Strategic and Technical Considerations for the Endovascular Embolization of Intracranial Meningiomas

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KEYWORDS

• Meningioma • Endovascular • Embolization • Technique • Dangerous anastomoses

KEY POINTS

- Endovascular embolization can be used as an adjunct to surgical resection of meningiomas.
- Meningiomas that may benefit most from embolization are large, vascular tumors in surgically challenging locations.
- Critical endpoints for assessment of embolization efficacy are difficult to quantify.
- Optimal timing of endovascular embolization remains unclear.

INTRODUCTION: NATURE OF THE PROBLEM

Meningiomas comprise approximately 15% to 20% of all intracranial tumors.[1–3] Although small incidental tumors can be followed,[4,5] larger, symptomatic tumors are most often treated with a goal of curative gross total resection and symptom resolution.[1] However, meningioma resection is not benign. Surgical morbidity has been shown to be 30% and mortality 4% in the general population[6] and 48% and 6.6%, respectively, in the elderly.[7] Preoperative endovascular embolization has been advocated to reduce intraoperative blood loss and improve ease of surgical resection.[1,8] Embolization of tumor arteries, not anatomically accessible during the surgical approach, may be of benefit to the surgeon. Tumor softening and necrosis after embolization may aid in the resection of firm tumors and decrease the need for brain retraction within confined operative corridors. On rare occasions, therapeutic embolization can be performed to prevent tumor growth and/or decrease tumor burden. The role for such palliative embolization should be restricted to poor candidates for surgery with extensive comorbidities.[9,10]

Despite refinement in catheters, wires, and embolic agents, complications still occur during preoperative embolization of meningiomas. Because the procedure is not typically curative, concerns over the usefulness of this treatment

Conflict of Interest: No funding was received for this, and no conflict of interest exists among any of the authors.

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Neurosurg Clin N Am 27 (2016) 155–166
http://dx.doi.org/10.1016/j.nec.2015.11.005
1042-3680/16/$ – see front matter

have been raised and warrant further investigation.[11] Here we review the decision-making processes and technical considerations that help guide preoperative embolization of meningiomas.

INDICATIONS AND CONTRAINDICATIONS

Little consensus exists as to which meningiomas benefit most from preoperative embolization. Focusing on intraoperative blood loss, reports have suggested that embolization may be most beneficial in meningiomas greater than 5 cm, those that demonstrate a multidirectional external carotid artery (ECA) blood supply, and tumors that possess substantial vascularity[3,11–14] Tumors in anatomically challenging locations, including the middle cranial fossa, sphenoid wing, and paracavernous region may also benefit. Tumors with dural and/or sinus involvement warrant consideration for preoperative embolization.

Studies suggest that preoperative embolization is highly effective in cases of exclusively ECA supply. However, tumors harboring mixed vascular supply with predominantly external contribution also benefit from embolization. Embolization of the ECA feeders serving tumors with mixed vascular supply may result in increased blood flow from the vessels of the internal carotid artery (ICA). This change in flow pattern may negate, or even reverse, the beneficial effects of embolization on blood loss and surgical complexity.[14] Tumors supplied exclusively by branches of the ICA are not ideal for preoperative embolization owing the difficulty involved in safe catheterization and the presence of en passage vessels.[3,12,14]

OPERATIVE TECHNIQUE AND PROCEDURE

Preoperative Planning

A thorough preoperative medical history, detailed neurologic examination, and appropriate serologic analysis can reveal a contrast allergy or renal insufficiency before catheter angiography. Premedication, hydration, and/or minimization of contrast agent may be warranted in these patient populations. Patients often present to the neurosurgeon with a basic MRI study. However, in some cases (sella region, cerebellopontine angle), a fine cut MRI, with and without contrast, is useful for precise anatomic tumor localization. A computed tomography scan may be beneficial in identifying lesional calcifications. These studies will guide both the operative planning and the determinations of whether or not to evaluate the tumor angiographically. Surgeons can consider preoperative MRI or computed tomography angiography to help elucidate whether the tumor may benefit from embolization before submitting the patient to the risks of catheter angiography.

A preoperative diagnostic catheter angiogram should include, as appropriate, selective evaluation of the ECA, ICA, vertebral arteries, and, if location of the tumor warrants, the thyrocervical and costocervical trunks (typically cervicomedullary or spinal tumors). A bilateral evaluation is critical for parasagittal tumors, because they can recruit blood supply from both sides (**Fig. 1**). Detailed angiographic information assists in guiding the embolization and aids the surgeon with preoperative planning (eg, identification of arterial feeders to be encountered and patency of dural sinuses). Often, the arterial pedicles directly supplying the meningioma must be selected to identify anastomoses that place cranial nerves and key structures at risk during embolization (discussed elsewhere in this paper).

The blood supply to meningiomas arises from the ECA in addition to dural branches of the vertebral and ICA. However, meningiomas can also recruit substantial supply from cortical, pial, and/or scalp–transosseous arteries (see **Fig. 1**). Typically, meningiomas exhibit an intense vascular tumor blush that lasts through the late venous phase on angiography. Superselective angiography of feeding arteries often demonstrates a “sunburst” pattern of tumor staining.[2]

PROCEDURAL CONSIDERATIONS

Timing

Once it is decided to undertake preoperative meningioma embolization, the next consideration is timing. Although no consensus exists, most authors suggest that preoperative embolization should take place shortly before open resection, typically within a few days. Should embolization be performed on the same day as resection, it is prudent to examine the patient’s neurologic function between procedures. One study supports delaying surgical resection for at least 24 hours after embolization, exhibiting a reduction in blood loss after a 24-hour delay; however, optimal latency was not quantified.[8] Kai and colleagues[15] propose that the optimal duration between embolization and resection may be 7 to 9 days. The group demonstrates maximal tumor softening, decreased operative times, and lower Simpson grades at this delayed time point. A similar study compared 16 patients with tumor embolization 7 days or greater from the time of resection with a group of 12 patients who underwent surgery less than 7 days from embolization. The authors showed greater reduction in surgical time and blood transfusion volume in the delayed embolization group.[16] However, delayed resection also may