Fouad E. Gellad, MD • Norihiro Sadato, MD • Yuji Numaguchi, MD • Alan M. Levine, MD

Vascular Metastatic Lesions of the Spine: Preoperative Embolization[1]

Preoperative embolization of vascular metastatic tumors of the spine, particularly carcinomas of renal and thyroid origin, is an adjuvant technique that significantly decreases the intraoperative blood loss and resultant surgical morbidity. Surgical decompression was achieved in 24 spinal vascular metastatic lesions, 20 of which were treated with preoperative embolization and four of which were not. The embolic materials used were gelatin sponge, polyvinyl alcohol foams, and metallic coils. In patients who underwent adequate embolization, an average of 1,850 mL of estimated blood loss was reported; in those who underwent inadequate or no embolization, greater than 3,500 mL of estimated blood loss occurred. When gelatin sponge is used, surgery should be performed within 24 hours to prevent preoperative recanalization.

Index terms: Arteries, therapeutic blockade, 30.33, 9*.1299[2] • Spinal cord, compression, 30.33 • Spine, angiography, 30.124 • Spine, secondary neoplasms, 30.33

Radiology 1990; 176:683–686

Metastatic tumors that invade the epidural space involve the vertebral body and usually occur anterior to the spinal cord. Anterior surgical decompression of the spine has become the treatment of choice for radiation therapy–resistant, symptomatic metastatic spinal tumors (1–3). Some of these metastatic lesions are highly vascular, particularly those of renal and thyroid origin, so surgeons encounter substantial intraoperative bleeding during tumor resection. Preoperative embolization has become necessary in the more aggressive and curative approach taken by today's surgeons (4–8). Few data have been published regarding the correlation between embolization and the amount of intraoperative blood loss. In this report, we describe our experience with a variety of metastatic spinal lesions.

PATIENTS AND METHODS

We retrospectively reviewed the cases of 23 consecutive patients with a total of 26 metastatic spinal lesions who underwent spinal angiography between 1984 and 1989. The 13 men and 10 women ranged in age from 25 to 74 years. Seventeen patients had metastatic renal carcinoma, two patients had thyroid carcinoma, and one each had melanoma, pheochromocytoma, paraganglioma, and adenocarcinoma with primary tumors of unknown origin. Three lesions were in the cervical region, 14 were in the thoracic region, and nine were in the lumbar region. Twenty-six spinal angiograms were obtained, and 22 spinal emobilizations were performed. Embolization was not performed for four lesions, either because the lesion was hypovascular ($n = 2$) or because of atherosclerotic vascular disease involving the feeding vessels themselves ($n = 2$). Palliative embolization was performed for two lesions but subsequent surgery was not performed. A total of 24 surgical decompressions were performed in 20 lesions that were treated with preoperative embolization and four that were not.

Patients with destructive metastatic spinal lesions, whether or not the site of the primary vascular tumor was known, met the initial criteria for angiography and embolization. The embolization procedure was usually performed within 24 hours before surgery. Devascularization of segmental vessels was attempted bilaterally at the level of the lesion as well as cephalic and caudal levels. Digital subtraction angiograms were obtained before and after the embolization procedure to identify and evaluate any residual tumor vascularity. Particular attention was paid to the demonstration of the radiculomedullary branches to the anterior spinal artery (artery of Adamkiewicz). Magnified subtraction views in the anteroposterior projection were routinely used; if needed, oblique or lateral digital views were obtained as well. If the artery of Adamkiewicz was visualized in the preembolization digital view, embolization of this segmental vessel was not performed.

The embolic materials used were gelatin sponge (Gelfoam; Upjohn, Kalamazoo, Mich) in 34 vessels, polyvinyl alcohol foam (PVA) (International Therapeutics, San Francisco) ranging in size from 150 to 500 μm in nine vessels, and metallic coils (Mini Gianturco stainless steel or Hilal titanium microcoils) (Cook, Bloomington, Ind) in seven vessels. The spinal arteries were catheterized with a Simmons cerebral catheter (Sim-2; Cook), a headhunter cerebral catheter (H1, Cook), or a Cobra visceral catheter (C_1; Cook). In the latter 6 months of the study, Tracker catheters (Target Therapeutics, San Jose, Calif) were frequently used for superselective catheterization.

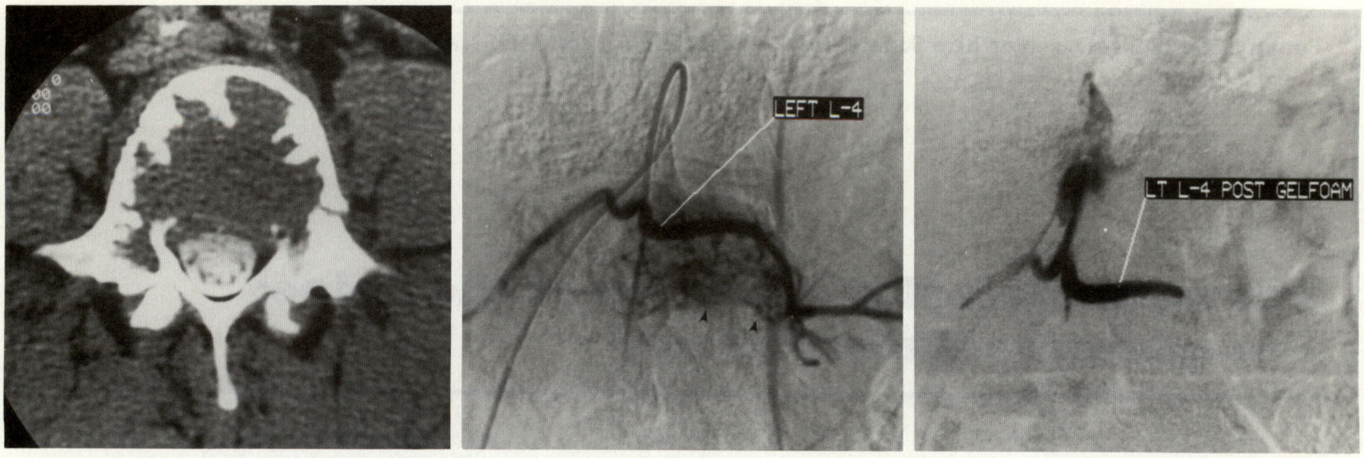
RESULTS

The embolization was judged to be satisfactory by both the surgeon and the radiologist if both 75% obliteration of the tumor stain after embolization and less than 3,000 mL of estimated blood loss (EBL) at surgery were noted. Fourteen cases with an average EBL of 1,850 mL satisfied these criteria (Table; Figs 1, 2).

Abbreviations: EBL = estimated blood loss, PVA = polyvinyl alcohol foam.

[1] From the Department of Radiology, Division of Neuroradiology (F.E.G., N.S., Y.N.), and the Department of Orthopedic Surgery (A.M.L.), University of Maryland Medical System, 22 S Greene St, Baltimore, MD 21201. From the 1989 RSNA scientific assembly. Received December 5, 1989; revision requested January 3, 1990; revision received April 30; accepted May 14. **Address reprint requests to** F.E.G.

[2] 9* indicates generalized vein and artery involvement.



a. b. c.

Figure 1. Satisfactory embolization in a 46-year-old man with thyroid carcinoma metastatic to L-4. **(a)** Postmyelography axial computed tomographic (CT) scan demonstrates a destructive lesion of the L-4 vertebral body with minimal epidural extension. **(b)** Anteroposterior view of the left L-4 digital subtraction angiogram before embolization demonstrates tumor vascularity (arrowheads). **(c)** Anteroposterior view of the left L-4 digital subtraction angiogram after embolization with gelatin sponge demonstrates occlusion of the feeding artery with complete obliteration of the tumor vascularity.

The embolization was judged to be unsatisfactory if there was either less than 75% obliteration of the tumor vascularity or more than 3,000 mL of blood loss at surgery. Eight cases with an EBL of 3,500–15,000 mL were included in this group. Two of these eight patients in whom surgery was delayed 3 and 5 days after embolization had an average EBL of 9,450 mL even though both lesions were more than 75% obliterated during embolization. This unsatisfactory result occurred early in our experience. The embolization was completely unsuccessful in two cases because of marked atherosclerotic changes in the segmental vessels. Patients in this group had an average EBL of 8,750 mL during surgery.

Partial embolization (less than 75%) was achieved in four patients due to either the proximity of a major feeding vessel to the spinal cord (artery of Adamkiewicz) (Fig 3) or brain (vertebral artery) or reflux into the aorta. Posterior decompression (laminectomy), rather than anterior decompression (corpectomy or costotransversectomy), was performed in these cases, with an average EBL of 720 mL.

In two patients, no tumor stain was detected on preoperative spinal angiograms, and embolization was therefore not performed; at surgery, an EBL of 900 mL was noted. Two additional patients with recurrent renal metastasis to the spine underwent successful embolization with PVA for pain control, with no subsequent decompression surgery.

None of the patients developed postangiographic or postembolization complications. Duration of spinal arteriography and subsequent embolization averaged 90 minutes. The location of the vertebral metastasis did influence the results of the embolization. Embolization of metastases in the cervicothoracic region were more difficult because their blood supply arose from the vertebral arteries or thyrocervical trunk. The thoracic or thoracolumbar metastases were relatively less dangerous and easier to embolize when no artery of Adamkiewicz was seen.

Outcome of Surgery and Embolization

Angiography/Embolization	No. of Cases	EBL (mL)/Corpectomy
Satisfactory	14	1,850
Unsatisfactory	8	3,500–15,000
Successful embolization (>3 d)	2	9,450
Unsuccessful embolization	2	8,750
Partial embolization	4	720 (laminectomy)
No embolization (hypovascular)	2	900
Palliative embolization	2	No surgery (pain control)

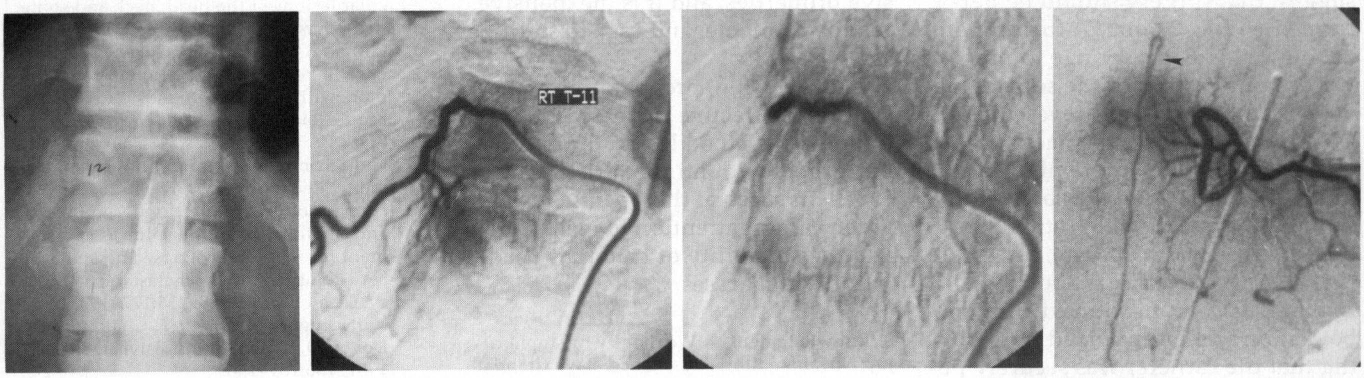
DISCUSSION

Decompression of the spinal cord is the goal of surgical intervention in patients with radiation therapy–resistant spinal tumors associated with neurologic compromise. Surgical intervention in these patients with vascular metastatic lesions is frequently complicated by excessive intraoperative blood loss. Preoperative embolization of the tumor facilitates surgical resection primarily by decreasing bleeding during surgery and shrinking the tumor, thus making more complete tumor resection possible (9,10). Hospital stays are shorter, and the need for transfusion and its attendant risks are decreased. Embolization may also be used as palliative treatment in unresectable tumors to decrease tumor growth and aid in pain control.

The majority of metastatic lesions to the spine involve the vertebral body as opposed to the posterior elements. In more than 75% of affected patients, dural compression from metastatic lesions to the spine is documented to be caused by an anterior mass; in only 10% is the compression caused by a posterior mass. The roles of the various treatment modalities in the management of metastatic disease of the spine have been controversial, due in part to the failure to standardize the types of spinal involvement and the treatment indications. Two basic classes of patients require surgical treatment of metastatic disease of the spine: (*a*) those with severe involvement of the vertebral body with or without mild anterior epidural compression in whom radiation therapy has failed and the tumor has progressed or pain control has been unsatisfactory, and (*b*) those with a neurologic deficit secondary to anterior dural compression. Although "decompression" by means of posterior laminectomy has been

a. b. c. d.

Figure 2. Satisfactory embolization in a 45-year-old man with renal carcinoma metastatic to C-4. **(a)** Postmyelography axial CT scan demonstrates a destructive lesion on the right side of the C-4 vertebral body with substantial epidural extension. **(b)** Anteroposterior view of the right vertebral digital subtraction angiogram before embolization demonstrates tumor vascularity (arrowhead). **(c)** Anteroposterior view of the right vertebral digital subtraction angiogram after embolization with gelatin sponge and one steel coil. Residual tumor stain is noted. Note the prominent radiculomedullary branch to the anterior spinal artery (arrow). **(d)** Anteroposterior view of the right vertebral digital subtraction angiogram after embolization with a second coil. The coil was released proximal to the feeding vessel but distal to the origin of the radiculomedullary branch. Note the obliteration of the tumor stain and preservation of the radiculomedullary branch (arrowheads).



a. b. c. d.

Figure 3. Unsatisfactory embolization in a 59-year-old man with renal carcinoma metastatic to T-11. **(a)** Anteroposterior myelogram demonstrates a complete block at the level of T-12 with displacement of the cord to the left. **(b)** Anteroposterior view of the right T-11 digital subtraction angiogram before embolization demonstrates the tumor stain. **(c)** Anteroposterior view of the right T-11 digital subtraction angiogram after the third embolization with gelatin sponge demonstrates occlusion of the intercostal artery with complete obliteration of the tumor stain. **(d)** Anteroposterior view of the left T-11 digital subtraction angiogram demonstrates the artery of Adamkiewicz (arrowhead) precluding embolization of the residual tumor stain.

cited in the treatment of this type of metastatic disease, it has been conclusively shown to be routinely ineffective. Black has demonstrated, in a review of a number of large series, that laminectomy is routinely ineffective for relief of neurologic symptoms in patients with anterior dural compression (11). Because these patients form the majority, laminectomy is not considered an effective modality. Radiation therapy alone has been shown to aid in the improvement in neurologic status in approximately 50% of patients with metastatic disease to the spine. More recently, however, several authors have demonstrated that approximately 85% of patients with neurologic impairment and pain will demonstrate substantial recovery after anterior decompression (2,12).

Anterior decompression is indicated for patients with anterior or anterolateral tumors with dural compression. Posterior decompression should be reserved predominantly for those patients with posterior compression of the dural sac (approximately 10% of all patients).

The differences in morbidity and mortality are not significantly different for anterior corpectomy than for posterior laminectomy when the tumor is encountered. Thus, if a laminectomy is performed and no tumor is found posteriorly, the results of the surgery are significantly inferior, with less than 30% improvement compared with anterior corpectomy. Because the tumor is not directly removed and decompressed, morbidity may appear to be less than when direct debulking of the tumor is performed. The risk of laminectomy cannot be substantiated, however, because the surgery is clearly ineffective. Radiation therapy alone is clearly more effective than laminectomy in most tumors. The overall mortality for anterior corpectomy is approximately 2%. The morbidity from the wound is significantly less than that of a posterior approach because preoperative radiation therapy may have been administered through a posterior portal in the thoracic and lumbar spine. The wound complications can be substantially increased in patients who receive long-term steroid therapy before surgery. Thus, steroid therapy in the patient with a neurologic deficit should be restricted to a very short-term preoperative regimen and then rapidly tapered postoperatively to minimize wound complications.

The EBL in patients undergoing posterior decompression was lower than in those with satisfactory embolizations undergoing anterior decompression. Laminectomies that do not approach the tumor mass have lower EBLs than those that directly decompress the mass. If the mass is not directly excised, however, the surgery is less effective. If the tumor is debulked, via an anterior or posterior procedure, EBL is comparable.

Various embolic agents were used in our study. Particulate embolizations were performed with PVA or gelatin sponge, a temporary vascular occlusive agent that is degraded by proteolytic enzymatic pathways and resorbed within 7–21 days, according to Kunstlinger et al (13). The dissolution of the intravascular thrombus may actually begin within 24 hours after embolization (5). These data suggest that surgery should be performed within 24 hours after embolization with gelatin sponge to prevent recanalization of the segmental vessels and subsequent revascularization of the tumor from adjacent collateral sources. The postembolization morbidity due to vascular occlusion of normal vessels is theoretically reduced with gelatin sponge, as vessels that are inadvertently embolized will recanalize. Complications during embolization were minimized by ensuring that the catheter was securely positioned in the vessel before embolization. In our earlier experience with two patients operated on 3 days or more after successful embolization with gelatin sponge, the substantial bleeding encountered at surgery seems to be attributed to recanalization of the occluded vessels, as if no prior embolization had been done.

PVA, a permanent nonresorbable occlusive agent that is available as a compressible sponge or as particles of known diameter, should be used if surgery is expected to be delayed or if eventual surgery is not planned. Accidental embolization of normal vessels will be permanent with PVA, which can increase the risks associated with embolization.

Coils, which provide permanent vascular occlusion, can be used as the only occlusive agent or in conjunction with other embolic materials. We used gelatin sponge and PVA for peripheral embolization and coils for proximal occlusion.

Other authors have used ethanol for occlusion of the vascular supply to the vertebral bodies. Ethanol is an excellent vascular occlusive agent due to its low viscosity and nonadhesive properties, and it is inexpensive, readily available, and easy to sterilize (14).

In conclusion, preoperative embolization is effective in decreasing intraoperative blood loss and can be performed with minimal risks and excellent surgical therapeutic results, given careful attention to technique and the suitability of materials used in individual cases. ■

Acknowledgments: We thank Christopher Joy, MD, for editorial assistance, Dave Crandall for photographic assistance, and Vicki Farmer for secretarial assistance.

References

1. Siegal T, Robin G, Lubetzki-Korn I, Fuks Z. Anterior decompression of the spine for metastatic epidural cord compression: a promising avenue of therapy? Ann Neurol 1982; 11:28–34.
2. Sundaresan N, Galicich JH, Lane JM, Bains MS, McCormick P. Treatment of neoplastic epidural cord compression by vertebral body resection and stabilization. J Neurosurg 1985; 63:676–684.
3. Cybulski GR. Methods of surgical stabilization for metastatic disease of the spine. Neurosurgery 1989; 25:240–252.
4. Choi IS, Berenstein A. Surgical neuroangiography of the spine and spinal cord. Radiol Clin North Am 1988; 26:1131–1141.
5. Mehta BA, Jack CR, Boulos RS, Patel SC, Ausman JI, Malik GM. Interventional neuroradiology: Henry Ford Hospital experience with transcatheter embolization of vascular lesions in the head, neck and spine. Henry Ford Hosp Med J 1986; 34:19–30.
6. Soo GS, Wallace S, Chuang UP, Carrasco CH, Phillies G. Lumbar artery embolization in cancer patients. Radiology 1982; 145:655–659.
7. Feldman F, Casarella W, Dick H, Hollander B. Selective intraarterial embolization of bone tumors. AJR 1975; 123:130–139.
8. Wallace S, Chuang VP, Swanson D, et al. Embolization of renal carcinoma: experience with 100 patients. Radiology 1981; 138:563–570.
9. Hilal SK, Michelsen JW. Therapeutic percutaneous embolization for extraaxial vascular lesions of the head, neck and spine. J neurosurg 1975; 43:275–287.
10. Ellman BA, Parkhill BJ, Curry TS III, Marcus PB, Peters PC. Ablation of renal tumors with absolute ethanol: a new technique. Radiology 1981; 141:619–626.
11. Black P. Spinal metastases: current status and recommended guidelines for management. Neurosurgery 1979; 5:726–746.
12. Harrington KD. Anterior decompression and stabilization of the spine as a treatment for vertebral collapse and spinal cord compression for metastatic malignancy. Clin Orthop 1988; 233:177–197.
13. Kunstlinger F, Brunelle F, Chaumont P, Doyon D. Vascular occlusive agents. AJR 1981; 136:151–156.
14. Pevsner PH, Klara P, Doppman J, et al. Ethyl alcohols: experimental agent for interventional therapy of neurovascular lesions. AJNR 1983; 4:388–390.