Surgery of Giant Aneurysm

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20.1 Sign and Symptoms

Aneurysm bigger than 25 mm is called giant aneurysm [1], further subdivided by morphology into saccular, fusiform, or dolichoectatic aneurysms [2]. Epidemiologically, they are very rare, comprising only 0.5% of all intracranial aneurysms, while others describe it as 3–5% of all intracranial aneurysms [1, 3, 4]; the epidemiology of intracranial aneurysms among the general population amounts to 0.2–9.9% [5]. In pediatric patients, the incidence of giant aneurysms and aneurysms of the posterior circulation is greater than those in adult patients [6]. The most common type is the saccular giant aneurysm, accounting for 98% of cases [7]. Fusiform types are more commonly found in the posterior circulation and MCA [1]. These lesions have a female preponderance and are diagnosed mostly between 40 and 60 years of age [2]. These lesions are found most often in the anterior circulation, affecting the ICA, MCA, and ACA [1, 2], while in the posterior circulation, they most commonly occur at the basilar artery, vertebrobasilar junction, PCA, and PICA [2]. Multiple giant aneurysms can be found in 7% of patients [2].

The most common presenting symptoms for these lesions are mass effect complaints, seizures caused by irritated neural tissue, or compression of cranial nerves [2, 4], which are very different from the subarachnoid bleed usually found in smaller aneurysms [2, 4]. Additionally, the occurrence of thrombus formation in these aneurysms may produce symptoms of thromboembolic event in the parent vessel or perforator vessels [2]. Thromboembolism may occur in up to 60% of giant aneurysms, and its probability increases along with aneurysm size. Hydrocephalus had been reported due to the compression of giant aneurysms near the cerebral aqueduct, and carotid-cavernous fistulae (CCF) can result from ruptured aneurysms of the ICA cavernous segment [2].

20.2 Investigation

These aneurysms must be thoroughly investigated as to its vascular anatomy, such as the presence of perforators, the size and orientation of the aneurysm neck, and its distal outflow (Fig. 20.1). Giant aneurysms frequently display calcification,
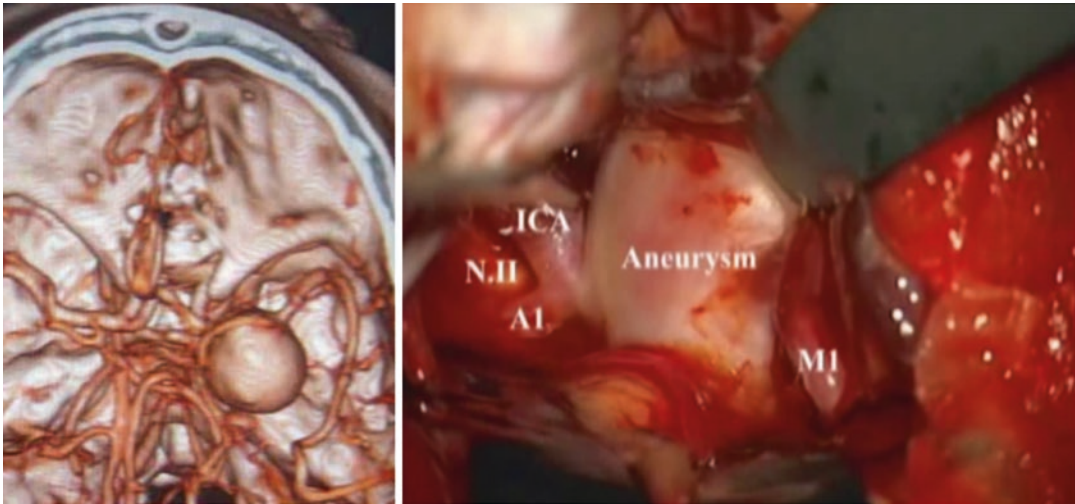
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Fig. 20.1 *Left:* Three-dimensional CT scan of a 50-year-old, female with left M1 giant aneurysm. *Right:* Intraoperative finding after a wide sylvian fissure dissection

thrombosis, and wall thickening around the neck, while there may be multiple perforator vessels present from the parent artery or even from the aneurysmal sac in the case of fusiform aneurysms [4]. The gold standard diagnostic procedure would be digital subtraction angiography (DSA), which provides the best picture of cerebrovascular anatomy and provides information about the suitability for vessel bypass. DSA can be combined with CT angiography to provide information about surrounding bony anatomy for surgical approach and monitor the presence of calcified thrombus. CT scan is very useful in evaluating for calcification [1], and MRI may be performed if there is a suspected ischemic event, to investigate peritumoral edema and to evaluate intraluminal thrombus [1]. Preoperative assessment of these patients includes balloon occlusion tests during angiography, if the surgeon plans to sacrifice the ipsilateral ICA [2]. Intraoperatively, patients may be monitored using electroencephalography (EEG) to detect any changes in the electrical activity, as well as continuous transcranial Doppler (CTD) to check the cerebral blood flow [2].

The natural course of giant unruptured aneurysm has been previously reported by Wiebers et al. [8]; in anterior circulation the 5-year cumulative risk is about 40%, while in the posterior circulation including posterior communicating artery, the risk is about 50%. A study by ISUIA (International Study of Unruptured Intracranial Aneurysms) group shows the rupture rate at 6% in the first year after diagnosis alone [5, 9], with a more recent study by the UCAS Japan investigators reporting a rupture risk of giant aneurysms at 76.26% within 3 years [3], with aneurysms at the posterior and anterior communicating arteries being more likely to rupture [3, 5, 9]. The mortality rate of such ruptures reaches 20–70% [10, 11], reaching higher than 60% within 2 years of diagnosis [12]. It is therefore established that such rupture rates were similar or worse to the risks taken when a similar lesion is treated, either through surgery or endovascular treatment. More recent studies on the natural course of aneurysms have not found any other parameters indicative of rupture risk [13].

20.3 Steps of Surgery

20.3.1 Surgical Approach

Microsurgical clipping has the advantage of being able to relieve mass effect associated with nerve compression, especially in aneurysms with thrombus formation or atheroma [14].

The main principles of giant aneurysm surgery are to prepare the proximal and distal control, avoid the blunt dissection, and appreciate all the perforators, and to achieve circumferential dissection of the aneurysm might be very difficult [12]. The goals of surgical management of giant aneurysms are:

1. To isolate the aneurysm from the blood circulation
2. To preserve cerebral blood flow distal to the aneurysm
3. To relieve mass effect on neural structures caused by the aneurysm [1, 2, 15].

Several microsurgical techniques which are used in the management of giant aneurysms include: microsurgical clipping, bypass of parent artery (ICA) using saphenous vein graft or the MCA, temporary ligation of the ICA to help clipping, aneurysm wrapping with muscle or fascia, or combined microsurgical and endovascular treatment [2].

Microsurgical clipping of giant aneurysms can be performed, because all aneurysms must have a "neck." [4] With the use of fenestrated clips, aneurysms with large necks can undergo vessel reconstruction to create an aneurysm neck [4] (Fig. 20.2).

The presence of perianeurysmal edema, which is most often found in the MCA circulation, may complicate the microsurgical clipping [16].

There are several approaches available for microsurgery of giant aneurysms of the carotid artery or the basilar tip; an approach through the middle fossa is recommended. The important surgical anatomy in this region is the cavernous sinus, which includes several natural corridors available to access this region, usually divided into the ten triangular spaces [2]. Skeletonization of the ICA in the carotid canal through Glasscock's triangle [12] is performed to treat intracavernous aneurysms [2]. Orbito-zygomatic approach is used to maximize exposure [12].

Certain location of the posterior circulation aneurysm could be approach through subtemporal such as the upper basilar artery segment [2]. The transpetrosal approach or far-lateral approach may be used for lower lesions [12, 17].

To reduce mass effect of the giant aneurysm after clipping is performed, the aneurysm dome can be directly punctured to exsanguinate the sac when no thrombus is present and perform suction decompression [4, 12] (Fig. 20.3). If there is thrombus, calcification or atheroma is present, thrombectomy may be performed on the aneurysm sac, also called endoaneurysmectomy [4].

Fig. 20.2 *Left:* Same case of Fig. 20.1 shows intraoperative view of giant aneurysm undergoing vessel reconstruction with multiple fenestrated clips. *Right:* Angiography confirmation of MCA flow
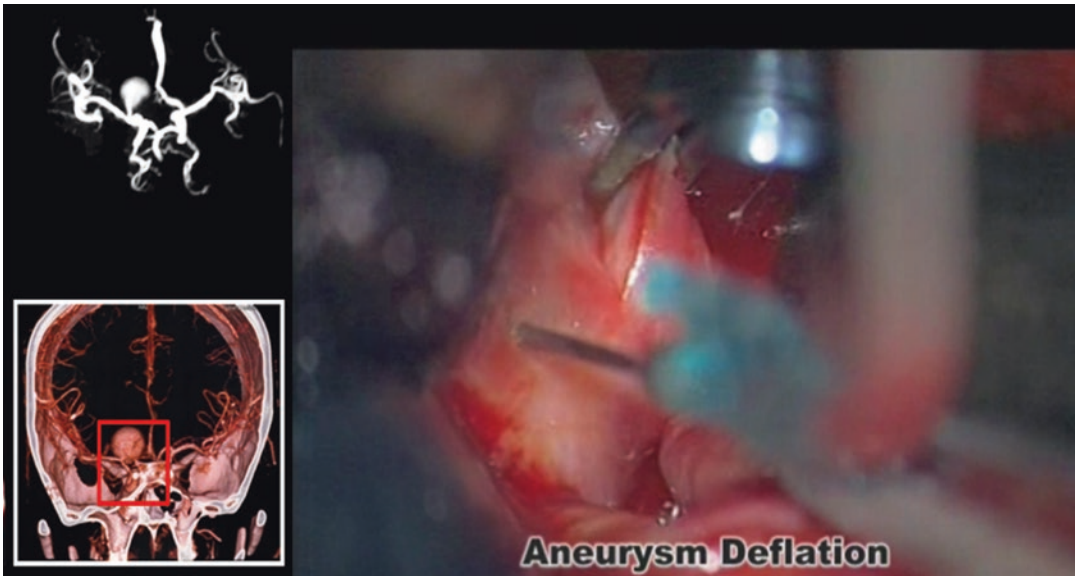
Fig. 20.3 Aneurysm deflation using the wing needle no 25G

Aneurysm repair using wrapping or clip wrapping with the muscle or fascia can be used to maximize outcomes in ruptured aneurysms [12]. Aneurysms which are broad-based, frail, or complex may also be clipped using augmented "cotton-clipping" technique [18]. This technique can also be used to perform emergency repair in the case of ruptured aneurysm.

Low-flow and high-flow bypass techniques have been used to provide revascularization of the distal circulation in the treatment of giant aneurysms [4]. Vessel reconstruction using clips also serve the same function, which is to guarantee CBF distal to the aneurysm [4].

Microsurgical treatment may be advantageous in comparison with endovascular treatment in cases of complex basilar artery aneurysms. Performing surgical clipping of the aneurysm may provide selective occlusion of the basilar artery aneurysm while avoiding damage to the thalamoperforators which may adhere to the posterior aspect of the aneurysm, compared to endovascular treatment where visualization of the perforators cannot be achieved, and the risk of brainstem damage due to ischemia is greater [19].

Adjunctive techniques which can be used in giant aneurysm surgery include deep hypothermic circulatory arrest (DHCA) [4, 20, 21] and the use of excimer laser-assisted nonocclusive anastomosis (ELANA) bypass [22, 23]. DHCA may be performed to temporarily reduce blood flow to the aneurysm, facilitating the surgeon to perform surgical clipping and neck reconstruction. However, it has several drawbacks, including unpredictable recovery after circulatory arrest and possibility of postoperative brain hemorrhage [24]. A study by Ponce et al. also shows significant mortality and morbidity rates for using DHCA, even though most patients had improved neurological function after surgery [21]. Neuroprotective agents may also be used to improve outcome after surgery, especially if DHCA will be used. Barbiturates are traditionally used to reduce cerebral blood volume and metabolism before the ischemic procedure [12].

The ELANA technique enables surgeons to perform a high-flow bypass without utilizing temporary clips, which makes it a reasonable alternative to other methods of direct revascularization, such as direct anastomosis [23]. The elimination of temporary clips from the procedure provides the surgeon with longer safe operating time without cerebral ischemia and eliminates the need of exposing the proximal parent artery before the procedure, which is especially beneficial in the posterior fossa [23].

20.3.2 Endovascular Approach

Endovascular management has the advantage of decreased morbidity, due to its nonsurgical nature [25]; aneurysms at the posterior circulation especially show higher morbidity after microsurgery [26]. The endovascular management of giant aneurysms can be performed as long as the aneurysm does not show signs of intraluminal thrombus; if there is thrombus, then endovascular management will not be able to relieve the mass effect caused by the aneurysm itself, even though it could occlude the aneurysm from the circulation.

The endovascular management for giant aneurysms are [25]:

1. The parent artery could be occluded by using coils or balloons.
2. Coiling of the aneurysm coiling of the aneurysm and spare the parent artery.
3. Balloon-, stent-, or neck-bridging-assisted device for selective coiling [27].
4. Selective occlusion with ethylene vinyl alcohol copolymer (ONYX).
5. Sacrifice the parent artery after bypass surgery.

Parent vessel occlusion is a very simple technique which is guaranteed to exclude the aneurysm from cerebral circulation [4, 25]. This is the endovascular treatment of choice if the patient can tolerate parent vessel occlusion [25]. Multiple tests must be done before this treatment, using balloon occlusion test, to ensure that the cerebral circulation is not compromised by blocking the parent artery [25]. A study by Linskey et al. demonstrated that even without previous BOT, up to 75% of patients can tolerate ICA occlusion [28]. The vertebral artery, however, can be safely occluded, except where the patient only has a single vertebral artery without a patent PCoA [25].

Selective occlusion of giant aneurysms, whether using coils or ONYX embolization device, emphasizes on filling the aneurysm lumen and occluding the aneurysm from the circulation as thrombus forms within the lumen [25]. As most giant aneurysms are formed with large necks, coil-assisted

devices such as stents, balloons, or flow diverters are often used [25]. The re-endothelialization of the parent artery after such a procedure is key to preserving a patent lumen and reducing reopening of the aneurysm [29].

Another treatment option is to use flow-diverting stents [4]. These devices have more metal coverage and lower porosity in comparison with standard intracranial stents and have the capability of creating blood flow inside their artificial lumen and induce thrombus formation in the dome of giant aneurysms as blood flow into the dome decreases. These stents are also capable of providing a scaffold for neointimal growth in the vessel. The role of flow diverters against giant aneurysms is effective, with permanent major complication occurring in 3% of patients in a study by Piano et al. [30] and 5–10% of patients in other studies [31]. Previous studies have documented encouraging results when these stents are used against aneurysms of the anterior circulation [32, 33], defined as aneurysms from the ICA below the anterior choroidal artery. However, they are not as effective against aneurysms in the vertebrobasilar system [34]. It is thought that the vertebrobasilar system with its many perforators are not suitable for flow-diverting stents, as these stents also occlude the perforators, in some cases up to 2 years after stent placement [34]. The resulting ischemia of the pons may lead to unacceptable morbidity [34]. These devices may also be used in conjunction with coils to achieve complete occlusion of the aneurysm [35].

The main concern about selective occlusion is that the embolization device may disengage over time, either by coil become compaction, the coil sometimes migrate, degeneration of the thrombus intraluminal or migration of the ONYX clot into the parent artery [25, 26, 36]. This problem is caused by the inherent nature of giant aneurysms, with their large lumen volume, which sometimes cannot be adequately packed with these devices [25, 26]. Stable occlusion of these aneurysms requires at least 25% packing of its volume, which is difficult to achieve with large-volume aneurysms [25]. In a study by van Rooij et al. [25], it is found that nearly all giant aneurysms show reopening after endovascular treatment in

the 6-month postoperative period, even up to several years of stable condition. The follow-up strategy for these patients is to schedule additional coiling procedures along with routine follow-up, with decreased patient compliance as a result [25, 37]. MRA has also been suggested as a routine follow-up procedure after endovascular treatment [37].

20.4 Expert Opinion/Suggestion to Avoid Complication

In several cases such as paraclinoid giant aneurysms, combined approach using microsurgical and endovascular management can be performed [38]. Paraclinoid giant aneurysms are often atherosclerotic and calcified, difficult exposure and dissection of the aneurysm dome, and difficulty in exposure and proximal control through temporary clipping [38, 39]. In such cases, temporary occlusion of the parent artery can be achieved through the endovascular method, while microsurgery is used to expose and clip the tumor, followed with suction decompression of the aneurysm dome [4]. Flow alteration using a combined microsurgical and endovascular method may be used to treat fusiform basilar artery aneurysms [40]. Sughrue et al. [18] championed a combined approach using microsurgery and endovascular therapy as an adjunct in the treatment of giant aneurysms.

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