



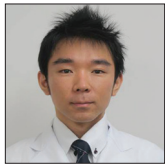
Case Report

Trapping, dome puncture, and direct suction decompression in conjunction with assistant superficial temporal artery-middle cerebral artery bypass to clip giant internal carotid artery bifurcation aneurysm

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ABSTRACT

Background: Very large and giant aneurysms (≥ 20 mm) of the internal carotid artery (ICA) bifurcation (ICAbif) are definitely rare, and optimal treatment is not established. Endovascular treatments are reported as suboptimal due to difficulties of complete occlusion and tendencies to recanalization. Therefore, direct surgery remains an effective strategy if the clipping can be performed safely and reliably, although very difficult.

Case Description: Two cases of ICA bifurcation aneurysms (>20 mm) were treated. Prior assistant superficial temporal artery (STA)-middle cerebral artery (MCA) bypass was performed to avoid ischemic complications during prolonged temporary occlusion of the arteries in both cases. In Case 1 (22-mm aneurysm), the dome was inadvertently torn in applying the clip because trapping had resulted in insufficient decompression. Therefore, in Case 2 (28-mm aneurysm), almost complete trapping of the aneurysm and subsequent dome puncture was performed, and the aneurysm was totally deflated by suction from the incision. This complete aneurysm decompression allowed safe dissection and successful clipping.

Conclusion: Trapping, deliberate aneurysm dome puncture, and suction decompression from the incision in conjunction with assistant STA-MCA bypass can achieve complete aneurysm deflation, and these techniques enable safe dissection of the aneurysm and direct clipping of the aneurysm neck. Direct clipping with this technique for very large and giant ICA bifurcation aneurysms may be the optimal treatment choice with the acceptable outcome if endovascular treatment remains suboptimal.

Keywords: Dome puncture, Giant aneurysm, Internal carotid artery bifurcation aneurysm, Suction decompression, Trapping

INTRODUCTION

Internal carotid artery (ICA) bifurcation (ICAbif) aneurysms are not common, accounting for about 2–9% of all intracranial aneurysms.^[5,11,19,25] Very large and giant aneurysms (≥ 20 mm) of the ICA bifurcation are far less common, so the optimal treatment has not been well characterized.

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Despite modern endovascular techniques, coil embolization for ICAbif aneurysms is suboptimal due to the unfavorable configuration of the ICAbif, which causes much hemodynamic stress.^[7,8,15,19,25] Consequently, endovascular treatment for ICAbif aneurysms has achieved lower complete occlusion rate and higher minor recanalization rate compared to surgical clipping.^[8] Coil compaction and recanalization are relatively common with larger aneurysms, resulting in increasing mass effect and greater risk for hemorrhage in the next decade.^[24] Thus, the current treatment of choice for very large and giant ICAbif aneurysms remains surgical clipping, but this is much more challenging. The surgical nuances of clipping ICAbif aneurysms have been well described,^[2,9,11,12,22,26] but the optimal surgical procedure for very large and giant ICAbif aneurysms is less well understood.

We recently treated 2 cases of ICAbif aneurysms of more than 20 mm with surgical clipping. In both cases, surgical clipping was successfully achieved finally, but many challenges had to be overcome. We clarify the critical steps and consider the optimal strategy in surgical clipping for very large and giant ICAbif aneurysms.

PREOPERATIVE PRESENTATIONS

Case 1

A 69-year-old man presented with dysarthria and transient right hemiparesis. Head magnetic resonance imaging

revealed left subcortical infarctions, and magnetic resonance angiography identified a large aneurysm of the right ICA. Digital subtraction angiography (DSA) demonstrated a very large aneurysm of the right ICAbif, with a maximum diameter of 22 mm [Figure 1a-c]. After treatment for cerebral infarction, we performed surgical clipping of the aneurysm.

Case 2

A 67-year-old man presented with sudden right hemiparesis and aphasia. Head computed tomography revealed left frontal intracranial hematoma centered on the caudate nucleus and intra-ventricular hemorrhage, and a suspected large mass lesion in the hematoma [Figure 2a and b]. DSA revealed a 28-mm giant aneurysm of the left ICAbif [Figure 2c-e]. We performed surgical treatment for this ruptured ICAbif aneurysm. In both cases, DSA demonstrated good collateral flow to the ipsilateral anterior cerebral artery (ACA) from the contralateral side through the anterior communicating artery.

SURGICAL STRATEGY

Surgical clipping of very large or giant ICAbif aneurysm requires reduction of blood flow and pressure in the aneurysm by parent artery occlusion to prevent uncontrolled intraoperative rupture of aneurysm and to safely dissect the aneurysm from the surrounding structures. Occlusion time

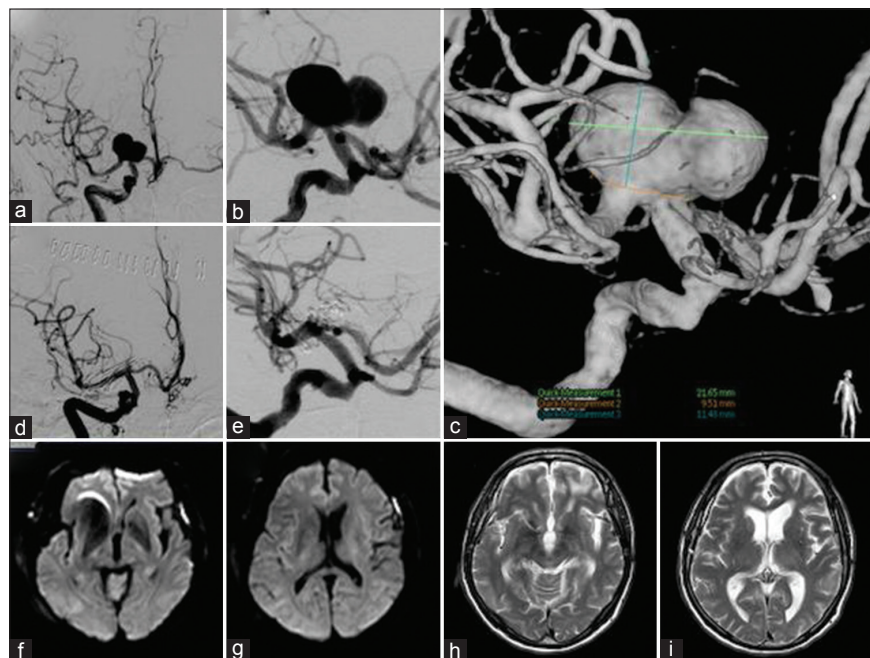


Figure 1: Case 1 – preoperative digital subtraction angiography (DSA) showing a very large aneurysm of the right internal carotid artery bifurcation of 22 mm maximum diameter (a-c). Postoperative DSA showing complete obliteration of the aneurysm (d and e). Diffusion-weighted imaging on postoperative day 1 showing no infarction (f and g). T2-weighted imaging at 6 months after the operation indicating no new lesion (h and i).

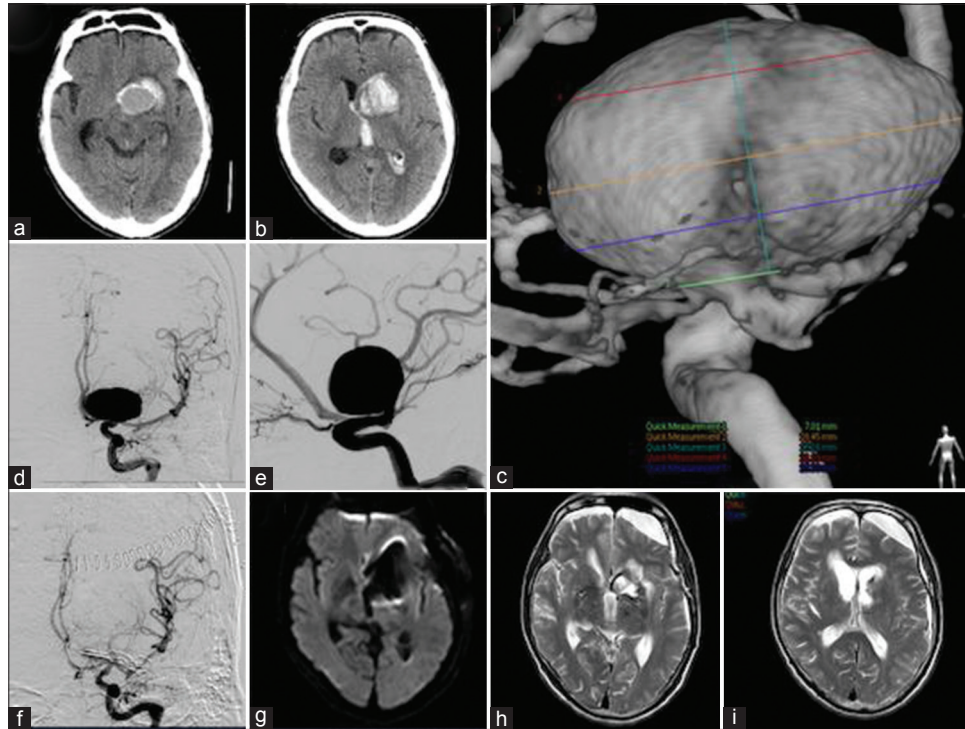


Figure 2: Case 2 – head computed tomography on the day of admission revealing left frontal intracranial hematoma centered on the caudate nucleus and intra-ventricular hemorrhage, and a suspected large mass lesion in the hematoma (a and b). Digital subtraction angiography (DSA) showing a 28-mm giant aneurysm of the left internal carotid artery bifurcation (c and e). Postoperative DSA showing complete obliteration of the aneurysm (f). Diffusion-weighted imaging on postoperative day 1 showing no infarction (g). T2-weighted imaging at 6 months after the operation indicating no new lesion (h and i).

of the parent artery tends to be prolonged in such cases, so we planned to conduct superficial temporal artery (STA)-middle cerebral artery (MCA) bypass before clipping of the aneurysm to maintain adequate blood flow and avoid ischemic complications caused by temporary occlusion of the ICA.

OPERATION

Common steps in both cases

Neuroanesthesia was induced under the monitoring of somatosensory evoked potentials of the contralateral extremities and motor evoked potentials of the upper limb.

First, the cervical ICA was exposed through a short linear skin incision just across the medial edge of the sternocleidomastoid muscle. After the introduction of the operating microscope, the parietal branch of STA was harvested meticulously, and its lumen was filled with heparinized normal saline after cutting the distal end. Standard frontotemporal craniotomy was made, and the sphenoid ridge was drilled to flatten the lateral orbital wall and expose the temporal tip. Adequate drilling of the sphenoid ridge is critical to obtain the anterior-temporal view and clearly visualize the retro-carotid space and ICAbif

aneurysm buried in the frontal lobe without severe retraction of the frontal lobe. Before opening the Sylvian fissure, STA-MCA bypass was performed by meticulous anastomosis of the parietal branch of the STA to the temporal cortical branch of the MCA. The Sylvian fissure was widely opened, and the temporal tip was sufficiently retracted posteriorly to visualize the retro-carotid space. The M1, ICA, A1, anterior choroidal artery (AChOA), posterior communicating artery (PcomA), and ICAbif aneurysm protruding into the frontal lobe were identified.

Critical steps: Control of aneurysm pressure and clipping

In Case 1, after temporary occlusion of the cervical ICA, A1, and M1, the aneurysm was dissected from the frontal lobe. After confirming both sides of the aneurysm neck, the permanent clip was applied carefully. However, the aneurysm dome near the neck was torn during the closing of the clip blades. Fortunately, the aneurysm was successfully clipped after deflating the aneurysm by suction from the torn hole. This inadvertent tearing of the aneurysm indicated that temporary occlusion of only the ICA, A1, and M1 was not the optimal strategy in treating very large and giant aneurysms for the following reasons: adequate aneurysm decompression was not obtained because of the residual inflow from the

PcomA, AChoA, and ophthalmic artery, and the broad neck of very large and giant aneurysms could be damaged by excessive stress when closing the blade without adequate aneurysm decompression resulting in collapse.

In Case 2, to prevent inadvertent tearing of the aneurysm, almost complete trapping was achieved by clamping not only the cervical ICA, A1, M1, and PcomA, and making an intentional small incision in the aneurysm dome, performed before clipping the aneurysm. Suction from the incision ensured that the aneurysm was totally deflated. These critical steps ensured that the aneurysm was deflated, dissected safely and certainly from the surrounding structures, and finally successfully clipped. Patency of all vessels was confirmed by indocyanine green video-angiography in both cases after clipping of the aneurysm [Video].

POSTOPERATIVE COURSE

No new postoperative deficits occurred in either patient. Diffusion-weighted imaging detected no new infarction on postoperative day 1 [Figure 1f, g, and 2g], and DSA revealed complete obliteration of the aneurysms [Figure 1d, e, and 2f]. T2-weighted imaging obtained at 6 months after the operation disclosed no new lesion [Figure 1h, i, and 2h, i].

Case 1 was followed up in the outpatient hospital without neurological events for 3 years. Case 2 underwent ventriculoperitoneal shunt surgery for secondary hydrocephalus after subarachnoid hemorrhage. The patient's preoperative symptoms, right hemiparesis, and aphasia, gradually improved with rehabilitation, and independence in activities of daily living, equivalent to modified Rankin scale 1, were achieved in 6 months.

DISCUSSION

Treatment for very large and giant intracranial aneurysms remains challenging for most neurosurgeons. Endovascular coiling is known to be effective, but satisfactory results are not guaranteed for very large and giant aneurysms. The complete obliteration rate of such aneurysms is lower, and the recanalization rate is higher than for small aneurysms.^[3,4,10,16,17,23] Less packing may be achieved in larger aneurysm volumes. Consequently, coil compaction is relatively common in large aneurysms, and most large aneurysms recanalize and require additional treatment.^[24] Histological studies have demonstrated absence of organized thrombus, fibrosis, and endothelialization of the necks of large or giant wide-neck aneurysms previously treated with endovascular coiling.^[13,14] Endovascular retreatment rate is especially high in large aneurysms exceeding 10 mm.^[25] Four of six large aneurysms (≥ 10 mm) showed recanalization, and one patient died of subarachnoid hemorrhage after endovascular treatment, despite interdisciplinary treatment

selection.^[8] Delayed ruptures occurred in 10 of 12 cases after endovascular coiling of large or giant aneurysms.^[16] Despite recent progress in endovascular treatment, very large and giant intracranial aneurysms remain hard to treat. The current curative treatment of choice remains surgical clipping: a direct approach that guarantees certain exclusion of aneurysms and patency of the parent artery. However, surgical challenges make many giant aneurysms notoriously difficult to clip.

Some cases of giant aneurysms have been successfully treated by the high-flow extracranial-intracranial bypass,^[1,6,18,20,21,27] and the retrograde suction decompression technique is useful for giant ICA ophthalmic/paraclinoid segment aneurysms. However, the optimal surgical procedure for giant aneurysms of the ICAbif remains unclear. Many series have described the operative techniques and surgical outcomes for aneurysms of ICAbif,^[5,9,11,12,22] but few reports have demonstrated the treatment of very large or giant aneurysms of ICAbif. Four of five cases of giant ICAbif aneurysms were successfully clipped, but one case suffered postoperative hemorrhagic infarction due to perforator injury.^[19] In a series of nine cases of giant ICAbif aneurysms, eight patients underwent direct clipping, and one had a high-flow extracranial-intracranial bypass with aneurysm trapping. All aneurysms were exposed through the frontotemporal approach.^[1] The high-flow extracranial-intracranial bypass with trapping for giant aneurysm of the ICAbif was successfully performed, but we have serious concerns as to whether the blood flow of the AChoA is reliably preserved. We assume that patency of the AChoA after trapping with high-flow bypass is never guaranteed because the orifice of the AChoA is located near the ICA terminus. Therefore, adequate blood flow of the AChoA cannot be guaranteed even if the vessel is morphologically preserved. In both our cases, the distance between the AChoA and ICA terminus was not sufficient to appropriately preserve the AChoA if trapping with high-flow bypass was performed.

Numerous previous series have emphasized that crucial operative step in direct clipping of ICAbif aneurysms is dissecting the aneurysms and preserving the surrounding perforators, such as the AChoA, lateral lenticulostriate artery (LSA), PcomA perforators, and A1 perforators. Since the importance of careful dissection of perforators away from the aneurysm wall was described,^[26] various strategies to preserve perforators have been reported. The angle of the operating microscope from lateral to medial can visualize the lateral LSA and AChoA, medial LSA, and recurrent arteries from A1.^[12] Cotton balls can be used to displace the perforators away from the aneurysm wall.^[11] However, giant aneurysms have complicated relationships with these numerous perforators so that surgical clipping is more challenging, even with the techniques mentioned above. Furthermore, giant aneurysms often exhibit broad

aneurysm neck incorporating the orifice of the A1 and M1, so appropriate clipping orientation to preserve the A1 and M1 is required. In one case, the A1 was impossible to preserve, so the nondominant ipsilateral A1 was coagulated, clipped, and divided.^[19] Except for this rare case, preservation of the original vasculature, perforators, and parent arteries, by direct clipping is optimum. Therefore, adequate dissection of the aneurysm is critical, despite the surgical difficulty.

The reduction of blood flow and pressure in the aneurysm by temporary occlusion of arteries is an essential concept for safe and sufficient dissection. Aneurysm dissection can proceed without temporary occlusion of parent arteries in small or medium-sized aneurysms with a relatively free dome,^[19] but trapping by temporary occlusion of the parent arteries is indispensable in large and giant aneurysms or ruptured aneurysms. The duration of temporary occlusion tends to be longer for larger aneurysms, although the duration should be definitely <5 min with at least a 10-min gap between two consecutive periods.^[19] Therefore, prior STA-MCA bypass is mandatory to avoid ischemic complications in the MCA area. The specific problem with this method is whether only STA-MCA bypass can avoid the complication of ischemia during complete trapping.

Trapping duration was 3 min, and no ischemic complications appeared in our Case 2. Although the acceptable time of clamping is controversial and only STA-MCA bypass cannot absolutely prevent ischemia, this assistant bypass is supposed to be an effective strategy for direct clipping in giant ICAbif aneurysms. However, this revascularization is not sufficient for the AChOA, which originates near the ICA top, and the ACA territory. In our two cases, the collateral flow to the ipsilateral ACA from the contralateral side through the anterior communicating artery was good, and both ACA areas were perfused from contralateral side during temporary occlusion of parent arteries. Even with STA-MCA bypass, the acceptable time for temporary occlusion of the arteries is controversial, and subsequent steps must be promptly performed.

After our experience with Case 1, we realized that more thorough control of aneurysm pressure than trapping was needed in cases of very large and giant aneurysms. Gentle traction on the clip may be useful to see the adjacent perforators behind the aneurysm,^[19] but performed without complete aneurysm decompression may result in inadvertent tearing of the dome or neck, as in our Case 1. Both temporary occlusions of the arteries and decompression of the aneurysm are essential to dissect the aneurysm from the surrounding structures, confirm both sides of the aneurysm neck, and secure adequate space for the clip. Retrograde suction decompression is very difficult to conduct in very large or giant ICAbif aneurysms because of the residual inflow from the PcomA, AChOA, and ophthalmic artery.

Therefore, we planned to conduct STA-MCA bypass followed by temporary occlusion of the cervical ICA, M1, A1, and PcomA in Case 2, and to make an intentional little incision in the dome to decompress the aneurysm. This latter step facilitated dissection of the aneurysm and confirmation of the surrounding important structures. Case 2 convinced us that complete aneurysm deflation by incision of the dome and suction after complete trapping was necessary. Such complete aneurysm deflation allowed confirmation of the adjacent arteries and the optimal clipping line to preserve the parent artery so that complete direct clipping was successfully performed.

CONCLUSION

Trapping, deliberate aneurysm dome puncture, and suction decompression from the incision in conjunction with assistant STA-MCA bypass can achieve complete aneurysm deflation, and these techniques enable safe dissection of the aneurysm and direct clipping of the aneurysm neck. Direct clipping with this technique for very large and giant ICAbif aneurysms may be the optimal treatment choice with acceptable outcome if endovascular treatment remains suboptimal.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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