Interventional Management of Vertebral Body Metastases

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Abstract

Metastases to the vertebral column are often due to hypervascular primary tumors, the most common of which is renal cell carcinoma. Clinical symptoms attributed to vertebral body metastases include localized pain, mechanical instability of the vertebral column, and neurologic deficits resulting from mass effect. Treatment options include targeted radiotherapy, percutaneous vertebral augmentation with or without thermal ablation, and surgical resection with subsequent fusion. Overall, surgical resection of the tumor and stabilization of the vertebral column provide the best prognosis for the patient in terms of symptomatic improvement and long-term survival; however, resection of hypervascular vertebral body metastases can result in significant intraoperative blood loss that can add to the morbidity of the procedure. Preoperative embolization of hypervascular metastases of the vertebral column has been shown to significantly reduce intraoperative blood loss at the time of surgery. The goal of this manuscript is to describe the role of embolization therapy in the management of patients with vertebral body metastases.

Keywords

- ▶ vertebral body
- ▶ metastasis
- ▶ embolization
- ▶ ablation
- ▶ interventional radiology

Objectives: Upon completion of this article, the reader will be able to identify the role of preoperative embolization for hypervascular vertebral metastases, including technique, outcomes, and potential complications of preoperative embolization.

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Metastases are the most commonly encountered vertebral body tumors. These result in significant cancer-related mor-

bidity. Multiple treatment options are available, but the best therapy remains surgical resection of the tumor and spinal fusion¹; since these metastases are often hypervascular, there is a high likelihood of significant blood loss during surgery. Preoperative embolization of the target metastases can significantly reduce intraoperative blood loss.²

Background

Preoperative transarterial embolization of hypervascular vertebral body metastases was first described in 1974.³ Studies have shown that preoperative embolization can decrease intraoperative blood volume loss from 5,000 to 1,500 mL.² Incomplete or partial tumor embolization also has demonstrated statistically significant reduction in blood loss.² While the type of embolic material employed in this procedure has varied over the years, in general medium size particle embolization is now recognized as the most effective practice. Coil embolization results in proximal occlusion of the feeding vessel, incomplete embolization, and does not allow

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subsequent access into the tumor vessel bed. Liquid embolic embolization, such as *N*-butyl cyanoacrylate (NBCA) or denatured alcohol, carries a higher risk of nontarget embolization and, in the case of vertebral body tumors, raises the risk of inadvertent embolization of the spinal artery and associated clinical consequence of spinal cord infarction.

Recently, there have been several case series reporting success using direct percutaneous access to the involved vertebral body followed by liquid embolization of the tumor or thermal ablation followed by cementoplasty.^{4,5} The advantages of this technique include ease of needle placement, possible decreased risk of nontarget embolization, and increased completeness of tumor embolization.

Anatomical Considerations

Arterial blood supply to the vertebral body and intervertebral discs comes from the radicular arteries (►Fig. 1). These arteries are branches from segmental intercostal and lumbar arteries in the thorax and abdomen, and from the vertebral arteries in the cervical region. The posterior branches of these segmental arteries enter the vertebral column through the intervertebral foramen; once inside the spinal column, they are known as radicular arteries, where they travel in the epidural space and branch to supply their anatomic targets. In general, the primitive intervertebral disc is more vascular than the adjacent vertebral bodies and because of this there is

Figure 1 AP angiogram in a patient with spinal dural arteriovenous fistula. The segmental artery (open black arrow) gives rise to the radicular artery and somatic branches, which enter the spinal canal through the neural foramen (solid white arrow) and continues as the intercostal artery (open white arrow). The radiculomedullary branch feeds the anterior spinal artery of Adamkiewicz (solid black arrow), which in this patient is hypertrophied and tortuous.

a concentration of vessels in the discs and endplates of the bones. This disco-centric blood supply accounts for the phenomenon of dual blood supply to each vertebral body level centered at the developing disc above and below.

The spinal cord receives both an anterior and a posterior blood supply. The anterior spinal arteries are fewer in number, and receive fewer collateral feeders; therefore, injury to these vessels poses a greater risk for neurological injury. In general, it is believed that the anterior spinal artery receives collateral supply from 6 to 8 radicular arteries in the thoracolumbar spine, including the arteria radicularis magna (artery of Adamkiewicz).

For a more complete discussion of the arterial anatomy of the spine, please refer to the article entitled “Basic Vascular Neuroanatomy of the Brain and Spine: What the General Interventional Radiologist Needs to Know” in this issue.⁶

Technical Considerations

Preoperative embolization of vertebral metastases can be performed anywhere along the vertebral column. Statistically, the majority of these tumors are located in the thoracic and lumbar spine. Cervical metastases obtain blood supply from the vertebral arteries, and embolization of these carries the added risk of ischemic stroke in the posterior circulation of the brain. The following discussion will focus on embolization in the thoracic and lumbar spine.

The performance of preoperative embolization of hypervascular vertebral column metastases begins with review of available imaging. In particular, the interventional radiologist should evaluate the location and extent of vertebral lesions, identify the vertebral body levels in reference to the cranio-cervical junction above and the lumbosacral junction below the targeted segments, and correlate these to the surgical plan and imaging reports. Any potential discordance must be resolved prior to intervention. Transitional vertebral bodies and variant anatomy may lead to confusion at the time of intervention, which should be avoided by careful pre-procedural planning. Informed consent should be obtained from the patient, and risks pertinent to the procedure including hemorrhage or hematoma at the common femoral artery access site, catheter- or guidewire-related trauma to the arteries, contrast reaction, technical failure without improvement in intraoperative blood loss, and nontarget embolization including spinal cord infarct and skin or muscle necrosis should be discussed.

Vertebral body embolization is commonly performed using a right common femoral artery approach. A 5-French sheath is positioned and placed to continuous heparinized saline flush. Conscious sedation is frequently employed, although consideration of general endotracheal anesthesia may be warranted as this can allow suspension of respirations during imaging. Elimination of subtraction artifact may improve the safety of the procedure by allowing better visualization of the spinal arteries. A 5-French reverse curve diagnostic catheter is preferred to allow selection of the intercostal or lumbar arteries depending on the vertebral level(s) of interest. Frequently used catheters include the

Mickelson (Cook Medical, Inc., Bloomington, IN), SOS Omni 1 (AngioDynamics, Queensbury, NY), and the Simmons 1 (Merit Medical, South Jordan, UT). Coaxial use of a peripheral microcatheter is commonly employed to allow subselection of the appropriate vessel for safer intervention.

The segmental arteries arise posterolaterally from the aorta and typically coincide with the location of the intervertebral disc. Hand injection of contrast volume and rate is typically in the range of 1 to 2 mL/s for a total of 2 to 4 mL. Imaging is best obtained in the posterior-anterior and lateral projections, facilitated by the use of a biplane angiography unit. For complete examination of the blood supply, bilateral arterial supply at the vertebral body level of interest as well as one level above and below should be evaluated. Often, adjacent levels may be parasitized by the tumor.

Embolization should be performed only if a secure catheter position is attainable and the spinal arteries are not visualized during diagnostic angiography (→Fig. 2). Tumor vascularity or blush shares a common appearance with the normal enhancement of the vertebral body (→Fig. 3); however, it is frequently of higher density, includes discrete margins that coincide with bony destruction, and may extend outside of the cortical margin of the vertebral body especially when there is paravertebral soft tissue involvement. Particle embolization is the method of choice and small to medium size particles should be chosen to minimize the blood supply in the operative setting. A common choice would be 150 to 250 μ m diameter particles of polyvinyl alcohol. Embolization is performed until complete stasis is achieved. One helpful maneuver for intraoperative identification of targeted vertebral level(s) is placement of microcoils after complete particle embolization. As the microcoils can act as markers for the

Figure 2 AP spinal angiogram demonstrating the artery of Adamkiewicz (open black arrow) in addition to tumor vascularity (white oval).

Figure 3 AP spinal angiogram demonstrating a usual appearance of tumor vascularity (white circle).

vertebral body level(s) of interest under fluoroscopy and may also be palpated manually, the authors routinely place microcoils to assist the operating surgeon to identify the appropriate level. Microcoil embolization may also improve the completeness of embolization. Care should be taken not to place coils if reintervention is anticipated; also, the surgeon should be informed if coils are placed to decrease the risk of coil extrusion into the aorta at the time of operation.

Another technique to consider for reducing operative blood loss during surgical management of hypervascular vertebral column lesions is percutaneous access with liquid embolization.^{4,5} Multiple small case series have reported excellent technical success and low complication rates with this approach.^{4,5} This technique is similar to vertebral augmentation in terms of transpedicular needle placement. Once the cannula is placed in the ventral midline of the vertebral body, a contrast vertebrogram (fluoroscopic imaging of the accessed vertebral body) can be performed through the cannula to assess for extraosseous blood flow. This is essential, since nontarget embolization to the central nervous system is a potential complication and has been described in at least two cases.⁴ Liquid embolization using NBCA mixed with lipiodol is performed under fluoroscopic control. Theoretical benefits of this technique include directed access into the affected vertebral body without the need for catheterization, more complete embolization of the tumor, and better stability compared with catheter-based techniques. The temptation to use polymethyl methacrylate (PMMA) instead of NBCA should be avoided because the firm consistency of PMMA makes surgical resection of the tumor more difficult.⁴ It is reported that tumors embolized using NBCA remain soft and are easily resected. Direct percutaneous liquid embolization of the involved vertebrae has been described as an adjunctive therapy following incomplete or partial transarterial catheter embolization⁴; however, it may also be used as a standalone procedure, at least theoretically.

Clinical Outcomes

The timing of embolization prior to surgery has been evaluated using both retrospective and prospective analyses. In general, the results appear to support that embolization is most effective at minimizing intraoperative blood loss when performed within 24 hours prior to surgery but no more than 48 hours prior.⁷ The authors adhere to this timing in their own practice.

The reduction in blood loss during surgery depends to some degree on the level of completeness of preoperative embolization. It is not uncommon to have substantial transfusion-dependent hemorrhage during spinal surgery for hypervascular metastases and resultant increased mortality due to blood loss. Blood loss in the range of 5 L has been commonly reported during these operative procedures.⁸ Particle embolization has been shown to reduce the degree of bleeding during the procedure by an average of 50%.⁷ There are nonsignificant trends toward less blood loss with more complete tumor embolization; however, any degree of embolization is more likely to result in significant reduction in blood loss even if the embolization is incomplete.² Unfortunately, the performance of preoperative embolization does not exclude the possibility of substantial intraoperative blood loss.³

Complications

The most feared complication of embolization of vertebral body metastases is spinal cord ischemia and resultant cord infarction with neurologic changes. This complication is rare enough that incidence rates have not been reported. Literature suggests that embolization should be withheld if the spinal arterial supply is identified arising from the same level as tumor enhancement, if stable catheter positioning cannot be obtained, or if the patient experiences neurologic symptoms during the intervention.⁷ Some authors support the notion that embolization of tumors can be performed carefully regardless of shared blood supply with the spinal cord as long as the position of the catheter is felt to be at a safe distance from the radiculomedullary branch.³ Erring on the side of being conservative is a reasonable approach in this circumstance, as incomplete preoperative embolization also has shown reduction in operative blood loss compared with no preoperative embolization.² Other complications are reported with much less frequency and include bleeding, vessel dissection, and skin or muscle necrosis.

Complications related to direct percutaneous liquid embolization are similar to those associated with catheter-directed techniques. At least two cases of major neurological injury following percutaneous NBCA embolization of a cervi-

cal vertebral metastasis, including one death, have been reported.⁴ Other reported complications include access site hematoma, wound infection, and pulmonary embolism.

Conclusions

Vertebral column metastases are relatively common, and frequently related to hypervascular primary solid organ tumors such as renal cell carcinoma. For appropriately symptomatic patients, the optimal treatment includes surgical resection and spinal fusion. Resection exposes the patient to a risk of significant hemorrhage, and therefore preoperative embolization is often employed to minimize blood loss at the time of surgery. Maximum benefit is realized when embolization is performed no more than 48 hours prior to surgery. The most ominous complication of vertebral body embolization is nontarget embolization of the anterior spinal artery resulting in neurologic injury. Alternatives to these treatments include percutaneous vertebral body augmentation with or without thermal ablation.

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