Number of patients	Radiculomyelopathy	Pain	Surgical	Embolization	Vertebroplasty	Ethanol	Surgical	Embolization	Vertebroplasty	Ethanol
Fox, et al	1993	11	11	0	11 (plus radiation therapy in 5)	0	0	0	3 recurrences (27%)	0	0	0
Murugan, et al	2002	13	12	1	8	1	0	4	2 "no improvement" (25%)	1 "minimal" pain (100%)	0	1 "no improvement" (25%)
Cohen, et al	2004	31	Not reported	31	0	0	31	0	0	0	7 required same or increased analgesics (23%)	0
Doppman, et al	2000	11	11	0	0	0	0	11	0	0	0	1 persistent radiculopathy[a] (9%)

[a] Two patients developed pathologic compression fractures due to excessive intravertebral ethanol injection.

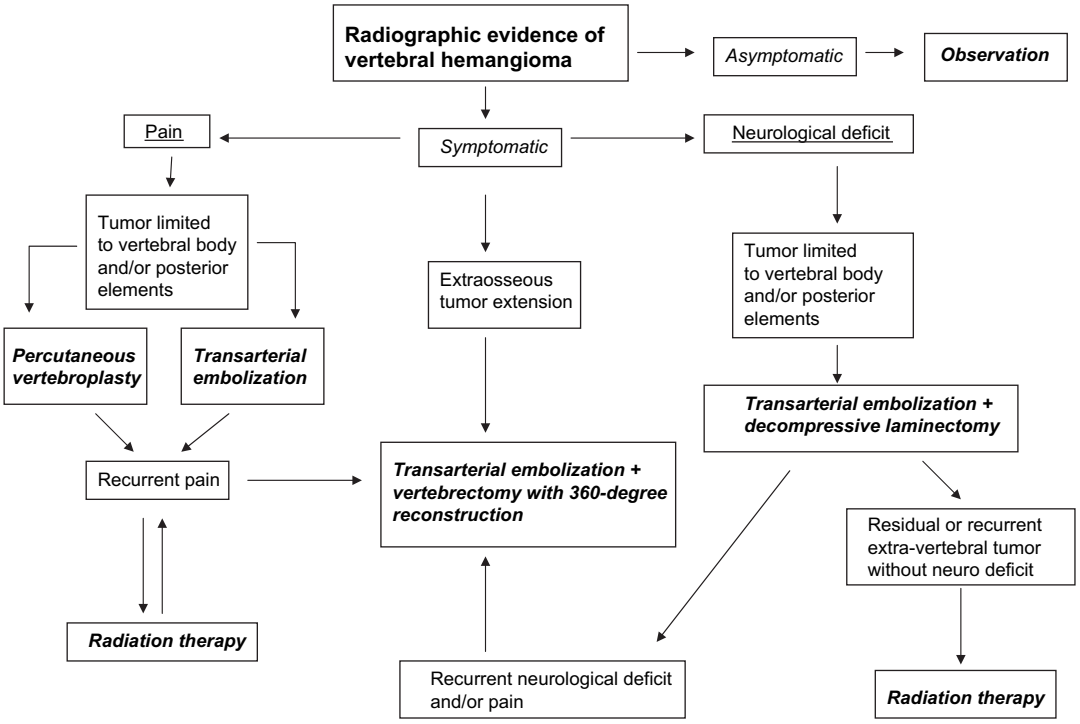

Fig. 7. Treatment algorithm for symptomatic vertebral hemangiomas. Surgical decompression, resection, vertebroplasty, transarterial embolization, and radiation therapy are included.

In cases where there is vertebral body involvement with extraosseous extension of tumor into the spinal canal causing cord compression and neurological deficit, a more radical surgical resection via corpectomy or intralesional spondylectomy has been advocated [4,9,14,16,48,49]. All nine patients who underwent vertebrectomy in this study had hemangiomas involving the circumferential vertebral body with extension into the spinal canal. Although patients undergoing corpectomy for vertebral body hemangiomas have traditionally reconstructed with anterior strut grafts without posterior stabilization [4,50], with advancements in pedicle screw-rod instrumentation, supplemental posterior fixation is now a relatively well tolerated and safe procedure that can provide increased spinal stability after anterior column reconstruction [51–53]. Thus, we now perform 360° fixation with a posterior pedicle screw-rod construct in all patients undergoing vertebrectomy (Fig. 8).

One of the main causes of perioperative morbidity for patients undergoing surgical treatment for vertebral hemangioma is excessive intraoperative blood loss and postoperative epidural hematoma [4,6,9,15,16,50]. Preoperative transarterial embolization has been found to reduce complications related to intraoperative blood loss and postoperative bleeding [3,13–15,50]. In our series, two patients experienced significant intraoperative blood loss. Neither patient was embolized preoperatively. All patients undergoing vertebrectomy underwent preoperative embolization and none had unmanageable intraoperative blood loss.

Transarterial embolization

Apart from the preoperative setting, endovascular embolization has been used by some as a sole therapy for vertebral hemangioma [29,30,32,37]. In 1972, Hekster and colleagues [54] showed that transarterial embolization could relieve spinal cord compression from vertebral hemangioma. Other investigators have shown that embolization alone can reduce hemangioma size, provide pain relief, and relieve subarachnoid block [30,37,55,56]. However, there are few long-term studies on

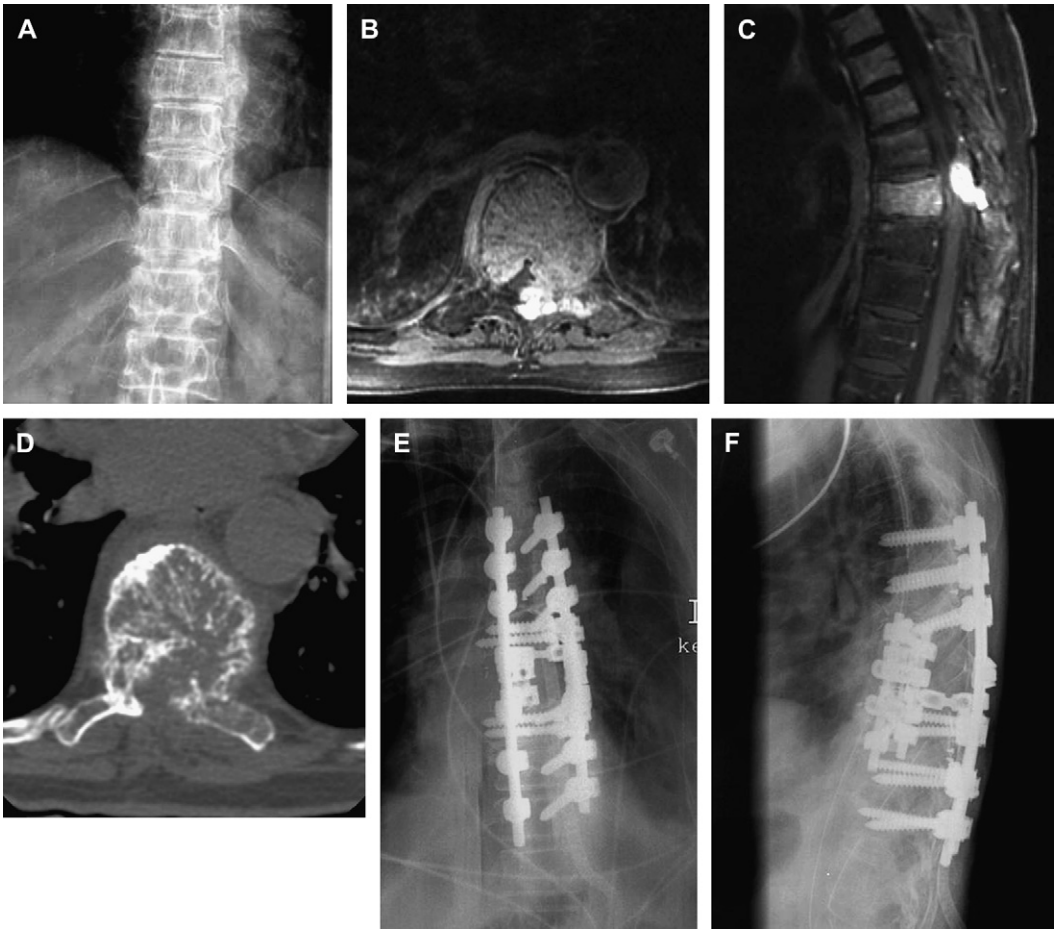

Fig. 8. Sixty-eight-year-old female presenting with left leg weakness and pain due to a T8 vertebral hemangioma status after T7–T8 laminectomy. (*A*) Plain anteroposterior radiograph demonstrates loss of height at T8. Axial (*B*) and sagittal (*C*) thoracic MRI show recurrent stenosis and epidural extension of the lesion. Axial CT (*D*) demonstrates the classic trabecular thickening (honeycombing) of the affected segment. Postoperative anteroposterior (*E*) and lateral (*F*) radiographs indicate adequate positioning of the T8 expandable cage following corpectomy and T7–T9 anterior fusion with T5–T11 posterior fusion.

outcome of vertebral hemangiomas treated with embolization alone. Smith and colleagues [37] found that two patients treated with transarterial embolization alone for vertebral hemangioma causing neurological symptoms failed to improve clinically. They recommended transarterial embolization only as an adjunct to surgical treatment for symptomatic vertebral hemangioma. In our series, three of four patients who underwent technically successful transarterial embolization for vertebral hemangioma had a resolution of pain symptoms without further treatment. Thus, transarterial embolization may be effective as a sole therapy for selected patients presenting with pain referable to an intraosseous vertebral hemangioma. Those with extensive lesions causing neurologic symptoms require embolization only in preparation for surgery.

Vertebroplasty

Percutaneous vertebroplasty, in which acrylic cement (usually polymethylmethacrylate [PMMA]) is injected into a vertebral body, is a relatively new technique that has been shown to provide pain relief in patients with vertebral hemangiomas [20,21,23,25,26,57–59]. The mechanism by which vertebroplasty results in pain relief is unknown,

but may be related to stabilization of microfractures and prevention of further compression or deformity, as well as a PMMA-induced chemical ablation of pain-sensitive nerve endings within the vertebral body [21,60–62]. Vertebroplasty, however, does not obliterate the hemangioma, and progressive expansion into the spinal canal can cause recurrent cord compression [42]. There have also been reports of spinal cord damage from leakage of PMMA into the spinal canal after vertebroplasty [58,61]. We used PMMA vertebroplasty in only four patients with painful hemangiomas of the vertebral body. Three of four patients experienced improvement after treatment. We recommend vertebroplasty as a potentially effective treatment for pain. The long-term efficacy of this procedure is unknown and requires further study. Because of the risk of reexpansion into the spinal canal and recurrent cord compression, vertebroplasty is not indicated for patients presenting with neurological deficit from an expansile vertebral hemangioma.

Other modalities (radiotherapy, ethanol injection)

Vertebral hemangiomas are radiosensitive lesions that have been shown to respond to low-dose radiation, typically 30 to 40 Gy [4,19]. Although most often used to treat lesions causing pain [4,19,63], radiotherapy has also been reported to effectively reverse neurological deficit from vertebral hemangiomas [19,64]. The use of radiotherapy as the sole treatment for vertebral hemangioma causing neurological symptoms, however, remains controversial, and most investigators recommend surgical decompression [4,7,47,56]. Because the operative morbidity and mortality associated with complete tumor resection in the past were unacceptably high, subtotal tumor removal for spinal cord decompression followed by postoperative irradiation was the traditional treatment protocol for these types of lesions [4,6,8,13–15,43,50,63,65,66]. However, modern techniques, such as preoperative transarterial embolization, advanced anesthesia and perioperative care, and improved design and safety of spinal instrumentation, have made feasible aggressive surgical resection and reconstruction for spinal tumors. Moreover, the effects of radiation therapy are delayed and radiation carries the risk of radionecrosis [7,64,67] and skin ulceration [7,64,68]. None of the three cases of vertebrectomy and gross total tumor resection in our series was treated with postoperative irradiation.

In 1994, Heiss and colleagues [69] reported relief of spinal cord compression from vertebral hemangioma after percutaneous ethanol injection in two patients. Since then, there have been reports of ethanol vertebroplasty effectively treating both pain and neurologic deficit from vertebral hemangioma [27,28,33,42]. Nevertheless, there have also been serious complications associated with ethanol vertebroplasty, including posttreatment Brown-Sequard syndrome [70] and pathologic fracture [27,28]. Because of this potential for significant morbidity, we have not used intralesional ethanol injection to treat symptomatic vertebral hemangioma.

Pregnancy-related hemangioma

Pregnancy is a recognized risk factor for developing a rapid onset of symptoms from these normally silent lesions [71,72]. Symptoms most often occur during the third trimester of pregnancy and most commonly affect the thoracic spinal levels, beginning as radicular or back pain and leg paresthesia, and progressing to spastic paresis with incontinence within weeks [13,38,73,74]. Diagnostic imaging reveals compression of the spinal cord from a vertebral and/or extradural hemangioma. Treatment of these lesions requires consideration of multiple factors, including the location of the spinal cord compression, the speed of neurologic decline, the stage of pregnancy, and the potential risks to the fetus from treatment modalities [71].

Treatment options for symptomatic hemangioma include radiation therapy, embolization, percutaneous sclerotherapy, vertebroplasty, and surgery. Radiation therapy is the treatment of choice for lesions causing pain only. Recent case series using radiation therapy (20–40 Gy over 2–4 weeks) demonstrate a symptom-improvement rate of up to 77% [13,19,39,75], including improvement in neurologic conditions in patients presenting with neurologic deficits. Risks include delayed radiation-induced myelopathy, which occurs with doses over 45 Gy to 50 Gy. Pregnancy is a relative contraindication to radiation therapy, though newer stereotactic radiosurgery may play a role in increasing the safety of radiation therapy during pregnancy [76]. Embolization has been reported in several case reports to improve symptoms in patients with pain and neurologic deficits [13,30,40,47], but is typically used as an adjunct to surgery to aid in minimizing blood

loss [77]. Complications include vascular injury and radiation exposure to the fetus during fluoroscopy. No cases of antepartum embolization for vertebral hemangioma have been reported. Percutaneous vertebral sclerotherapy and vertebroplasty is a promising new technique that seems to be effective for patients with both pain and neurologic deficits [22–24,28], but its use has yet to be reported in a pregnant patient. Surgery is the preferred treatment for patients with neurologic deficits, especially with rapid onset of symptoms. Surgery provides immediate and direct decompression of the spinal canal and avoids exposing the fetus to excessive radiation. Disadvantages include high intraoperative blood loss and the usual risks of surgery and anesthesia for a pregnant patient.

During pregnancy, treatment options have included (1) induction of preterm delivery, which places the fetus at a nearly 50% risk of morbidity or mortality if earlier than 32 weeks, (2) expectant observation and postparturition treatment, or (3) surgery. Because of the aggressive nature of pregnancy-related vertebral hemangiomas, surgical decompression is usually subtotal. Incomplete resection has been reported to result in up to 20% to 30% recurrence rates [47], arguing that adjunct therapy is warranted as soon as safely possible. Some patients may experience spontaneous improvement in symptoms postpartum without treatment, which allows for less urgent management of the lesion. However, future recurrence and deterioration is frequent and argues for early postpartum intervention.

Summary

Transarterial embolization followed by laminectomy is a safe and effective procedure for the treatment of cord compression by intraosseous vertebral body and posterior element hemangiomas. Vertebral corpectomy or intralesional spondylectomy preceded by embolization is used to treat cord compression from circumferential vertebral involvement with epidural extraosseous tumor extension, pathological fracture, and kyphotic deformity. Gross total resection obviates the need for postoperative irradiation and minimizes the likelihood of recurrence. Simultaneous anterior column reconstruction with an expandable cage and anterolateral plate fixation, supplemented with a posterior pedicle screw-rod construct implant makes this approach feasible. Transarterial embolization can be used without decompression to effectively alleviate pain symptoms only. Vertebroplasty is useful in improving back pain in the short term, but is less effective in providing complete and long-term pain relief. Radiation therapy and radiosurgery can be used as a second-line treatment for painful intraosseous lesions and for residual or recurrent extravertebral disease. Reoperation for circumferential vertebrectomy should be used to treat recurrent myelopathy, progressive deformity, or refractory painful lesions.

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