Treatment Strategy for Cerebral Aneurysms Based on the Evidence of the Efficacy of GDC Embolization

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Summary

The authors reviewed 531 patients with cerebral aneurysms treated with Guglielmi detachable coils (GDCs) over 5 years to clarify both the advantages and disadvantages of embolization based on the evidence of complications by aneurysm profile. There were 52 technical complications, 25 of which resulted in unfavorable patient outcomes. Intraoperative rupture, the most serious complication exacerbating the patient's condition, occurred in 19 patients, 4 of whom expired. All of these aneurysms were very small and were mostly located in the AcomA and PICA portions. Thirteen patients encountered thromboembolic complications, 6 of whom were elderly with acute ruptured aneurysms at MCA and the tip of BA. For large or giant aneurysms manifesting the mass effect, particularly those in the ICA-C2 portion compressing the optic nerve, the saccular packing did little to ameliorate the symptoms, and subsequent surgical or endovascular trapping was needed.

Therefore, saccular embolization of endovascularly difficult, very small AcomA aneurysms and large C2 aneurysm with visual symptoms should be used sparingly based on a risk-benefit assessment.

Introduction

Microsurgical clipping and endovascular embolization are alternative options in treating cerebral aneurysms. The goals of the treatment of intracranial aneurysms are to exclude the lesion from the cerebral circulation, to prevent subsequent haemorrhage, and to relieve the mass effect due to the compression of nerves and brain parenchyma. It has been suggested that embolization with the Guglielmi detachable coil (GDC) may be safer than the clipping of selected aneurysms in locations where surgery may be especially difficult or risky such as giant aneurysms or those located in the posterior circulation, aneurysms in older patients, and in those with patients with comorbid medical conditions^{1,2}. While, there have been several concerns expressed about the GDC procedure, including its failure to embolize, potential recanalization due to coil compaction, and regrowth of the aneurysm. These potential complications of endovascular treatments or patient illness may offset the advantages of embolization in some cases¹.

The purpose of this study is to identify unsuitable and risky aneurysms on the basis of our clinical results and complications we have experienced.

Material and Methods

We conducted a retrospective review and analysis of 531 consecutive cases of intracranial aneurysms managed by the endovascular neurosurgery team at Nagoya University Hospital and 17 affiliated hospitals. Embolization was performed in 497 of those aneurysms using endovascular methods. In 34 cases, embolization was aborted because of inaccessibility in 1, too wide neck for saccular packing in 15, direct branching in 5, and inability to tolerate trapping in 5. In 8 patients the procedure was prematurely terminated because of intraoperative complications including rupture in 7 and ischemic events in 1. Intraprocedural and post-procedural complications were analyzed by location and cause. The location of the aneurysms is shown in table 1. There were 310 aneurysms in the anterior circulation and 221 in the posterior circulation. About 57% of the total were unruptured.

Results

Complications occurred in 52 procedures, including perforation in 19, thromboembolism in 20, retrograde thrombosis in 5, regrowth and coil compaction in 9, rerupture in 6, and other complications in 2. Twenty-five patients had the permanent deficits due to complications.

Intraoperative ruptures occurred in 19 aneurysms including 7 unruptured and 12 ruptured (table 2).

Higher-grade ruptured aneurysms tended to rerupture during the embolization. Since 12 ruptures occurred in the final stage of embolization, the operation was carried to completion. A guidewire or microcatheter penetrated the aneurysm during the navigation of the microcatheter in 7 patients. In all these cases, the procedure was stopped and other methods were substituted. Aneurysms located in the anterior communicating artery (AcomA) and vertebral artery (VA) had a particularly strong tendency toward intraprocedural rupture.

Ischemic complications occurred in 24 patients (table 3). The frequency was somewhat higher in ruptured aneurysms. There were 14 events of distal embolism due to the insufficient heparinization, and immediate local fibrinolysis was performed in all such cases (except those involving spontaneous regression), and 80% of them were recanalized. Branches arising

from the neck were occluded by coils or fresh clots in 10 aneurysms. The evidence of such thrombotic complications in C1 and C2 portions of internal carotid artery (ICA) aneurysms was higher than in other locations.

There were 49 patients presenting with mass effects of aneurysms. Of these, C2 portion aneurysm patients frequently developed visual symptoms. However, we could not obtain any symptomatic improvement after subtotal embolization with superomedial projection, and were only marginally effective in treating superior projection cases (table 3). These aneurysms finally required surgical or endovascular trapping.

Discussion

Coil embolization of cerebral aneurysms has surely expanded treatment indications and may yield much better clinical results than those in the era of clipping alone. However, this interventional method theoretically has an inherent weak point, i.e., embolic materials must be manipulated through a microcatheter, and this delicate maneuver is absolutely dependent on fluoroscopy. It occasionally develops into the uncontrollable situation because of a very tortuous access route or unintentional movements of the microcatheter or microguidewire such as kickback or jumping. Such movement may cause the vessel or aneurysm injury when treating difficult cases. In our experience, intraoperative ruptures usually occur during the embolization of AcomA and VA aneurysms. These aneurysms share common anatomical characteristics. In AcomA aneurysms, it is particularly difficult to identify each branch of the AcomA-A1-A2 complex because they are superimposed on each other, thus obscuring the best working projection for embolization³. Moreover, access to the aneurysms was rather difficult because of the atherosclerotic carotid siphon and a sharp turn at the origin of the A1 segment. Further problems arose since these aneurysms were tiny and long or arch-shaped rather than round, and their projection was different from the axis of the A1 segment. This situation may lessen microcatheter maneuverability. In 3 of 5 cases of intraprocedural ruptures that underwent subsequent clipping, the penetrating point was not the tip of the dome but relatively close to the neck, which is located on

Table 1 Location of Aneurysm

Location		Ruptured	Unruptured		Total No.
			Mass effect	Incidental	
ICA	C3-5	10	15	35	60
	C2	16	9	39	64
	C1	49	8	32	89
ACA	Acom	20	-	24	44
	ACA	8	-	9	17
MCA		13	1	22	36
BA	tip	38	4	45	87
	SCA	7	1	8	16
	trunk	7	2	2	11
VA	PICA	21	1	4	26
	dissec. (fusiform)	33	5	20	58
others, distal		9	3	11	23
		231	49	251	531

Table 2 Intraoperative Rupture

Location		No.	Unruptured	Ruptured (H&H Grade)	Treatments		Outcome				
					continue	stop	E&G	F	P	V	D
					(treatments to follow)						
ICA	C3-5	1	1	-	-	1 (none)	1	-	-	-	-
	C2	1	-	1 (3)	1	-	-	1*	-	-	-
	C1	1	1	-	-	1 (trapping)	-	-	-	-	1
ACA	Acom	5	3	2 (2,4)	2	3 (clipping)	3	1*	-	1	-
	ACA	1	1	-	-	1	1	-	-	-	-
MCA		1	-	1 (4)	1	-	-	-	-	-	1*
BA	tip	1	1	-	1	-	1	-	-	-	-
	SCA	1	-	1 (2)	1	-	-	1	-	-	-
	trunk	-	-	-	-	-	-	-	-	-	-
VA	PICA	3	-	3 (3,4,4)	3	-	1	1	-	-	1*
	dissec.	4	-	4 (3,4,4,4)	3	1 (none)	3	-	-	-	1*
distal		-	-	-	-	-	-	-	-	-	-
		19	7	12	12	7	10	4	0	1	4
* morbidity due to vasospasm or primary brain damage.											

the end of the extension line of the A1 segment in all cases. Such difficulties may suggest the microcatheter is not smoothly inserted along the direction of the aneurysmal tip, and there is a damage that excessive stress might be put on the lateral wall of the aneurysmal neck resulting in penetration at its weakest part. Tiny aneurysms in the region of the VA-posterior inferior cerebellar artery (PICA) junction created similar problems. Trackability of the microcatheter may be limited once you have gone beyond the tortuous vertebral artery at the upper cervical portion or when aneurysms arise from the PICA itself which occasionally has a sharp turn in the course of vertebral artery. If radioanatomic evaluation using 3-dimensional imaging indicate that these aneurysms are regarded as difficult to access endovascularly, an elective surgical approach or other treatment methods should be considered before irreparable complications arise^{4,5}.

The ischemic complications we frequently experienced in the embolization of ICA aneurysms included 4 branch occlusions, 3 embolic complications and 3 temporary hemodynamic ischemias due to parent artery occlusion. In other locations, all of the complications were

caused by branch occlusions, except for one aneurysm at the basilar bifurcation involving an embolic stroke of the cerebellar hemisphere. In some patients treated with VA trapping for ruptured vertebral dissecting aneurysms, brain stem ischemias were observed several hours after the embolization. This phenomenon may result from a retrograde thrombosis of the perforating arteries. Although these complications usually occurred in ruptured aneurysms by way of excuse of the less general heparinization, the same complications were noted in 10 unruptured aneurysms. They may be due to technical errors, mostly those of over-embolization or inadequate coil placement. To avoid these complications, fluoro imaging to fix the exact location of all branching networks from the artery-aneurysm complex should be mandatory⁶.

As for the mass effect, we obtained favorable results with embolization for oculomotor palsies due to the compression of PcomA or for intracavernous aneurysms⁷. However, the optic nerve impairment due to large or giant ophthalmic aneurysms was not improved after the embolization. These results were attributable to the following: all these aneurysms were wide-

Table 3. Ischemic Complications

Location		No.	Unruptured	Ruptured	Embolism	Branch occlusion	fibrinolysis	Outcome				
								E&G	F	P	V	D
ICA	C3-5	2	2	-	-	2*	-	1	-	-	-	1
	C2	4	2	2	4	-	4	2	1	-	-	1
	C1	4	1	3	3	1	3	2	1	1	-	-
ACA	Acom	3	2	1	2	1	2	-	3	-	-	-
	ACA	1	-	1	1	-	-	-	1	-	-	-
MCA		3	-	3	2	1	2	2	1	-	-	-
BA	tip	2	1	1	1	1	1	-	2	-	-	-
	SCA	1	1	-	1	-	-	-	1	-	-	-
	trunk	-	-	-	-	-	-	-	-	-	-	-
VA	PICA	-	-	-	-	-	-	-	-	-	-	-
	dissec.	3	-	3	-	3*	-	2	1	-	-	-
distal		1	1	-	-	1*	-	1	-	-	-	-
		24	10	14	14	10	12	10	11	1	0	2
* retrograde thrombosis in case of endovascular trapping												

necked and involved various kinds of incomplete packing including dome filling and a dog-ear remnant neck.

All of them were found to recanalize within one year due to the deviation of coils to the bottom of the aneurysm. Although our results never invalidate the indication of embolization for these aneurysms, endovascular surgeons should be fully aware of such unfavorable complications, and obtain sufficient patient consent in advance whenever the procedure may result in incomplete occlusion. For symptomatic aneurysms as well as for thrombosed giant aneurysms, trapping with or without flow reconstruction should be considered as the treatment of first choice^{8,9}.

In our series, the overall complication rate was 9.8%, and the morbidity associated with technical complications was 4.7%. However, a neurologically intact patient despite the complications may have only enjoyed a string of good luck. From the risk-management point of

view, our results suggest that aneurysms belonging to the high-risk group for endovascular treatment, particularly unruptured ones, should be weighed in the balance between embolization and clipping as long as our clinical results cannot exceed those of sophisticated vascular neurosurgeons^{1,2,10,11}.

Conclusions

Endovascular embolization with GDC has surely contributed to improve the treatment results of cerebral aneurysms based on the proper indication criteria. In particular, the decision between clipping and embolization should be regulated strictly by the clinical evidence. Based on our experience, tiny aneurysm of the AcomA and VA should be carefully treated because of their tendency to intraprocedural rupture. Intracranial aneurysms with mass effect should be trapped together with the parent artery with or without flow reconstructions.

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