PREOPERATIVE EMBOLIZATION OF HYPERVASCULAR SPINAL METASTASES USING PERCUTANEOUS DIRECT INJECTION WITH N-BUTYL CYANOACRYLATE: TECHNICAL CASE REPORT

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Received, August 12, 2005.
Accepted, February 16, 2006.

OBJECTIVE: Intraoperative blood loss constitutes a major cause of perioperative morbidity in surgical decompression and reconstruction of highly vascular spinal metastatic tumors. We propose a technique for embolization of highly vascular vertebral metastases using percutaneous direct injection using N-butyl cyanoacrylate (NBCA) instead of polymethylmethacrylate to complement preoperative transarterial embolization and to minimize operative blood loss.

METHODS: Five patients with renal cell carcinoma metastases to the spine (one cervical, one thoracic, and three lumbar) underwent embolization by percutaneous direct injection of the affected vertebrae with a mixture of NBCA and iodized oil to supplement transarterial embolization with polyvinyl alcohol particles and fibered platinum coils. This was achieved via a transpedicular approach in four cases and by direct vertebral body puncture in one case.

RESULTS: The percutaneous NBCA direct injection procedure was technically successful in all cases and was not associated with neurological or medical complications. All patients underwent subsequent vertebrectomy and spinal instrumentation. Surgical resection was performed with lower than expected blood loss and with a subjective improvement in tumor tissue handling and dissection.

CONCLUSION: The extent of tumor devascularization can be improved by supplementing transarterial embolization with NBCA direct injection to decrease operative blood loss and increase the safety of surgical resection and stabilization of highly vascular spinal metastases.

KEY WORDS: Embolization, N-butyl cyanoacrylate, Renal cell carcinoma metastasis, Vertebrectomy, Vertebroplasty

Neurosurgery 59:431-432, 2006 DOI: 10.1227/01.NEU.0000223503.92392.CE www.neurosurgery-online.com

Operative management of spinal metastases from renal cell carcinoma and other metastatic tumors can be challenging because of tumor hypervascularity (14, 17), which often results in significant intraoperative blood loss (13). Preoperative embolization of these lesions has been advocated to minimize blood loss (1, 2, 8, 18, 22). Several series have been published on the use of transarterial embolization to reduce operative blood loss as an adjunct to surgery (2, 18, 21) or as the only treatment modality (14). Preoperative tumor embolization has been shown to indirectly decrease the surgical morbidity, length of stay, and the need for perioperative transfusion of blood products (1, 2, 8, 10, 18, 22).

Transarterial embolization of a hypervascular vertebral lesion is possible in cases in which the blood supply to the tumor is well defined and distinct from the vascular supply to the spinal cord; in cases with overlapping blood supply, transarterial embolization can not be safely performed and may potentially compromise the native supply to the spinal cord, with consequent undesirable neurological deficit (7, 22). However, in the case of hypervascular tumors, even technically successful transarterial embolization can fail to completely penetrate the microvascular blood supply and permeate the tumor tissue, as judged by persistent bleeding at the time of surgery. Although vertebroplasty with polymethyl methacrylate (PMMA) can decrease the pain associated with spinal metastases and improve the biomechanical properties of the

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vertebral body (12, 20), it can make the vertebrectomy procedure considerably more difficult and tedious because of the need for drilling of the cement material. To achieve tissue permeation and devascularization without altering the tumor tissue mechanical characteristics adversely, we have used percutaneous direct injection of a mixture of N-butyl cyanoacrylate (NBCA) and iodinated oil instead of PMMA to complement conventional preoperative transarterial embolization. NBCA has traditionally been used for transarterial embolization of vascular malformations (11) and tumors (16), as well as for direct puncture embolization of vascular head and neck tumors (3, 5, 9). We present a series of five patients in whom we undertook this novel use of percutaneous direct injection with NBCA in preparation for vertebrectomy and instrumented spinal stabilization.

PATIENTS AND METHODS

Demographics

Five patients (three women, two men; age range, 49–66 yr) with known renal cell carcinoma and metastatic involvement of the spine underwent multimodality tumor embolization followed by vertebrectomy and spinal embolization between August 1998 and March 2004 (*Table 1*). All patients had local back or neck pain in the area of the lesion; three patients (Patients 1, 2, and 4) had radicular symptoms. The segmental localization of each tumor is shown in *Table 1*.

Transarterial Embolization Technique

All spinal angiograms were performed via a percutaneous transfemoral approach with the patient under general anesthesia and in the supine position. A spinal diagnostic catheter (HS1, HS2, or C2; Cook Inc., Bloomington, IN) was used to selectively catheterize the radicular vessels around the lesion in a sequential fashion after administration of intravenous heparin to achieve an activated clotting time of longer than 180 seconds. Single-plane digital subtraction angiography was performed with each catheter position. The blood supply to the metastasis and the location of the anterior and posterolateral spinal arteries were identified before proceeding to exchanging the diagnostic catheter to a 6-French spinal guiding catheter. The major feeding arteries to the tumor were then selectively catheterized via a 0.010 or 0.014 microcatheter. With the microcatheter in position, transarterial embolization was performed by flow-directed injection of polyvinyl alcohol particles measuring 150 to 250 μm (Boston Scientific Inc., Natick, MA), or, in some cases, by direct transarterial injection of a mixture of NBCA adhesive (Cordis Endovascular, Miami Lakes, FL) and Lipiodol iodinated oil (Cordis Endovascular), until complete stasis was achieved. In cases in which the feeding pedicle was embolized with particles, an additional proximal platinum fibered coil was deployed to decrease the likelihood of recanalization before surgery. In one case (Patient 3), the vascular supply was diffuse and not amenable to complete transarterial embolization.

Percutaneous Direct NBCA Injection Technique

The procedure was performed under high-resolution biplane digital subtraction fluoroscopy with roadmapping to enable visual tracking of the radio-opaque NBCA:Lipiodol mixture. Simultaneous negative roadmapping and live fluoroscopy was used to improve the ability to detect any NBCA migration into the spinal canal, into the paravertebral venous plexus, or in retrograde fashion into the feeding radicular artery. The patients with thoracolumbar tumors were positioned in a prone position and the external landmarks were identified using biplane imaging. Cervical embolization (direct puncture) was performed with the patient in supine position (Patient 5). The skin was prepared using a standard operative technique and the skin puncture sites were identified for the bipedicular approach for direct puncture in patients with thoracolumbar tumors. The subcutaneous tissue and muscle was infiltrated with lidocaine along the trajectory tract to the pedicle. An InterV bone marrow biopsy needle (Medical Device Technologies, Inc., Gainesville, FL) was then advanced through the target pedicles into the anterior third of the target vertebral body; bipedicular access was obtained. In the patient with a cervical tumor (Patient 5), a roadmap injection was used to localize the right vertebral artery and a 22-gauge spinal needle was passed into the right neck posterior to the right vertebral artery via the right lateral approach and into the C3 vertebral body/tumor. A vertebrogram was performed to exclude injury to the vertebral artery. After confirming appropriate working projections in both planes, a mixture of NBCA and Lipiodol (25:75) was prepared in a 5-ml syringe, along with trace tantalum powder, added to improve fluorographic visualization, according to the manufacturer's recommendation. The Lipiodol is used to slow the polymerization reaction time to enable predictable handling. The mixture was then slowly hand-injected using a 3-ml syringe under both biplane negative roadmap imaging and plain fluorography to follow the progress of the opaque NBCA mixture. Care was taken to avoid reflux of blood into the syringe to avoid premature polymerization of the NBCA mixture. After obtaining adequate tumor tissue permeation and noting an increase in resistance, the needle was carefully withdrawn to a more proximal position within the vertebral body, and the injection was repeated one to two additional times. When the needle tip was close to the pedicle, injection was halted and the syringe was placed under light suction and withdrawn. The procedure was then repeated via the previously inserted contralateral bone marrow biopsy transpedicular needle. The typical injected volume of NBCA per vertebral level was 2.5 to 3 ml.

Surgical Decompression

Standard anterior and anterolateral exposure of the involved vertebrae was performed. Subperiosteal dissection of the vertebral bodies above and below the lesion was performed. The disc spaces adjacent to the lesion were identified, and an intraoperative x-ray was obtained to confirm the operative level. The vertebrectomy was performed in piecemeal fashion with rongeurs. The tumor was resected to the end plates of the level above and below, and back to the level of the

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TABLE 1. Demographics, presentation, and characteristics of the surgical resection in the five patients[a]

Patient no.	Age (yr)/sex	Presentation	Location	Procedure	EBL (ml)	Complications	Interval between embolization and surgery (d)	LOS (d)
1	63/F	Low back pain, right hip and radicular leg pain	T12–L1	Left retroperitoneal T12 and L1 vertebrectomies, T11–L2 anterior thoracolumbar arthrodesis/fusion, using interbody cage prosthesis T11–L2 anterior thoracolumbar spinal instrumentation using TPS-TL implant packed with locally harvested rib autograft.	300	None	0	11
2	59/M	Low back pain radiating in the hips and right leg	T11–L3, S1	Retroperitoneal L2 and L3 vertebrectomies, resection of epidural metastatic spinal tumor, L1–L4 anterior lumbar arthrodesis/fusion using morselized allograft bone in TPS-TL interbody cage, L1–L4 anterior lumbar instrumentation using TPS-TL screw plate fixation	400	None	4	11
3	49/F	Low back pain	L3	Radical left nephrectomy via thoracoabdominal approach with L3 vertebrectomy and L2 through L4 interbody stabilization using cage plate system	800	None	2	8
4	66/F	Right radicular chest pain	T6	Right thoracotomy, T6 vertebrectomy, T5–T7, anterior thoracic arthrodesis using locally harvested rib, autograft packed into interbody titanium mesh cage, component, of TPS-TL device, T5–7 anterior thoracic instrumentation using TPS-TL device	300	None	2	10
5	62/M	Neck pain	C3	C3 vertebrectomy, C2–4 anterior fusion, occiput–C4 posterior fusion	150	Glue cast is seen within the C3 basivertebral veins, the epidural veins (extending from C2 through C4), as well as the vertebral venous plexi bilaterally	4	25

[a] EBL, estimated blood loss; LOS, length of stay; TPS-TL, telescoping plate spacer-thoracolumbal.

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TABLE 2. Features of the transarterial and direct percutaneous embolization in the five patients of this series[a]

Patient no.	Anesthesia	Transarterial Embolization	No. of embolized arterial feeders	Arterial feeder pedicles embolized	PVA particles (μm)	Coils	Transarterial NBCA glue embolization	Transarterial embolization result	Transpedicular direct NBCA embolization
1	GETA	Yes	4	Bilateral L1–L2	150–250	Fibered	No	Complete	Yes
2	GETA	Yes	3	Right L1, Bilateral L2	150–250	Fibered	No	Complete	Yes
3	GETA	Yes	4	Bilateral L2–3	150–355	Fibered	No	Incomplete (minimal left L4 feeder)	Yes
4	MAC	Yes	3	Right T5–7	None	Fibered	Yes	Complete	Yes
5	MAC	Yes	1	Distal neuromeningeal branch of the right ascending pharyngeal artery	150	Fibered	No	Incomplete	Yes

[a] PVA, polyvinyl alcohol; NBCA, N-butyl cyanoacrylate; GETA, general endotracheal anesthesia; MAC, monitored anesthesia care.

spinal canal. The posterior longitudinal ligament was resected to expose the dural tube and assure the adequacy of neural decompression. After vertebrectomy, segmental spinal stabilization was performed. An intraoperative x-ray was obtained to confirm satisfactory spinal alignment and spinal instrumentation position.

RESULTS

All patients underwent preoperative transarterial embolization (*Table 1*). This was performed under general anesthesia in three cases and monitored anesthesia care in two cases. In all but one patient, polyvinyl alcohol particles with a particle size between 100 and 355 μm were used in combination with fibered coils. In one patient (Patient 4), NBCA glue embolization was performed instead of particle embolization. In all patients, a direct percutaneous transpedicular injection with NBCA:Lipiodol was performed. In one case (Patient 4), the transarterial embolization was performed after the percutaneous direct injection procedure (*Table 2*).

Between one and four segmental arteries were embolized using the transarterial route; one to two vertebral bodies were treated using percutaneous direct injection with NBCA. Angiographically complete transarterial embolization was achieved in four of the five cases. In one patient (Patient 3) with an L2 and L3 tumor, a minimal arterial supply to the tumor from the left L4 radicular artery was noted after embolization of the L2 and L3 radicular arteries bilaterally. It was thought that the patient would not benefit from embolization of this residual supply.

After an interval ranging from 0 to 4 days after preoperative embolization, the patients underwent surgical decompression and stabilization. The estimated blood loss during surgery ranged from 300 to 800 ml. Of note, in Patient 3 (with the highest blood loss, measuring 800 ml), the radical nephrectomy was performed at the same time, and the estimated blood loss represents blood loss for the combined operation. In Patient 5, the estimated blood loss includes supplemental posterior stabilization, which was performed under the same general anesthesia. We estimate that approximately half of the blood loss in both of these cases can be attributed to the vertebrectomy and anterior stabilization portion of the procedure.

There were no complications encountered during the perioperative phase, after either the embolization or the surgery. No patient had a change in baseline renal function, and there were no instances of neurological worsening, postoperative hematoma, wound infection, subsidence, interbody graft dislodgement, or construct failure. In one patient, glue cast was seen on a routine computed tomography after the NBCA embolization within the C3 basivertebral veins, the epidural veins (extending from C2 through C4), as well as the vertebral venous plexi bilaterally. The patient remained asymptomatic and tolerated the procedure well. In Patient 4, an unintended small amount of NBCA reflux was noted in the subcutaneous, muscular, and transpedicular tracts after withdrawal of the bone marrow biopsy needles. Postembolization plain chest x-rays were obtained in anteroposterior and lateral projections in all patients; these showed no evidence of radio-opaque NBCA emboli to the lungs. The length of hospital stay ranged from 8 to 25 days, and all patients were discharged in a neurologically intact condition with adequate pain control on oral pain medication.

Illustrative Cases

Patient 1

A 63-year-old woman was diagnosed with renal cell carcinoma for which she had previously undergone a left radical nephrectomy (*Fig.*

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1). On follow-up examination for lower back pain, she was found to have spinal metastases to the T12 and L1 vertebra and underwent external beam radiation therapy to the spine. She subsequently presented with intractable mechanical back pain and radicular leg pain and was found to have severe compression deformities of the T12 and L1 vertebrae with epidural tumor extension and neural impingement. Contrast-enhanced magnetic resonance imaging (MRI) scans of the thoracic and lumbar spine demonstrated near complete replacement of the L1 vertebral body and of the dorsal half of the T12 vertebral body with metastatic tumor. In consideration of the intractable back and leg pain, despite previous radiation therapy, surgical intervention was offered. After embolization of the L1 and L2 segmental arteries bilaterally, and bilateral transpedicular percutaneous NBCA direct injection of the L1 and L2 vertebral body, while the patient was under general anesthesia, the patient was taken to the operating room. Left retroperitoneal T12 and L1 vertebrectomies and T11–L2 anterior thoracolumbar spinal instrumentation using a telescoping plate spacer-thoracolumbaal (TPS-TL; EBI, Parsippany, NY) implant packed with locally harvested rib autograft were performed without intraoperative complications. The blood loss was estimated to be 300 ml.

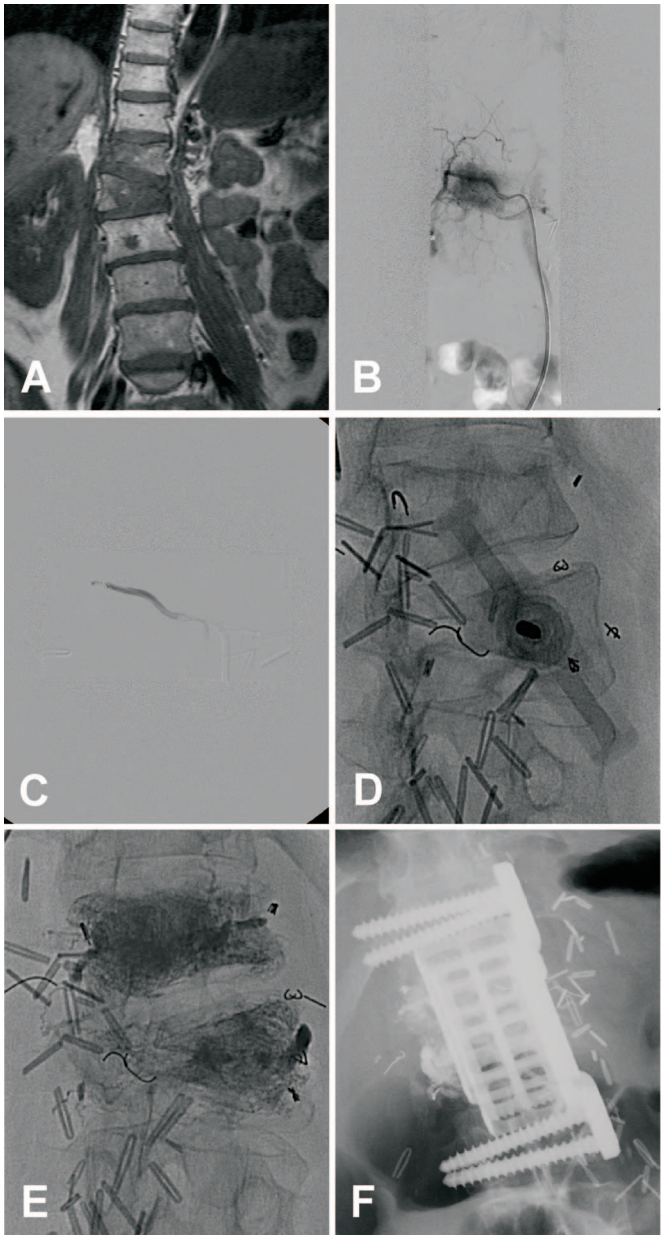


FIGURE 1. *Patient 1, a 63-year-old woman with renal cell carcinoma metastases to the T12 and L1 vertebral bodies. Coronal T1-weighted MRI scan (*A*) and spinal digital subtraction angiography in the anteroposterior projection showing the arterial injection of the right L1 segmental artery before (*B*) and after (*C*) transarterial embolization with polyvinyl alcohol particles and deployment of fibered coils.* D*, oblique projection digital fluorography showing the bone biopsy needle placed in the left L1 pedicle.* E*, anteroposterior digital fluorography after T12 and L1 percutaneous bipedicular NBCA direct injection showing the extent of the tumor casting in the vertebral body.* F*, postoperative anteroposterior plain x-ray showing the TPS-TL device in position.*

Postoperatively, the patient had an uneventful recovery. Chest tubes were discontinued on postoperative Day 2, and the patient was discharged on postoperative Day 11. At a routine follow-up examination after 3 months, the patient was in a stable condition, complaining of mild pain at the previous nephrectomy site and fatigue.

Patient 4

A 66-year-old woman was diagnosed with renal cell carcinoma 6 months before admission (*Fig. 2*). She was found to have a T6 metastatic tumor and underwent a T5–T6 laminectomy without fusion at an outside hospital, with a 5000-ml blood loss without fusion. Subsequently, the T4–T8 area was irradiated and the patient underwent a right radical nephrectomy. She then presented with increasing right thoracic radicular pain, but was otherwise neurologically intact. MRI scans of the thoracic spine demonstrated severe spinal cord compression from metastatic tumor at the T6 level. The degree of radiographic spinal cord compression was thought to be significant and would likely soon result in the development of myelopathy. Accordingly, surgical intervention was offered. She underwent transpedicular percutaneous NBCA direct injection of the T6 vertebral body, followed by transarterial embolization of the right T5–T7 segmental arteries with fibered coils and NBCA under monitored anesthesia care. Two days after the embolization procedure, the patient underwent a right thoracotomy, T6 vertebrectomy, and a T5–T7 spinal stabilization using a TPS-TL device packed with locally harvested rib autograft. The patient made an uneventful recovery from the procedure. The chest tubes were discontinued on postoperative Day 4 and the patient was discharged on postoperative Day 10. At the 1-year follow-up examination, the patient complained of mild thoracic back pain, which is managed with oral pain medication, and has advanced recurrent disease of the right posterior chest wall.

DISCUSSION

The hypervascular nature of some metastatic tumors, and most notably metastatic renal cell carcinoma, may prolong and complicate surgery. The effort aimed at controlling intraoperative tumor bleeding can be technically difficult and typically increases procedural time and operative morbidity and mortality, factors that render preoperative embolization an essential part of the management strategy (13, 14, 17, 22).

In the case of hypervascular vertebral tumors, even technically successful and subjectively complete transarterial embo-

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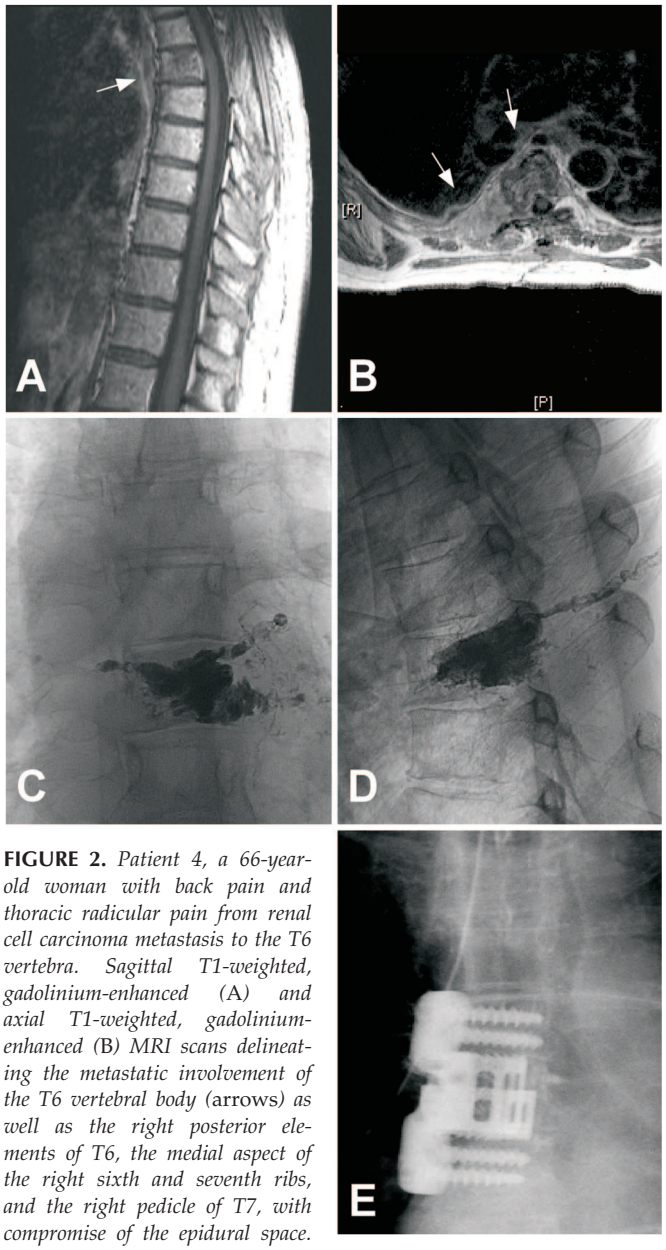


FIGURE 2. *Patient 4, a 66-year-old woman with back pain and thoracic radicular pain from renal cell carcinoma metastasis to the T6 vertebra. Sagittal T1-weighted, gadolinium-enhanced (*A*) and axial T1-weighted, gadolinium-enhanced (*B*) MRI scans delineating the metastatic involvement of the T6 vertebral body (*arrows*) as well as the right posterior elements of T6, the medial aspect of the right sixth and seventh ribs, and the right pedicle of T7, with compromise of the epidural space. Anteroposterior (*C*) and lateral (*D*) digital fluorography showing the extent of the percutaneous NBCA direct injection performed at T6.* E, *anteroposterior x-ray demonstrating postoperative result with the TPS-TL device in position.*

lization with angiographic occlusion of the feeding arteries often fails to completely eliminate persistent intraoperative bleeding of the tumor. Complete devascularization of a highly vascularized tumor requires that precapillaries, capillaries, and even the proximal parts of the draining veins are occluded by depositing the embolic agents as deeply into the tumor as possible (19). Mariani et al. (19) studied the incidence of direct arteriovenous shunts in the vascular beds of several tumors. They showed that renal cell carcinoma metastases exhibit a rapid circulation with early venous drainage, because of the widespread network of dilated capillaries responsible for the early venous drainage. The failure of transarterial embolization to satisfactorily eliminate intraoperative bleeding during tumor resection can be the result of several factors. First, if transarterial embolization is performed with particles, then adequate antegrade blood flow is needed to carry the particle to the microvascular bed, a phenomenon with diminishing returns when the microvascular bed is fed by multiple feeders. Second, the use of NBCA liquid adhesive in a transarterial fashion may not be sufficient to reach the core of the microvascular bed even if the NBCA:Lipiodol mixture is dilute, because of the limitation of the injection of the resultant viscous mixture through a diffuse arterial network before inducing unintended reflux into the proximal radicular artery, especially when the microcatheter is not wedged satisfactorily. Third, renal cell carcinoma metastases to the spine often show abnormally increased vascularity in pathological studies (17). Their appearance on spinal angiograms reveals large, irregular arterial feeders and an angiographic blush of the tumor with prominent arteriovenous shunts and dilated draining veins (14). This pattern of blood supply can frustrate even the most complete transarterial embolization attempts as the remaining central tumor core can recruit previously minor arterial supply in response to the occlusion of the previously primary arterial feeders.

We used combined transarterial embolization with direct percutaneous vertebral NBCA embolization. This procedure was first described by Trystram et al. (25) in a single case in which the spinal artery arose at the same level (T10) as the lesion, and an incomplete transarterial embolization had to be complemented with NBCA direct injection. In a similar case reported by Chiras et al. (6), a hypervascular pheochromocytoma metastasis of the sixth cervical vertebral body was embolized preoperatively by a direct intravertebral injection of an alcoholic embolizing emulsion. Transarterial embolization was considered too dangerous because of the possibility of inadvertent embolization of the intracerebral vertebrobasilar territory. In our experience, the NBCA:Lipiodol mixture can be seen under direct injection to permeate and cast the extensive and tortuous vascular tumor bed, resulting in excellent intraoperative bleeding control. The described technique achieves closer to a true end-organ embolization at the level of the capillary bed rather than the more proximal occlusion of the blood supply at the level of small arterioles that is usually achieved by transarterial embolization. Directly injected NBCA assumes the form of the entire tumor, including a portion of the epidural component, while maintaining a soft consistency. It does not seem to change the volume of the epidural component of the tumor and, thus, minimizes the risk of a neurological deficit. The embolized tumor has subjectively superior handling characteristics during the surgery—it is soft, easy to suction, and can be readily removed in a piecemeal fashion using a rongeur. The resultant ease and safety of the tumor dissection and handling make the vertebrectomy of highly vascularized spinal metastases consider-

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ably less problematic than in the past, by decreasing the persistent bleeding that frequently hampers such procedures.

It is important to caution that direct puncture embolization can be fraught with the risk of retrograde flow of embolic material through any one of multiple feeder arteries. This complication has been described previously by Casasco et al. (3, 4) when treating juvenile nasopharyngeal angiofibromas at the cranial base in two patients. They encountered a fatal polymerization of NBCA in the middle cerebral artery in one patient, and embolization of a collateral of the ophthalmic artery in another patient resulting in vision loss. Accordingly, we stress the need for meticulous biplane localization of the injection needle as well as preinjection arteriography to delineate the blood supply to the tumor and unforeseen collaterals and overlapping supply with the adjacent neural elements. In our cases, spinal angiography enabled the identification of the major arterial feeders to the tumor as well as the localization of the anterior and posterolateral spinal arteries to determine any possible overlap or risk of reflux. Although Casasco et al. (3, 4) recommended the use of carotid balloon protection in their cranial base cases, such an approach is not feasible or practical in the thoracic and lumbar cases treated in the current report, although it may have been a consideration in Patient 5 with the cervical lesion. In all cases, it would be safest to avoid direct NBCA injection altogether into any tumor receiving arterial supply from a vessel leading to a spinal or cerebral artery.

Percutaneous transpedicular injection of PMMA (12, 20) is a widely performed procedure for spinal tumors, including spinal angiomas, multiple myeloma, and plasmocytoma. In cases with a planned resection of the vertebral body, PMMA is far from an ideal material. It necessitates an extensive amount of drilling during the procedure because of its cement-like mechanical properties. Furthermore, the potential for extrusion of PMMA into the epidural space through tissue planes and bone weakened by the tumor can increase the risk of neurological deficits, including nerve root and spinal cord compression (15, 23). In contrast, embolization with NBCA is, in our opinion, advantageous when compared with PMMA for the current application. In a study by San Millan Ruiz et al. (24), PMMA exhibited a macroscopic and microscopic rim of tumor necrosis 6 months after implantation. NBCA, however, exhibited compressive effects on the nearby tumor tissue without signs of significant necrosis outside the acrylic tumor cast. Tumor captured inside the acrylic cast showed extensive to near complete necrosis. The extended effect of PMMA, when compared with NBCA, may be caused by the variable toxicity of acrylic implants, including the different degrees of the exothermic reaction during polymerization (24). It should be emphasized that vertebral embolization with NBCA is not intended or suited to replace PMMA vertebroplasty for the treatment of symptomatic osteoporotic vertebral compression fractures. NBCA does not restore vertebral axial load-bearing capacities and should be used for the described preoperative embolization purposes only.

The current exploratory study is obviously limited by the small number of patients. It does not provide for a direct comparison of operative blood loss or of any difference in the extent of tumor resection that can be attributed to the addition of direct NBCA injection. A randomized controlled study will be needed to quantify the magnitude of blood loss reduction offered by this technique and to assess whether it has any effect on the extent of tumor resection. In the limited sample size, percutaneous direct NBCA injection can be safely performed if precautions regarding the vascular anatomy and the early detection of NBCA reflux or extravasation are heeded.

CONCLUSION

In patients with highly vascular spinal tumors requiring surgical resection, the extent and completeness of preoperative embolization can be greatly improved by using percutaneous NBCA:Lipiodol direct injection as an adjunct to transarterial embolization. The intraoperative blood loss can be decreased while maintaining the qualitative ease of tumor tissue handling for an easier and more expedient dissection and a safer vertebrectomy and stabilization procedure.

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COMMENTS

Intra-arterial injection of highly vascular primary and metastatic tumors of the spine with agents to occlude the blood supply represents an important adjunct in the surgical management of these lesions. Before the advent of this technique, such tumors could be resected only with considerable, and sometimes uncontrollable, blood loss. Nevertheless intra-arterial injection has limitations. Lesions that are apparently well embolized may nevertheless bleed profusely at surgery. Embolization may be incomplete because of peculiarities of vascular anatomy or because embolization into vessels feeding the tumor may potentially compromise the vascularity of the spinal cord. Direct vertebral body injection used as an adjunct to more common techniques of embolization is a potentially powerful new weapon in our armamentarium and is an important contribution to the management of vascular tumors of the spine. It should be emphasized that, to avoid potentially disastrous complications, this must be performed with the utmost care and real-time imaging, as described by the authors.

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The authors describe a technique in which they percutanously injected NBCA into hypervascular vertebral metastatic tumors. All five metastatic lesions were from renal cell primaries. The authors also used transarterial embolization to decrease tumor vascularity before vertebrectomy and spinal reconstruction. There were no complications related to the percutaneous injection. The authors propose that their technique decreased blood loss and facilitated surgery.

Renal cell metastases to the spine present a major challenge to the spinal surgeon. Tremendous bleeding can occur during surgery. Transarterial embolization of hypervascular metastases, especially kidney and thyroid cancers, has become a useful tool in decreasing blood loss during subsequent surgery. The technique described by the authors may also be useful, and their report is encouraging. However, it may not provide incremental benefit to patients who have already undergone transarterial embolization. It may still be useful in cases in which transarterial embolization is not possible. I look forward to further reports comparing the authors' new technique to methods currently used.

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The article describes a novel technique for the embolization of hypervascular spinal metastases through a percutaneous technique. This technique may prove useful for lesions in which surgeons are unable to obtain a sufficient transarterial embolization because of unfavorable feeding vessel anatomy that may expose the spinal cord to risk of ischemia. It may be a useful adjunct to further decrease blood flow through the tumor at the time of surgery through a direct vertebral body injection before vertebrectomy. Despite aggressive embolization and segmental vessel ligation, some tumor types, such as hemangiomas and renal cell carcinomas, may still bleed significantly at the time of surgery. Direct injection of embolic material before resection may be helpful in this situation and would eliminate the risk associated with the percutanoeus corridor, such as pedicle breach. Other possibilities for decreasing blood loss in tumors that are incompletely embolized are adjacent level segmental artery ligation and the use of en bloc techniques rather than piecemeal resection. My clinic has found the latter two techniques extremely useful in this circumstance, but, given the data presented here, I am enthusiastic about trying the direct injection approach instead of the percutaneous method presented within this article.

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