# Management of Giant Aneurysm

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## Introduction

Giant intracranial aneurysms account for about 5 percent of all aneurysms, and are arbitrarily defined as having a diameter greater than 25 mm. These lesions, if left untreated, have an extremely poor natural history, with higher rates of morbidity and mortality than smaller saccular aneurysms. A retrospective review of untreatable giant aneurysms revealed an 80% risk of death or severe disability within 5 years of presentation.(5) In prospective natural history studies, patients with unruptured, untreated giant aneurysms had a 5 year cumulative hemorrhage rate of 40-50%.(6)

In contrast to patients with smaller aneurysms, 65 to 85% of patients with giant aneurysms present with symptoms related to mass effect. The presence of specific focal neurologic deficits, cranial neuropathies, and visual field defects are directly related to the size and location of the specific lesion.Subarachnoid hemorrhages occur in 25 to 35 percent of patients on presentation.(1) Thrombus formation within these large aneurysms may result in ischemic events from parent vessel thrombosis, perforator vessel occlusion and embolic events.

## Evaluation

Treatment of giant aneurysms can be particularly challenging. The size and complexity of these lesions, compared to smaller aneurysms, results in higher treatment morbidity and mortality. Successful outcomes require adequate proximal control, meticulous dissection, preservation of all perforating arteries, reduction of mass effect, and maintenance of distal outflow either directly or indirectly.

Adequate pretreatment planning requires a detailed understanding of the local vascular anatomy, the configuration of the neck, and the involvement of perforators. Problems can be anticipated in the presence of thrombus, plaques or calcification. A thorough evaluation and understanding of the collateral circulation across both hemispheres and from the external circulation usually reveals several options for excluding the aneurysm from the cerebral circulation. This knowledge also proves invaluable should an unexpected event occur during treatment.

Computed tomography (CT) scanning revolutionized neurosurgery when it first appeared several decades ago and remains an essential component of the diagnostic work-up.

The CT scan can be obtained easily and rapidly at most centers, and so is often the first study obtained when one suspects a subarachnoid hemorrhage. The CT scan also provides excellent visualization of calcifications within the aneurysm dome, neck and the surrounding vessels, since the presence of a highly calcified lesion can severely limit the possible treatment options.

The quality of CT angiographic studies has improved immensely over the past few years and provides excellent visualization of the size and configuration of the aneurysm dome, aneurysm neck, and associated vessels. Current CT 3D reconstruction techniques produces high-resolution multi-planar views of the lesion in relation to the base of the skull, and in many centers are preferred over magnetic resonance imaging (MRI) studies in this regard.
MRIs remain an excellent tool for evaluating the true size of the aneurysm dome.

Other imaging modalities visualize only the intra-luminal dimensions of an aneurysm, and so may underestimate the true size of the lesion, especially when there is thrombus within the aneurysm dome.

MRI also can also demonstrate the presence of edema or an ischemic event in the surrounding brain parenchyma.

Despite the rapid advance of other imaging modalities, digital subtraction angiography remains the gold standard for evaluating aneurysms. This test provides detailed information about the aneurysm neck, associated perforators, and the surrounding vascular anatomy. It furnishes information regarding the presence or absence of collateral flow and the suitability of intracranial and extracranial vessels for bypass. In conjunction with a balloon test occlusion, angiography yields valuable information about the adequacy of collateral flow across the circle of Willis and thus allows us to evaluate the patient’s tolerance for both temporary and permanent vessel occlusion.

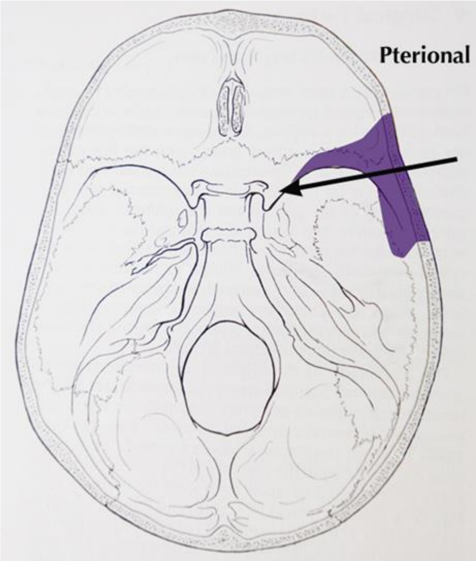
**Treatment**

*Direct Clipping*

Direct surgical clip application remains the treatment of choice for giant aneurysms. The large size of these aneurysms can make visualization of the neck challenging. Skull based approaches have been useful in widening the corridors of access to these aneurysm, thus providing better visualization of the aneurysm neck and important perforators. The wider angles allow more flexibility in clip application and decreases the amount of brain retraction needed for adequate exposure.

*Anterior Circulation Aneurysms*

The pterional craniotomy remains the standard approach for the vast majority of lesions located along the anterior circulation, providing access to the supraclinoid carotid, anterior communicating artery complex, and the middle cerebral arteries.




Patients are positioned in the supine position. The head is extended about 10 degrees and turned 30 degrees to the contralateral direction, and the bed is placed in about 30 degrees of reverse Trendelenberg to ensure that the head is above the level of the heart thus maximizing venous return. All giant aneurysms require intraoperative angiography, therefore, a radiolucent pin fixation device is preferred. The legs are kept straight, rather than slightly bent, to faciliate access to the groin for intraoperative femoral artery catheterization. A lumbar drain may be used to provide additional brain relaxation in when needed.

The frontotemporal scalp is shaved about 1-2 cm behind the hairline from the tragus to the midline. The femoral artery is cannulated during the cranial exposure and then draped until needed later in the case.

If we anticipate the need for proximal control of the carotid artery, the ipsilateral neck is also prepped and draped.

A transverse incision through the neck from the midline to the medial edge of the sternocleidomastoid muscle is sufficient for exposure of the common, and internal carotid arteries for temporary occlusion. If a bypass is contemplated, a vertical incision is made along the medial border of the sternocleidomastoid muscle from the tip of the mastoid down to the base of the neck.

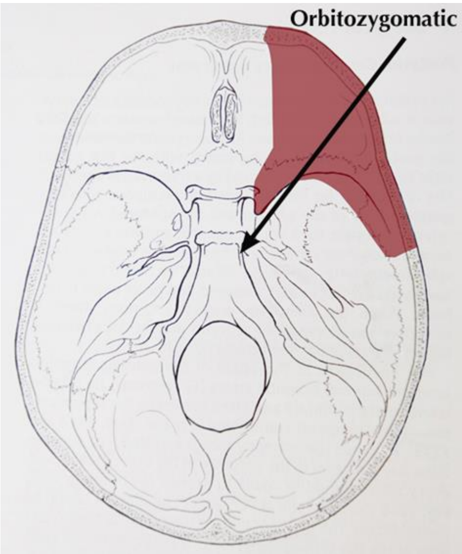
The scalp incision is made from the midline to the zygomatic arch, taking care to stay behind the hairline for cosmetic reasons. The initial incision is kept above the level of the temporalis muscle fascia. It is useful to identify and preserve the superficial temporal artery whenever possible. Even if no bypass is planned, it can be used as a supplemental bypass if an unexpected situation occurs. The dissection is kept below the frontal fat pad as the skin is pulled forward to avoid injuring the frontalis muscle branch of the facial nerve.

A second vertical incision is made through the temporalis muscle and fascia down to the base of the zygomatic arch. Superiorly, the incision is directed forward just under the insertion of the temporalis muscle at the superior temporal line, leaving a 1 cm cuff of tissue attached to the bone which aids in closure of the muscle at the end of the case. The incision is then reflected inferiorly along the frontozygomatic process about 2 cm, which allows the temporal muscle to be reflected a little more inferiorly away from the pterion.

A burr hole is placed at the superior temporal line, and additional burr holes are placed as needed. A frontotemporal craniotomy is performed. The lateral pterion is removed extradurally with a cutting high speed drill down to the superior orbital fissure. This provides a straight, flat trajectory down to the proximal carotid once the dura is opened. In most cases, the Sylvian fissure is opened to untether the frontal lobe from the temporal lobe. The arachnoid basal cisterns are opened. Release of CSF from these cisterns provides a substantial amount of brain relaxation, especially in unruptured cases.

The addition of an intradural anterior clinoidectomy provides access to the proximal carotid and cavernous carotid segments. A crescent shaped dural incision is made from the anterior clinoid process to the medial part of the optic canal is performed. The dura is stripped free from the underlying bone. The bone overlying the optic canal, as well as the optic strut down to the body of the sphenoid ridge, are removed with a small, high speed irrigating diamond drill, allowing mobilization of the optic nerve and circumferential access to the clinoidal and cavenous segements of the carotid.

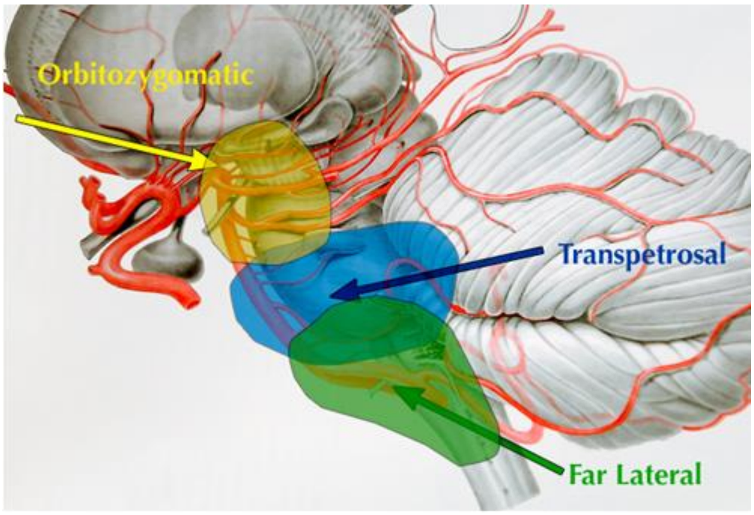
The addition of an orbitozygomatic osteotomy enlarges the angle of access by removing the orbital rim and allowing the temporalis muscle to be deflected further inferiorly.



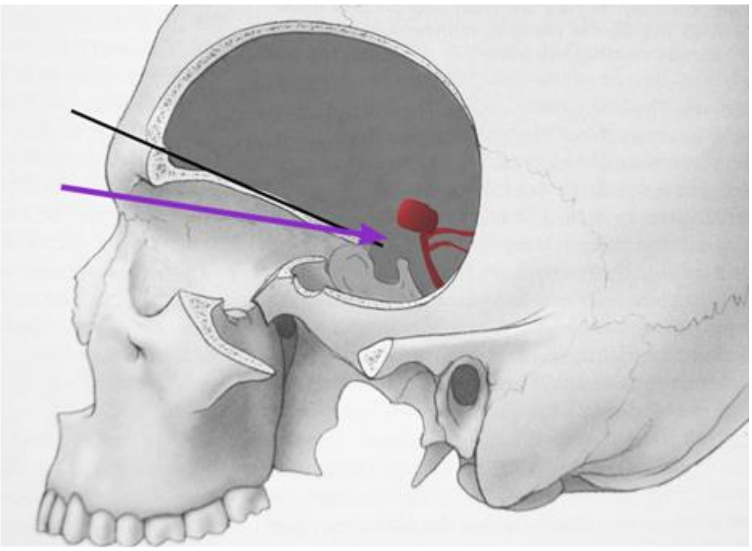

For this procedure, the frontal and temporal dural are stripped away from the base of the frontal and temporal fossa. The periorbita needs to be separated from the superior and lateral wall of the orbit to a depth of about 3 cm from the orbital rim. A sagital cut is made using a reciprocating saw from the orbital rim posteriorly to a distance of about 3 cm. The periorbita and frontal dural are protected with retractors during this maneuver. A horizontal cut is then made across the roof and lateral wall of the orbit down to the inferior orbital fissure. Anteriorly, the zygoma is cut starting at the inferior orbital fissue and continuing posteroinferiorly to the zygomaticofacial foramen which is seen over the malar eminence. An addition cut starts at the anterior inferior edge of the zygomatic arch forward to the zygomaticofacial foramen, connecting this to the previous cut. Finally, a cut is made at the root of the zygomatic arch. The entire block of bone can then be loosened and removed.

*Posterior Circulation Aneurysms*

When contemplating approaches to posterior circulations aneursms, it is useful to divide the posterior fossa into 3 zones: the upper basilar, mid basilar and vertebrobasilar segments.

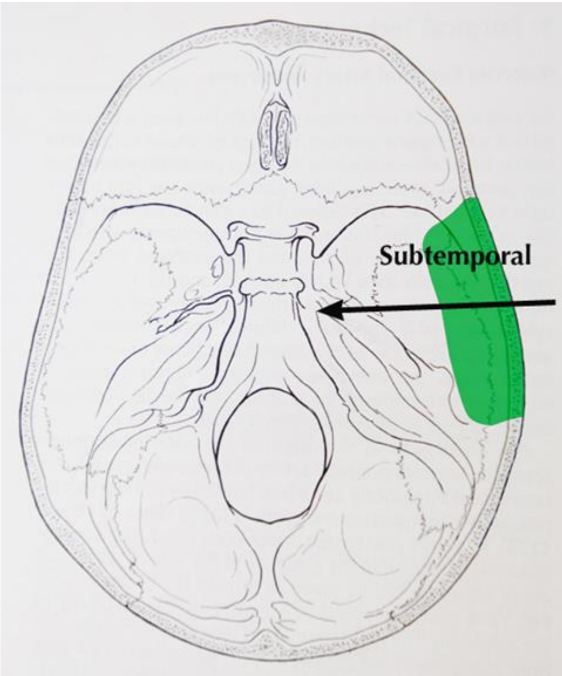



The pterional approach and its variations provide excellent access to the upper basilar region as previously described. The addition of an orbitozygomatic osteotomy provides a lower trajectory and is especially useful for high riding basilar tip lesions.



The "half and half" procedure opens the lateral corridor by transecting the anterior temporal veins and retracting the temporal lobe posteriorly. However, we have found that a medial temporal uncusectomy with mild lateral retraction on the temporal lobe gives a similar view without the need to sacrifice any temporal veins.(3)

For low lying basilar apex lesions located about 1 cm below the posterior clinoid, and for posterior pointing basilar apex aneurysms, we favor the subtemporal approach, which gives an excellent visualization below the posterior clinoid and the top of the clivus.

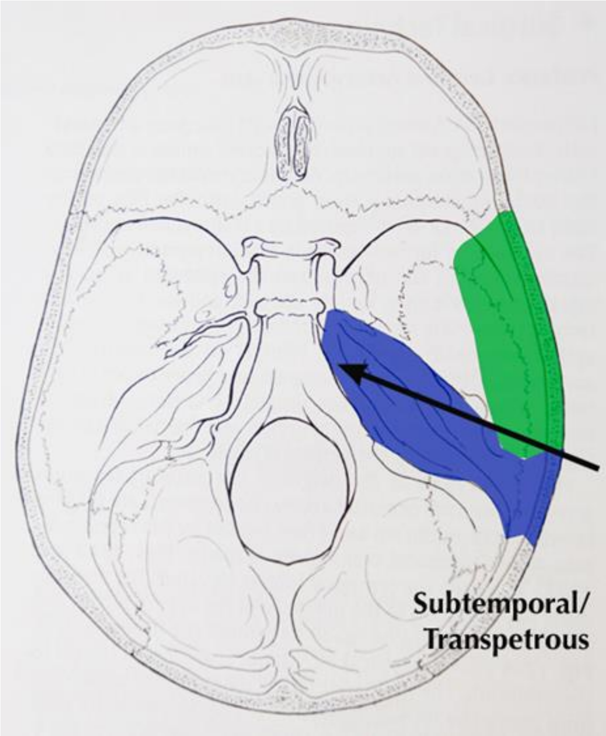



Important posterior perforators are well seen with this approach, although the contra-lateral posterior cerebral and superior cerebellar arteries are somewhat more difficult to visualize. The patients are positioned in the full lateral position. A lumbar drain is essential to decrease the amount of retraction on the temporal lobe. The head is tilted toward the floor. We use a horseshoe scalp incision, starting from the base of the zygomatic arch in front of the tragus. The incision extends upward, swings posteriorly over the ear, and then inferiorly down to the top of the mastoid bone. Two burr holes are placed at the inferior temporal fossa and the craniotomy is performed. Additional bone is drilled so that we are as flat as possible against the base of the temporal fossa. Retractors are usually required to lift the temporal lobe superiorly. The edge of the tentorium can also be cut or sutured back to provide additional exposure inferiorly.

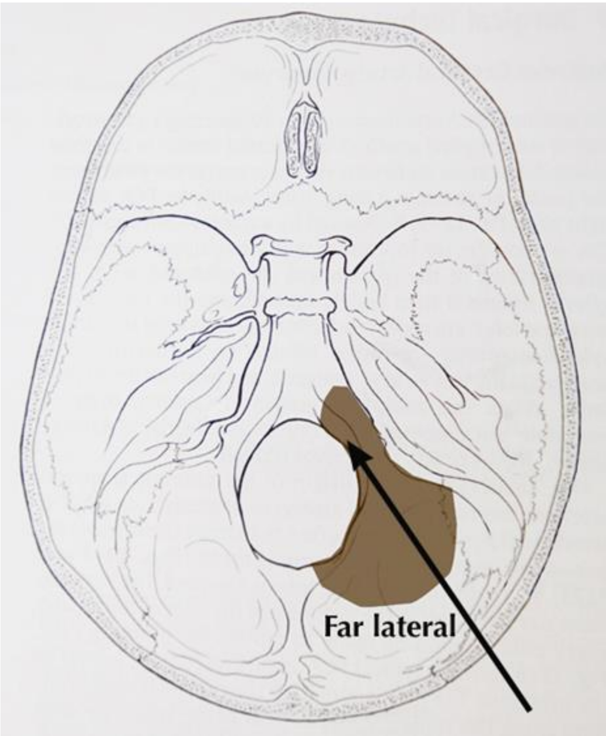
Mid basilar lesions require access deeper into the posterior fossa, and we prefer a combined subtemporal transpetrous approach.

The patient is placed supine on a shoulder role with the head turned to the lateral position. The supratentorial portion of the exposure is the same as described for the subtemporal approach. The posterior inferior portion of the incision is extended down to the suboccipital bone.

The suboccipital bone, mastoid and lateral petrous ridge are removed. This exposes the suboccipital dura, transverse and sigmoid sinuses, and the presigmoid dura. The dural opening extends along the base of the temporal fossa, crosses the superior petrosal sinus, and then extends down the presigmoid dura parallel to the sigmoid sinus. The tentorium can then be sectioned from lateral to medial, thus exposing the entire lateral pons, thus communicating the supra and infratentorial compartments.




Vertebrobasilar lesions are well exposed via a far lateral approach, which removes the suboccipital bone down to the foramen magnum and the lateral third of the occipital condyle.



The patient is again placed in the full lateral position as previously described. We prefer a hockey-stick incision starting over the mastroid, extending superiorly over the occiput, and then down the midline to the base of the neck. Sharp dissection is performed over the superior aspect of the C-1 lamina to indentify the vertebral artery. Bleeding from the perivertebral venous plexus can be controlled with bipolar coagulation or packing with Surgicel. A suboccipital craniotomy is performed including the foramen magnum. The lip of the foramen magnum sweeps forward to become the occipital condyle. A high speed drill is used to drill away the lateral rim of the foramen magnum and the medial third of the occipital condyle. A hemilaminectomy of C-1 is performed to the lateral mass.

*Additional Caveats*

The majority of patients with giant aneurysms require at least some period of temporary occlusion to aid in the dissection, and to soften the aneurysm during clip placement. Additional periods of ischemia are required if a bypass is needed. Prior to temporary occlusion, we will mildly elevate the blood pressure and deliver intravenous barbiturates. We prefer using thiopental sodium, a short acting barbiturate with a half life around 3-8 hours. Usually, a bolus dose of 3-5 mg/kg is sufficient for burst suppression.

The complexity of these aneurysms can make clip application challenging. Temporary proximal vessel occlusion helps soften the aneurysm dome by reducing blood flow to the aneurysm. This allows for more vigorous manipulation of the dome, improves visualization of the neck, and aids in the dissection of important perforators.

A large, pulsating dome can cause the clip to slide off the aneurysm neck, resulting in perforator or parent artery occlusion. Softening of the aneurysm can help adequately position the clip. For large paraclinoid lesions, a suction decompression technique performed via the internal carotid artery in the neck can be quite effective in deflating the aneurysm dome and improving the ease of clip placement. In some instances, particularly with posterior circulation aneurysms, the use of hypothermic circulatory arrest provides about 50 minutes of cerebral protection during the arrest phase. During arrest, the aneurysm becomes completely slack, allowing easier manipulation of the neck and dome, and improving the likelihood of a successful clipping. If there is a large thrombus within the aneurysm, or if the aneurysm had been previously coiled from a prior endovascular procedure, proximal vessel occlusion will be inadequate in softening the aneurysm. In these cases, the aneurysm must be opened, and the thrombus or coils removed, to allow adequate clip placement across the neck. Removal of the intra-aneurysmal coils should be avoided if 3 weeks pass after aneurysmal coiling.

Most of these aneurysms have wide necks. The longer aneurysm clips may not have sufficient closing pressure to completely occlude the aneurysm neck. Sometimes, a booster clip can be used to supplement the main clip. More frequently, application of multiple smaller clips, either in tandem or parallel, is required for successful occlusion. Given the complex nature of these lesions and the need for innovative clipping techniques, intraoperative angiography is important in confirming both successful occlusion of the aneurysm and patency of the surrounding vessels.

*Bypass*

Not infrequently, direct clip placement is not possible in giant aneurysms. In these situations, closure of the parent vessel may be a good alternative in excluding the aneurysm from the cerebral circulation. There must be adequate collateral circulation and no important functional perforators in the segment of vessel to be excluded. Aneurysms of the cavenernous carotid and paraclinoid region are often amenable to proximal ligation and simple trapping. If the collateral circulation is inadequate to perfuse the distal vasculature, then a bypass is necessary. The superficial temporal artery is readily available and easily accessible in most patients. This artery provides a relatively low flow rate, and cannot completely replace the carotid artery or even the main M1 trunk. However, it may be sufficient if there are additional, albeit less than adequeate, collaterals from the circle of Willis. It is also adequate for revascularizing a distal MCA branch vessel. A higher flow bypass is required to replace the flow demands of the carotid artery or M1 segment, and in this situation, a saphenous vein or radial artery grafts works very well. Unlike a low flow bypass, patients undergoing a high flow bypass are fully heparinzed during the actual contruction of the bypass. For the posterior circulation, the occipital artery can provide perfusion to proximal vessel segments. Distal supplementation usually requires a saphenous vein graft.

*Flow diversion*

When important perforators are incorporated within the walls of the aneurysm, or the aneurysm is fusiform with no discernable neck, it might not be possible to completely exclude the aneurysm from the cerebral circulation. Formation of these aneurysms is related to hemodynamic stress from proximal, or inflow, vessels. Theoretically, reversal of flow through the aneurysm should reduce the shear stress within the aneurysm and thus presumably alter the natural history. Flow reversal can be accomplished by occluding the proximal feeding vessel. The blood flow to the distal vessels is supplied by either natural collaterals or via a bypass. Reversal of flow through the aneurysm provides perfusion to important branches and perforators incorporated within the aneurysm itself. Although there appears to be a reduction in the hemorrhage rate from these aneurysms using this strategy, it is not completely protective with a long term rehemorrhage rate of approximately 11%. (2)

*Endovascular techniques*

Endovascular techniques continue to evolve, but its utility remains limited, especially in lesions with wide necks. Complete aneurysmal occlusion is difficult, although a larger number of lesions around the paraclinoid carotid have become amenable to successful treatment. Thrombus formation in giant aneurysms is quite dynamic, resulting in high rates of coil compaction and recanalization. The development of balloon remodeling techniques allow for tighter packing of wide necked aneurysms, reducing the incidence of coil migration into the intraluminal space. The development of stenting technology over the past several years has also allowed tighter, more complete packing of many wide necked aneurysms.

However, tight packing of large aneurysms, especially those compressing the brainstem and optic nerves, may result in increased mass effect, edema and progressive neurological deterioration.(4) Flow alteration techniques using multiple stents are currently being evaluated, but the long term results are unknown at this time.

**Conclusion**

The natural history of giant aneurysms is extremely poor with a high rate of hemorrhage, death and severe disability within 5 years of diagnosis. Despite the difficulty inherent in treating these lesions, good outcomes are still possible in the majority of cases. Successful treatment of these formidable lesions requires a detailed understanding of the vascular anatomy, as well as the sophisticated use of the entire range of neurosurgical and endovascular techniques.

**References**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**Case Studies**

<u>High flow EC-IC bypass:</u>

A 52 year old female presented with acute right eye blindness. The radiologic studies revealed a calcified, partially thrombosed ophthalmic segment aneurysm, and poor collateral circulation necessitating a high flow external carotid to M-1 segment bypass. This was followed by occlusion of the ICA in the neck, and trapping of the aneurysm with a clip.

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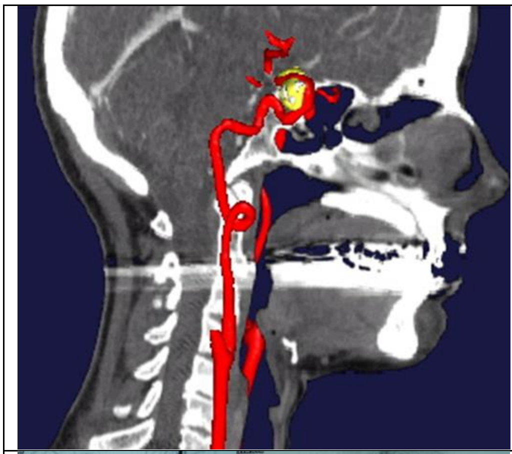
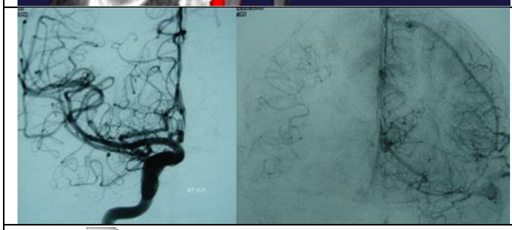
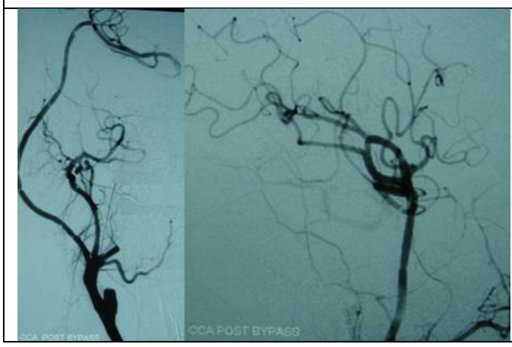
|  | A CTA showing a giant, partially thrombosed, and calcified paraclinoid aneurysm. |
|  | Balloon test occlusion showing delayed venous drainage on the right, indicating inadequate collateral circulation |
| .wmv bypass.wmv | An intraoperative microsurgical video demonstrating the construction of the radial artery EC-IC bypass. The distal intracranial end is constructed first. |
|  | An AP and lateral common carotid angiogram showing the high flow radial artery bypass. 6 months postoperatively the patient could count fingers with the right eye. |

Direct clipping:

A 45 year old nurse with subarachnoid hemorrhage. Neurologically she was intact. She underwent direct surgical clipping via a left pterional approach. Her postoperative course was uneventful.

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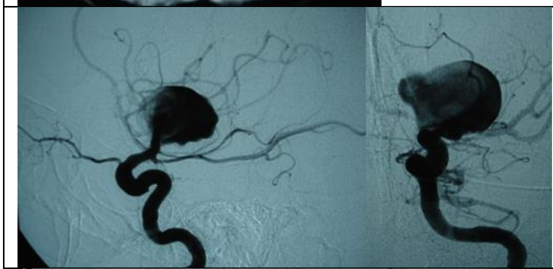
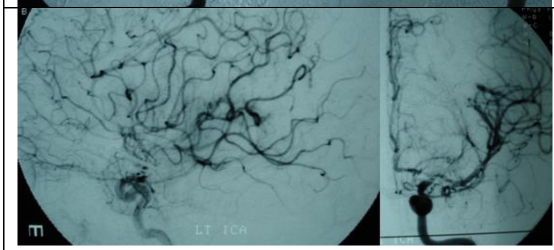
|  | A brain CT revealing the subarachnoid hemorrhage. The blood within the aneurysm could also be seen. |
|  | Left lateral and AP ICA angiography showing giant ICA bifurcation aneurysm. |
|  | A postoperative lateral and AP left ICA angiogram showing successful clipping of the aneurysm, and good distal filling of the distal intracranial circulation. |

<u>Parent vessel Occlusion:</u>

A 33 year old female 2 weeks after a subarachnoid hemorrhage from a basilar aneurysm. The aneurysm was not amenable to endovascular treatment, because of the presence of basilar perforators proximal to the aneurysm. She had very good collateral blood flow to the posterior circulation via bilateral posterior communicating arteries. The patient underwent direct proximal basilar occlusion with a clip through a far lateral approach. She was discharged neurologically intact 2 days after her surgery.

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|  | A CT scan of the brain revealing blood along the tentorium, and dilated ventricles. |
|  | 3-D vertebral angiography showing a giant basilar aneurysm. The proximal small brainstem perforators are not appreciated in this film. |
|  | Postoperative lateral ICA angiogram showing good basilar perfusion through the posterior communicating artery. The left lateral vertebral injection reveals that the left vertebral artery ends in PICA. |