Preoperative embolization of intracranial meningioma, do or don’t? : A literature review and case presentation

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Learning objectives

- Review the role of preoperative embolization of intracranial meningioma.
- Illustrate the possible known complications and adverse effects of embolization.
- Correlate outcomes with type of embolizing agents and other factors, and present cases from our practice.
Background

Meningiomas are the most common benign intracranial neoplasm, showing a prevalence of approximately 13% to 26% of adult intracranial tumors.[1]

Intracranial meningioma is a common pathology and, therefore, familiar to all neurosurgical units. Surgical excision is the mainstream way of treatment.

Preoperative endovascular embolization is aimed primarily at reducing this vascularity via the dural arteries.

Though, preoperative embolization of intracranial meningioma has been always controversial since it was first described. With benefits as decreased blood loss and "softening of the tumor" during subsequent surgical resection. However, the actual benefits still unclear, with the potential risks of an additional procedure along with the cost of embolization have limited its use to a small proportion of the meningiomas. One of the reasons it's still controversial as a treatment strategy is that it has not been examined in a large comparative series.[2]

Meningiomas are usually supplied by the middle meningeal, accessory meningeal, ascending pharyngeal, or occipital branches of the external carotid artery (ECA), which are easily accessible by selective microcatheterization.[3]
Findings and procedure details

We've performed a structured literature review across Medline and Pubmed databases, with concept map of terms: pre-operative, meningioma, embolization, complications, embolizing agent, with literature articles from 1993 to 2018 were retrospectively reviewed.

Inclusion criteria included prospective and retrospective in the aforementioned period in English, Exclusion criteria included case reports with small number of cases "less than 20 cases", or non-English language articles.

Studies included are tabulated in [table1] including 25 studies, with different techniques and variable embolizing materials.

Articles were screened for advantages of preoperative embolization of meningioma, complications happened in some cases, the outcomes correlation with the embolizing agents used and nature of the meningioma including site and any special tumor characteristics, and time between embolizations and surgery, as well as patient type and age.

Cases from our practice

We present 4 cases of our practice, the cases were performed in Egyptian military hospitals, in first half of 2016. [Table 2], [Table 3] show the different embolizing material used and advantages, and disadvantages of each in [figures 1, 2, 3, 4].

The technique used was transarterial intravascular catheterization. Embolizing material used were PVA particles 300-500 um and 250-300 um and Onyx#. Interdisciplinary risk-benefit weighing assessment was done for each and every case as general risk assessment couldn't be applied. Risks depend on Tumor localization, size of the tumor, vascular supply whether there is dangerous anastomoses, and possibilities of peripheral vs deep supply, in addition to pre-existing mass effect (post-embolization edema/swelling possibility).

Risk assessment is primarily indicated to balance surgery alone versus embolization and surgery. The time from embolization to surgery was 3-10 days.

Discussion, to embolize or not to embolize?

The real additive value of preoperative embolization for treatment of intracranial meningiomas remains contentious. With growing number of literature suggests that this can be a valuable and safe adjunct to surgical excision in selected cases, particularly those that are surgically challenging.[4], [5], [6]
The decision to embolize should be made following a risk-benefit discussion, within a multidisciplinary team meetings and it's worth mentioning that indications for treatment were not standardized.[7]

The complications experienced by [7] (Borg A. et al.) were mostly falling into 2 principal categories: excessive ischemic tumoral necrosis leading to postprocedural tumoral hemorrhage and nontarget embolization causing neuroparenchymal or extracranial ischemia (ie, skin), this was also demonstrated by (Gruber et al.) [5],[8],[9],[10]

Mass effect and other angiography related complications has been shown in other few studies.

It's been shown that the neuroparenchymal ischemic complications are mostly related to dissemination of embolic material via arterio-arterial anastomosis between dural and neuroparenchymal structures.

Conversely, a clear anatomic appreciation of these anastomosis is essential to prevent unintentional damage to the brain and cranial nerves. The middle meningeal artery and its proximal branches gives anastomosis with arteries supplying cranial nerves at the skull base. The sphenoidal branch of the middle meningeal artery supplies the oculomotor, trochlear, and abducens nerves, the cavernous branch, and the trigeminal nerve, with the petrosal branch supplying the facial and vestibulocochlear nerves.[11],[12]

Embolization causes histopathologic changes within meningioma, including necrosis, ischemic changes, and microvascular fibrinoid changes.[13]

These changes may make histologic examination of embolized meningiomas more difficult because they may histopathologically resemble higher grade tumors. [13],[14]

The leptomeningeal anastomoses developed through the tumor bed itself, may lead to particular risks with ultrasmall particles, thus connecting internal and external carotid causing parenchymal ischaemic infarction, which was shown by (Benzodus et al.) [8]. This complication can be avoided as described by (kai Y. et al., Horton JE. et al.) [15],[16] by provocation tests with Lignocaine and Amytal injections before progressing with embolization procedure. Using liquid glue in distal catheter locations and particles in more proximal results in lower rate of complications; little more than 1% permanent complications.[7]

Time from embolization to the surgery is another factor. Two to nine days are the best time as it allows necrosis to develop, edema to lessens, and tumor softening, yet it seemed to have no significant effect on the number of blood units transfused even when
other factors including "tumor location" and the "degree of devascularization" were taken into account as shown by (Borg A. et al.) [7]

**Hemorrhage** happening in most cases is usually of subarachnoid origin [17] and may also be caused by obstruction of the venous outflow by embolic material, resulting in high transmural intratumoral pressure. Tumor infarction itself may result in hemorrhage due to edema and venous obstruction or as a result of the rupture of pathologically fragile tumor vessels.[18]

The greatest tumor softening occurred 7-9 days after embolization. [19]

Surgery time and blood volume transfused were significantly lower in cases who had been embolized at least 7 days before definitive surgery. [20]

Intraoperative blood loss was greater for the immediate group (<24h) than for the delayed group. [21]

Tumors smaller than 6 cm, the blood lost during the operation was significantly less in the embolized group. In tumors larger than 6 cm, there was not difference in blood lost. [22]

Using this protocol (PVA) no embolization-related complications have occurred over the last 9 years.[5]

(Bendszus M. et al.) [8] found that only complete embolization (>90%) had an actual effect on blood loss.

(Borg A. et al.) [7] also stated that blood transfusion was significantly lower after embolization, however, he reported four patients had interventional complications.

Steve W. Hetts commented on (Borg A. et al.) [7], stating that "The most significant complications in this series occurred during the use of liquid embolic agents in 2 relatively high-risk arterial territories: the first one the anterior choroidal artery and the second dural skull base of internal carotid artery branches. This reminds us of the importance of tailoring the aggressiveness of embolization to the expected surgical risk of the specific tumor being addressed . Overall, however, this report underscores the overall safety of preoperative embolization of presumed intracranial meningiomas, with a trend toward reducing operative blood loss."

**Technical difficulties and anatomical considerations:**

Although some studies proved the procedure would decrease blood loss and facilitates tumor resection, it is difficult to draw definitive conclusions regarding the indications
and usefulness of embolization because of the lack of randomized controlled trials. The entire literature and standards of practice are drawn from level III evidence derived from case series. The potential complications arising from embolization and the added cost of intervention have limited its use to a subset of meningiomas, as stated by (Yoon N. et al.)[23]

There situations that preoperative embolization may be beneficial, like difficult vascular supply and access; edema that obfuscates the surgical plane, involvement of dural sinuses, scalp, and calvaria; and location near the eloquent cortex.[18], [5], [19]

Preoperative embolization may even eliminate the necessity to surgically excise meningiomas, as reported by (Bendszus et al.) [9], who treated seven such patients with embolization without subsequent surgery. They used trisacryl gelatin microspheres to embolize external carotid feeders. They were able to achieve angiographic devascularization in the five patients whose tumors were supplied exclusively by the external carotid; the internal carotid fed part of the tumor in two patients and was not embolized.

(Campero A. et al.) [24], demonstrated that the transzygomatic approach combined with mini-peeling of the anterior third of the middle fossa is effective for early devascularization of sphenoid wing meningiomas, which also becomes handy during resection of large tumors.

(Yoon N. et al.) concluded that subtotal embolization may not be associated with any reduction in operative blood loss, whereas aggressive embolization may be associated with serious complications. Thus, the needs of thorough devascularization of the tumor must be balanced with the attendant risks of a more aggressive approach, advocating adoption of a conservative approach that favors complication avoidance over more aggressive devascularization, which means avoiding any feeders arising from the ICA and using different devices based on the

vascular anatomy, such as # 300-µm PVA particles when there is risk of CN palsy, and NBCA or Onyx only when the microcatheter is sufficiently distal to any potentially hazardous anastomotic connections.[23]

**Dangerous anastomosis and choice of embolizing material**

**Small PVA particles** (45-150 mm) are more effective in preoperative devascularization than larger particles (150-250 mm) due to capability of more distal penetration into the capillaries feeding the tumor, yet shows higher risk of complications such as cranial nerve palsies and postprocedural hemorrhage.

**Larger PVA particles** (> 400 mm) are associated with fewer complications, but they result in less effective devascularization because they cause occlusion of larger vessels, which may lead to revascularization via collateral blood supply.[25]
(Przybylowski CJ. et al.) [26] states that use of Onyx should be reserved for dura matter based arterial pedicles without a distal supply to cranial nerves or extracranial-intracranial anastomoses.

There are major complications such as hemiparesis, cranial nerve palsies, tumoral swelling, ischemia, or hemorrhage. Minor neurological complications included headache, dizziness, and vomiting. [Table 4] outlines the complications and material used in some of studies with considerable number of patients (#=689).

**Limitations and Potential**

Till now there has been no reliable comparative control group. Data about surgical outcomes of the previously embolized meningiomas are still limited, extent of tumor resection and recurrence rates. A randomized trial comparing preoperative embolization with surgery and a surgery only control would elucidate the potential benefits of preoperative embolization for intracranial meningiomas.

For now, we must carefully select ideal cases for preoperative embolization, in which the safety and clinical benefit of the procedure has been clearly demonstrated, eg, highly vascular large meningiomas.
Fig. 1: Technique: selective microcatheter feeder embolization. Embolizing Material used: PVA particles 300-500um. Presentation: case of meningioma supplied by ECA at the scalp, via branches of middle meningeal artery and superficial temporal artery. (a) Shows a MRI FLAIR of left temporal meningioma (b) shows DSA of the meningioma preembolization (C) post-embolization- improved case without need for further surgical intervention.

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Table 1: [table1] including 25 most outstanding studies, with different techniques and variable embolizing materials.

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<table>
<thead>
<tr>
<th>Technique used</th>
<th>Embolizing material</th>
<th>Meningioma site</th>
<th>Vascular Supply</th>
<th>Time from embolizing to surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Case 1</strong></td>
<td>PVA particles 300-500um</td>
<td>Left temporal</td>
<td>ECA; branches of middle meningeal artery and superficial temporal artery</td>
<td>4 days</td>
</tr>
<tr>
<td><strong>Case 2</strong></td>
<td>PVA particles 250-300um</td>
<td>Left petros</td>
<td>Posterior circulation</td>
<td>7 days</td>
</tr>
<tr>
<td><strong>Case 3</strong></td>
<td>Onyx</td>
<td>Right parafalcine</td>
<td>Middle meningeal artery</td>
<td>10 days</td>
</tr>
<tr>
<td><strong>Case 4</strong></td>
<td>Embospheres particles 250-300um</td>
<td>Left parafalcine</td>
<td>Middle meningeal artery</td>
<td>4 days</td>
</tr>
</tbody>
</table>

Table 2: 4 cases of our practice [Table 2]
### Table 3:

<table>
<thead>
<tr>
<th>Material</th>
<th>Particle Embolization</th>
<th>Liquid Embolic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>50-150u particles: deeper penetration, necrosis</td>
<td>Allows penetration into small arterioles (100u)</td>
</tr>
<tr>
<td></td>
<td>Proximal catheter position is sufficient</td>
<td>Provides better control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can embolize intra and peritumoral anastomoses</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>It’s dependent of the flow</td>
<td>Depends on plug and push technique</td>
</tr>
<tr>
<td></td>
<td>Higher risk of transtumoral penetration causing brain or adjacent nerve ischemia</td>
<td>Distal, umbilicus-close position needed</td>
</tr>
<tr>
<td></td>
<td>150-250u particles: clogging in bigger arteries, without tumoral stroma penetration</td>
<td>Catheter clogging</td>
</tr>
<tr>
<td></td>
<td>Risk of quick revascularization</td>
<td>Catheter entrapment</td>
</tr>
</tbody>
</table>

**Table 3:** Table 3 shows the different embolizing material used and advantages, and disadvantages of each

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**Fig. 2:** Technique: posterior circulation selective catheterization into the vertebral, basilar and left posterior cerebral arteries. Embolizing Material used: PVA particles 250-300µm. Presentation: MRI and MRV was done to assess the left transverse and sigmoid affection by the meningioma, and planning for embolization (a) Shows MRI left petrous meningioma (b) shows MRV to detect affection of the sigmoid and transverse venous sinuses (c) shows angiography to determine its vascular supply.

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Table 4: [Table 4] outlines the complications and material used in some of studies with considerable number of patients.

Fig. 3: Technique: selective ECA catheterization, with superselective meningeal microcatheter introduction into the feeders. Detachable tip catheter was used. Embolizing Material used: Onyx Presentation: Interhemispheric large meningioma, compressing the corpus callosum. (a) and (b) show preembolization MRI, DSA of a parafalcine meningioma compressing the corpus callosum. (c) and (D) shows DSA post Onyx embolization.

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Fig. 4: Technique: Selective parafalcine embolization Embolizing Material used: Embospheres particles 250-300um. Presentation: these are the preembolization, post-embolization images. showing no blush

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Conclusion

Preoperative embolization has been proven to be an optimal option for some specific cases of meningiomas, meaning not all cases would benefit from it, and therefore should be considered on a case-by-case basis. The intraoperative complications, duration and degree of resection are independable factors of embolization.

With complete devascularization managed to obtain a lower blood transfusion requirement, considered an indirect measure of operative blood loss.

The use of small polyvinyl alcohol particles was more effective in devascularization than larger particles. Needs of thorough devascularization of the tumor must be balanced with the attendant risks of a more aggressive approach.
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