Techniques in
Vascular and
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Radiology

Transarterial Embolization of Bone Metastases

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Embolization of bone metastases is most commonly performed for hypervascular tumors prior to surgical resection. When employed in this fashion embolization can significantly decrease perioperative hemorrhage and improve surgical outcomes. In addition, embolization of bone metastases may lead to local tumor control and decreased tumoral associate bone pain. Careful techniques and choice of embolic material are required when performing embolization of bone lesions to ensure low procedural complications and high rates of clinical success.[4] The indications, technical considerations, and complications associated with embolization of metastatic hypervascular bone lesions will be discussed in this review with subsequent case examples.

KEYWORDS Embolization, Bone tumors, Metastases

Introduction

In cancer patients, disease that has metastasized to the skeleton often portends a poor prognosis with potential significant morbidity characterized by severe pain, impaired mobility, pathologic fractures, bone marrow aplasia, and hypercalcemia.[1] Treatments focus on slowing progression and improving quality of life by reducing pain and improving mobility.[2]

Indication for surgical treatment of bone metastases most commonly includes a present or impending pathologic fracture and prophylactic fixation surgery.[3] However, these surgical procedures are associated with prolonged operating times and large intraoperative blood loss, especially in hypervascular tumors.[3,4] Given these risks, preoperative embolization of bone metastases was developed with the goal of minimizing intraoperative blood loss and reduce surgical complications. Since that time embolization of bone lesions has expanded in its use and indications.[5] The indications, materials, technical considerations, and complications associated with embolization of bone lesions will be discussed in this review. The focus of this review will be on embolization of hypervascular bone metastases and not primary osseous malignancy, as metastases are significantly more common. However, it is worth noting that similar techniques can be applied to embolization of primary bone lesions.[1]

Indications

The most common indication for embolization of a bone metastasis is to decrease intraoperative hemorrhage during surgery which can result in improved simplicity of the surgical resection.[6] Less frequent indications include relief of pain and for local tumoral control.

Given the high intraoperative blood loss associated with hypervascular bone metastases, preoperative embolization is most commonly performed for these types of tumors which include metastatic renal cell carcinoma, thyroid cancer, melanoma, leiomyosarcoma, and prostate cancer.[7] Renal cell carcinoma metastases are the most common. Less commonly, embolization of primary bone lesions and metastases has been performed to decrease lesion associated pain. The

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operator's goal for this indication is to devascularize tumor in order to alleviate symptoms via tumor shrinkage. More recently, cryoablation has demonstrated promising results when employed for control of lesion associated pain and may be more clinically effective in this regard when compared to embolization.[8]

Preprocedure

Preprocedure planning should include a history and physical examination focused on elucidating specific sites of pain and identifying locations of planned surgical resections. Evaluate the planned access site pulses (common femoral or radial artery) and visualize the overlying skin at site of the planned embolization. Note neuromuscular status, skin color, capillary refill, and presence or absence of overlying wounds.

Preprocedure cross-sectional imaging is often obtained to confirm arterial supply and identify critical adjacent structures. CT angiography is preferred by the author given its ability to delineate arterial supply and anatomic details while avoiding the limitations of inappropriate MRI protocoling. However, recently at our institution preprocedure arterial-phase cross-sectional imaging has been omitted and replaced by intraprocedural cone-beam CT. In addition to convenience, cone-beam CT has the added benefit of ensuring adequate timing of the contrast bolus for appropriate visualization of the targeted arterial anatomy.

Technique

Prior to performing embolization operators should carefully consider vascular supply of at-risk vital structures. For example, within the lower extremity consideration should be given to arterial supply to the vasa nervorum of the sciatic nerve which most commonly arises from the medial circumflex femoral artery.[9] If a spine metastases will be treated, careful evaluation for spinal cord vascular supply is mandatory.

Arterial access is most often determined based on favorable anatomy (i.e., lack of atherosclerotic disease) and the location of the targeted tumor(s). For upper extremity lesions the author prefers lower extremity common femoral artery access. This is due to the anatomy of arterial branching points within the extremities to be commonly oriented from proximal to distal. Approaching these branching points from a proximal to distal approach facilitates greater ease of cannulation and decreases excessive device manipulation that may damage or spasm targeted arteries. For similar reasoning the preferred access sites when procedures involve the lower extremities includes the contralateral retrograde common femoral artery, the ipsilateral antegrade common femoral artery, or the left radial artery. If the embolization is being done preoperatively, arterial access in the same extremity should be avoided since surgeons will often perform extensive manipulation of the proximal joint. Access site complications may be potentially higher and undetected from these intraoperative movements.

During treatments involving the upper extremities the operator should take particular care near the aortic arch and great vessels due to the theoretical complication of inciting an ischemic stroke from catheter manipulation in this region.[10] For this reason the author prefers to use a 4 or 5 French (Fr) Glidecath (Terumo, Tokyo, Japan) for navigating through the aortic arch as we have found the catheter to be the most atraumatic while having a high degree of success in cannulating the targeted vessel. When patient anatomy results in difficulty cannulating an arch vessel a specific neurointerventional catheter is utilized, such as the headhunter (Merit, South Jordan, UT).

After access to the targeted region is accomplished power-injection angiography is performed. In the upper extremity a rate of 4 mL/s for a total of 15-20 mL of contrast is usually sufficient. When choosing contrast injection rate and amount in the lower extremity distance between the catheter and the targeted lesion must be considered. For proximal lesions a rate of 4 mL/s for a total injection amount of 15-20 mL is usually sufficient. For more distal lesions a larger amount of contrast is required, usually 20-30 mL. Angiography is then repeated with performance of a cone-beam CT which obtains excellent arterial and soft tissue anatomy which aides in identification of all arterial supply to the targeted tumor. An appropriate delay time on the cone-beam CT will allow perfusion of the entire tumor to be visualized. This delay time can be chosen by the obtaining the time elapsed for maximal tumor enhancement on the preceding digital subtraction angiogram. Postprocessing of the cone-beam CT with 3D reconstruction and maximum intensity projections is particularly helpful in this regard and allows the operator to determine the optimal working obliquity when cannulating targeted vessels.

Selection of branching arteries is performed with a microsystem to decrease the risk of nontarget embolization. Targeted vessels in this procedure tend to be particularly small in caliber and therefore 2.0-2.4 French (Fr) microcatheter is often required. Depending upon anatomy and vessel size the authors preferred microcatheters are the 2.4 Fr Direxion bern shaped tip (Boston Scientific, Marlborough, MA) and the 2.0 Fr Progreat alpha (Terumo, Tokyo, Japan). Microwires that are most commonly used include the Fathom 14 (Boston Scientific, Marlborough, MA), and the Synchro soft microwire (Stryker, Kalamazoo, MI). Once access into the targeted vessel is obtained, 100-200 mcgs of nitroglycerin can be given intra-arterially to reduce spasm and facilitate a more complete embolization.

Embolization of targeted vessels is then performed. Hypervascular osseous tumors frequently have several arterial feeders. Embolization of a single artery is inadequate, and will result in collateralization via the larger feeding arteries. Therefore, we intentionally select and treat the smaller arteries first, with treatment reserved for the largest arterial feeder at the end. All arteries should be treated in a single session if possible. Choice of embolic is largely operator dependent but the authors recommend permanent particulate agents. Liquid agents, such as glue or Onyx (Medtronic, Dublin, Ireland), carry an increased risk for nontarget embolization with the anatomy often found in the extremities. Gelfoam (Pfizer, New York, NY) is an attractive choice for an embolic agent for this procedure given its temporary nature of lasting approximately 2-4 weeks. Unfortunately, its practicality is limited given the need to deliver the embolic within the small microcatheters required to cannulate the targeted vessels. This limits the ability to safely deliver Gelfoam (Pfizer, New York, NY) due to decreased operator control, increased chance for reflux, and a high likelihood of occluding small microcatheters.[11]

With regards to choice of other particulate agents, previous investigations have shown no difference between the use of nonspherical polyvinyl alcohol (PVA) particles and trisacryl gelatin microspheres.[12] If cost is a consideration PVA particles could be utilized. The authors preferred particulate embolic are calibrated microspheres given their tightly regulated sizing which has been observed by the author to lead to greater reliability. When sizing particulate embolics the operator must carefully evaluate initial angiographic imaging to assess for the presence of nontarget supply and for the presence of intratumoral shunting. In the absence of arterial shunting particle sizes utilized are often between 75 μm and 200 μm. The most commonly used particles and size by the authors are 100 μm Embozene (Varian, Palo Alto, CA). If shunting is present larger particles are chosen to ensure entrapment of particles within the tumor, such as 100-500 μm. The targeted goal for embolization is a significant reduction in tumoral blush with preservation of nontumoral supply. A goal of complete stasis is ill advised in these procedures given the increased likelihood of complications including nontarget embolization in an area of often high-risk anatomy (ie, upper extremities). When performing prior to planned surgical resection, it is not imperative to achieve complete devascularization. While this remains the goal, it should not be done at the expense of significant nontarget embolization. The use of microcoils is not routine in our practice due to the possibility of impeding or complicating surgical resection with likely little clinical benefit. If microcoils are being considered it is recommended to first discuss with the surgeon performing the subsequent tumoral resection.

Postprocedure

Embolization of bone metastases is often associated with significant postprocedure pain. Therefore, embolization should be performed within close proximity to the planned surgical resection to minimize patient suffering. Embolization at our institution is arranged to be performed in the late afternoon the day before surgical resection is to be performed the following morning. Patient controlled analgesic (PCA) pumps are routinely arranged for in preparation for the significant postprocedural pain while the patient awaits surgical resection.

Complications from embolization of bone metastases are similar to other embolization procedures and overall the procedure is associated with low complication rates.[13] The most common complication is postembolization syndrome due to tumor necrosis and presents with symptoms of pain, fever, and fatigue. Other complications include access site complications, infection, pain, and complications related to sedating medications. More rare complications are most commonly associated with nontarget embolization, such as skin ulcerations or limb ischemia. Transient paralysis has been reported in the literature and is thought to be secondary to nontarget embolization of vascular supply to an adjacent nerve.[14]

Conclusion

Interventionalists are well trained in embolization procedures throughout the vascular system. As such, expanding one's embolization repertoire to include the bone has the potential to provide significant clinical benefit to patients with bone metastases, a debilitating disease that carries a poor short-term prognosis. The most common indication for embolization of bone tumors is for preoperative embolization for metastatic hypervascular bone lesions (renal cell carcinoma or thyroid cancer) and when utilized for this indication the perioperative bleeding is significantly reduced resulting in decreased complexity during surgical resection.

References

1. Macedo F, Ladeira K, Pinho F, et al: Bone metastases: An overview. Oncol Rev 11:321, 2017. https://doi.org/10.4081/oncol.2017.321
2. Coleman RE: Clinical features of metastatic bone disease and risk of skeletal morbidity. Clin Cancer Res 12(20 Pt 2):6243s-6249s, 2006. https://doi.org/10.1158/1078-0432.CCR-06-0931
3. Mercadante S: Malignant bone pain: Pathophysiology and treatment. Pain 69:1-18, 1997. https://doi.org/10.1016/s0304-3959(96)03267-8
4. Pazionis TJC, Papanastassiou ID, Maybody M, et al: Embolization of hypervascular bone metastases reduces intraoperative blood loss: a case-control study. Clin Orthop Relat Res 472:3179-3187, 2014. https://doi.org/10.1007/s11999-014-3734-3
5. Carpenter PR, Ewing JW, Cook AJ, et al: Angiographic assessment and control of potential operative hemorrhage with pathologic fractures secondary to metastasis. Clin Orthop Relat Res 123: 6-8, 1977
6. Owen RJT: Embolization of musculoskeletal bone tumors. Semin Intervent Radiol 27:111-123, 2010. https://doi.org/10.1055/s-0030-1253510
7. Kickuth R, Waldherr C, Hoppe H, et al: Interventional management of hypervascular osseous metastasis: role of embolotherapy before orthopedic tumor resection and bone stabilization. AJR Am J Roentgenol 191:W240-W247, 2008. https://doi.org/10.2214/AJR.07.4037
8. Wallace AN, McWilliams SR, Connolly SE, et al: Percutaneous image-guided cryoablation of musculoskeletal metastases: Pain palliation and local tumor control. J Vasc Interv Radiol 27:1788-1796, 2016. https://doi.org/10.1016/j.jvir.2016.07.026
9. Georgakis E, Soames R: Arterial supply to the sciatic nerve in the gluteal region. Clin Anat 21:62-65, 2008. https://doi.org/10.1002/ca.20570
10. Segal AZ, Abernethy WB, Palacios IF, et al: Stroke as a complication of cardiac catheterization: Risk factors and clinical features. Neurology 56:975-977, 2001. https://doi.org/10.1212/wnl.56.7.975
11. Vlahos L, Benakis V, Dimakakos P, et al: A comparative study of the degree of arterial recanalization in kidneys of dogs following transcatheter embolization with eight different materials. Eur Urol 6:180-185, 1980. https://doi.org/10.1159/000473322
12. Basile A, Rand T, Lomoschitz F, et al: Trisacryl gelatin microspheres versus polyvinyl alcohol particles in the preoperative embolization of bone neoplasms. Cardiovasc Intervent Radiol 27:495-502, 2004. https://doi.org/10.1007/s00270-003-0147-1
13. Ma J, Tullius T, Van Ha TG: Update on preoperative embolization of bone metastases. Semin Intervent Radiol 36:241-248, 2019. https://doi.org/10.1055/s-0039-1693120
14. Barton PP, Waneck RE, Karnel FJ, et al: Embolization of bone metastases. J Vasc Interv Radiol 7:81-88, 1996. https://doi.org/10.1016/s1051-0443(96)70738-8