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Feasibility & Limitations of Endovascular Coil Embolization of Anterior Communicating Artery Aneurysms

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Objective : The purpose of this study is to analyze aneurysm morphology and define limitations and feasibility in endovascular Gugliemi detachable coil(GDC) embolization for anterior communicating artery (ACoA) aneurysms.
Methods : From January 2000 through October 2003, 123patients were treated with endovascular coil embolization for ACoA aneurysms. There were 75women and 48men, with a mean age of 63years. All ruptured aneurysms were treated within 15days of rupture. Aneurysm morphology was classified according to neck size and projection of aneurysm dome as follows - A : neck of aneurysm < 4mm & anterior projection, B : neck of aneurysm (4mm & anterior projection, C : neck of aneurysm < 4mm & posterior (superior) projection, D : neck of aneurysm (4mm & posterior (superior) projection, E : neck of aneurysm < 4mm & inferior projection, and F : neck of aneurysm (4mm & inferior projection. Endovascular procedures were categorized as either "successful" or "unsuccessful". Clinical follow-up was estimated at discharge and at 6months, post treatment results were classified according to Glasgow Outcome Scale(GOS)
Results : Successful embolization for ACoA was performed in 86patients of 123patients (69.9%). Complete or near complete aneurysm occlusion was observed in 102patients (82.9%); a neck remnant was observed in 6patients (4.9%); partial embolization was done in 3patients (2.4%); and embolization was attempted in 12patients (9.8%). Among 55patients with follow-up angiographic results, 18patients (32.7%) were defined as recanalization of the aneurysm sac. Morphological analysis demonstrated that anterior projecting aneurysms and morphological classifications (morphological classifications worsens (A - D), chances of successful coil occlusion significantly decrease) were major factors in successful embolization, and, inferiorly projecting and wide neck (≥ 4mm) aneurysms are highly related to recanalization of aneurysms.
Conclusion : Endovascular coil embolization of ACoA aneurysms shows good outcome in our study. Nevertheless, there is a limitation in the endovascular approach to ACoA, even though advanced modern techniques evolve rapidly. Compensatory surgical approach with the endovascular approach is required for successful treatment of ACoA aneurysms.

KEY WORDS : Aneurysm occlusion · Guglielmi detachable coil embolization · Anterior communicating artery aneurysm · Outcome.

Introduction

Until recently, the standard method of treatment for anterior communicating artery(ACoA) aneurysms was craniotomy and microsurgical clip ligation[2,10,12,13,19,22,39,40]. However, the continuing evolutions of endovascular techniques and devices have dramatically changed the ability of endovascular coiling to offer a therapeutic alternative for certain ACoA aneurysms[1,3,6,11,15,17,18,21,27]. Coil embolization for ACoA aneurysms has become increasingly popular; in some institutions, embolization is now proposed as the initial method of treatment. Several papers have reported successful embolization of ACoA aneurysms with minimal complications[7,27,30]. Nevertheless, how best to choose between endovascular treatment and a microsurgical approach remains a source of controversy.

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Table 1. Study Patients Summary (N=123, 2000.1 ~ 2003.10)

Clinical characteristics	Number of patients (%)
Mean age (years)	63 (29~89)
Male:Female	48:75 = 1:1.56
Successful embolization	86 (69.9)
Unsuccessful embolization	37 (30.1)
Ruptured aneurysm	114
H & H grade	
I	14 (11.4)
II	21 (17.1)
III	41 (33.3)
IV	31 (25.2)
V	3 (2.4)
Unruptured aneurysm	9
Aneurysm size	
> 4mm & < 10mm	116 (94.3)
> 10mm & < 25mm	6 (4.9)
> 25mm	1 (0.8)
Clinical outcome (at discharge, N=123)	
unchanged or improved	98 (79.7)
deterioration	6 (4.9)
death	19 (15.4)
embolization related	4 (3.3)
embolization unrelated	15 (12.2)
*Clinical outcome (6months F/U, N=45)	
unchanged or improved	44 (97.8)
deterioration	1 (2.2)
death	0

*H&H grade : Hunt & Hess grade, GOS: Glasgow outcome scale, N : number of patients, F/U : follow up * these results for patients of a successful embolization*

Table 2. Cause of unsuccessful embolization of aneurysm (N=37)

Cause	No of patients (%)
Recanalization	18 (48.6)
Attempted	9 (24.3)
Intra or delayed bleeding	6 (16.2)
Thromembolism	2 (5.4)
Partial embolization	2 (5.4)
*Postop. hemorrhagic infarction	1 (2.7)

* *probably related to excessive heparinization*

The purpose of this report is to describe our experience with endovascular Guglielmi detachable coil(GDC) coil embolization for ACoA aneurysms focusing on an analysis of aneurysm morphology, in order to assess the limitations and feasibility of coil embolization as a means for predicting which ACoA can be successfully treated with endovascular technique.

Materials and Methods

Patient population

From January 2000 to October 2003, 123patients presenting with an intracranial ACoA aneurysms were treated using GDC embolization technique in our hospital. All ruptured aneurysms were treated within 15days of rupture.

Seventy-five patients were female (61%), and 48 were male (39%). The ages ranged from 29~89 (mean age : 63years). Ten patients (8.1%) were 40years old or younger, 67 (54.5%) were between 41 and 60years of age, and 46 (37.4%) were 60years of age or older(Table 1).

Description of aneurysm

Size of aneurysm

One hundred sixteen aneurysms (94.3%) were small (4-10mm in their largest diameter); 6 (4.9%) were large (11-25mm); and 1 (0.8%) was giant (>25mm). None of the large or giant aneurysms were partially thrombosed.

Size of the neck

Ninety-eight aneurysms (79.7%) had a small neck (<4mm), while 25 aneurysms (20.3%) had a wide neck (≥4mm). Thirty-two aneurysms (26%) had a fundus to neck ratio (F/N ratio) of aneurysms greater than 2; 91 aneurysms (74%) had a ratio of with less than 2.

Classification of aneurysm by morphology

To determine the effects of aneurysm morphology, we classified ACoA aneurysms into 6 categories based on neck size and projection of the aneurysm dome. The following categories were used, class A : neck of aneurysm<4mm & anterior projection, class B : neck of aneurysm ≥4mm & anterior projection, class C : neck of aneurysm<4mm & posterior(superior) projection, class D : neck of aneurysm ≥4mm & posterior (superior) projection, class E : neck of aneurysm<4mm & inferior projection, and class F : neck of aneurysm ≥4mm & inferior projection.

Hunt and Hess grading

Nine patients had unruptured aneurysm (Grade 0). Among them, 6patients presented with incidental finding, 1 patient with seizure, 1 patient with blackout spell, and 1 patient with tinnitus. But, there was no patient with mass effect. Fourteen patients (11.4%) were classified as Grade I, 21 (17.1%) as Grade II, 41 (33.3%) as Grade III, 31 (25.2%) as Grade IV, and 3patients (2.4%) as Grade V.

Timing of treatment

Forty-four patients (35.7%) underwent GDC embolization within 48hours after the primary hemorrhage; 29 (23.3%) underwent GDC embolization between 3 and 6days posthemorrhage; 28 (22.7%) underwent GDC embolization 7 to 10days posthemorrhage; and 12 (9.6%) were treated between 11 and 15days posthemorrhage. Five patients were treated after developing a recanalization or rebleeding following GDC embolization or surgical clipping of aneurysms. And, also five patients were treated with postsurgical residual aneurysm.

Patient selection

Surgical exclusion of the 131patients was the primary factor considered in the selection of GDC embolization technique as the therapeutic alternative. The causes for surgical exclusion in this group included : attempted surgical exploration; poor neurological grade; poor medical status; and refusal of surgery. In some cases, GDC embolization was not attempted if an aneurysm of ACoA was very small (less than 3mm) or had a complex morphology (broad-based with incorporation of normal vessels).

Method of GDC embolization

All patients underwent complete cerebral angiography prior to the endovascular coil embolization. Patients with unruptured aneurysm received intravenous for anticoagulation to an activated clotting time(ACT) of twice baseline. In cases when a patient presented with a subarachnoid hemorrhage, heparin was not administrated until the aneurysm dome was protected with coils. Most aneurysms can be embolized with coils through 6 French guide catheter (Envoy, Cordis, Miami FL). With the guide catheter in position within the internal carotid artery or vertebral artery, the aneurysm can be accessed by either a 10 or 14 microcatheter (SL-10, Boston Scientific, Fermont, CA; Excel-14, Boston Scientific, Fermont, CA; Prowler-10 or 14, Cordis, Miami FL). Soft-tipped microg-uidewire (Transend 14, Boston Scientific, Fermont, CA; Synchro, Precision Vascular Systems (PVS), West Valley City, UT) can be used to steer the microcatheter. When necessary the microcatheter tip would be steam-shaped to ease subsequent negotiation through the A1 segment into the aneurysm. The microguidewire/catheter was into the aneurysm under "roadmap" condition. Angiograms were performed intermittently during the coiling procedure at the discretion of the primary surgeon. A final angiogram with multiple bi-plane views was obtained upon completion of the coil embolization.

Post-operative management

Following the procedure, all patients were transferred to the Neurosurgical Intensive Care Unit. Intravenous heparin was continued for 24hours post procedure to maintain a partial thromboplastin time (aPTT) in the range of 60~80seconds. After heparin was discontinued, Dextran 40 was started for another 24hours. Dextran 40 is used as a volume expander and for its intrinsic antiplatelet effect. Femoral sheaths were removed on the first post-operative day when the aPTT normalized. Patients were continued on clopidogrel and aspirin postoperatively for six weeks. At six weeks clopidogrel was discontinued but aspirin maintained indefinitely.

Follow-up

Follow-up angiograms were usually obtained at 6 and 12 months after embolization if complete or near-complete aneurysm occlusion was achieved. Patients with partial aneurysm occlusion had an angiographic follow-up examination 3months after embolization. Patients at risk for coil compaction, such as those with giant or partially thrombosed aneurysm, also underwent early (3months) follow-up at 6months. Clinical status was graded according to the Glasgow outcome scale (GOS).

Successful and unsuccessful embolization

To analyze the effects of aneurysm morphology, we defined "successful embolization" as complete or near complete (occlusion by coil embolization or greater than or equal to 90%) coil embolization. In addition, a "successful embolization" did not suffer any procedural related complications and did not experience rebleeding or recanalization during the follow-up period. We defined "unsuccessful embolization" as failure of embolization, recanalization of aneurysm, incomplete occlusion (occlusion by coil embolization of less than 90%), thromboembolic event related coil embolization, unplanned artery occlusion or related coil embolization complication (Table 2).

Statistical analysis

Univariate and multivariate analysis were performed to evaluate factors for successful endovascular embolization and recanalizations of ACoA aneurysms. Univariate analysis were Chi-square, Fisher's Exact test for categorical variables and t-test for continuous variables.

Multivariate analysis covariates with p-values<0.5 were included in the multivariable logistic model. Final models were obtained using backwards selection and a significance criterion of 0.05. Two models were run for each outcome-one including neck size, projection, and aneurysm size but not morphological class, and a second including morphological class but not neck size, projection and aneurysm size.

Results

Clinical Outcome (at discharge)

Complete or near complete aneurysm occlusion ($\geq$95%) was observed in 102patients (82.9%); a neck remnant ($\geq$90%) was observed in 6patients (4.8%); partial embolization ($<$90%) was done in 3patients (2.4%); and an attempted embolization (inability to place coils due to technical difficulties such as vessel tortuosity or instability of coil placement) occured in 12patients (9.7%).

All patients were evaluated prior to their discharge from hospital. Ninety-eight patients (79.6%) improved or remained neurologically unchanged, 6 (4.8%) experienced postembolization clinical deterioration, and 19 (15.4%) died within one week of coil embolization procedure.

Four (3.2%) deaths were directly related to the coil embolization, 3patients suffered intraoperative or delayed rebleeding and 1patient experienced a thromboembolic event followed by massive cerebral infarction. Deaths in nine patients (7.3%) were related primarily to their original intracranial hemorrhage, while in the other 6patients (4.8%) death was due to various medical co-morbidities.

Clinical Outcome (follow-up at 6 months)

Follow-up clinical outcomes at 6 months were obtained in 45 (48.3%) of 89patients except mortality cases, partial embolization and attempted cases at 6 months.

Among 55patients with follow-up angiographic results, 18 patients (32.7%) were defined as having recanalization of the aneurysm sac. Five of these 18patients had large aneurysms. Forty-four patients of 45patients unchanged or improved neurologically during follow-up period. Only one patient deteriorated neurologically.

Nine patients with unruptured aneurysm, who received coil embolization, had a GOS score of 5 at discharge at 6 months follow-up. There was no case of recurrent or new hemorrhage during the follow-up period, and no case of clinical deterioration.

Procedure related complications

Of 123patients, nine patients (7.3%) suffered perioperative complications. These complications included : 6 episode of intraprocedural or delayed bleeding (4.8%); 2 ischemic events (1.6%); and one case of postoperative hemorrhagic infarction probably due to excessive heparinization (0.7%).

Outcome by morphology

1) Successful embolization (Table 3). Successful embolization for ACoA aneurysms was performed in 86patients of 123 patients (69.9%) in this study. Table 3 shows that successful embolization of ACoA aneurysms does relate to specific "small neck" morphology; The number of aneurysms with small neck (72 aneurysms, 83.7%; type A, C, E) was decisively larger than that with wide necks (14 aneurysms, 16.2%; type B, D, F) in successful embolization. Table 3 also shows that the projection of aneurysm is also a major determinant because there were more successful anterior projection aneurysms than any other type.

Table 3. Successful embolization of aneurysm: morphological analysis (N=86)

Type	No of patients (%)
A	43 (50)
B	7 (8.1)
C	15 (17.4)
D	3 (3.4)
E	16 (18.6)
F	2 (2.3)

A : neck of aneurysm<4mm & anterior projection, B : neck of aneurysm (4mm & anterior projection, C : neck of aneurysm<4mm & posterior (superior) projection, D : neck of aneurysm (4mm & posterior (superior) projection, E : neck of aneurysm <4mm & inferior projection, F : neck of aneurysm (4mm & inferior projection

Table 4. Unsuccessful embolization of aneurysm: morphological analysis (N=37)

Cause	Morphological type(number of patients)
Recanalization (N=18)	A(0), B(2), C(2), D(2), E(9), F(3)
Attempted (N=9)	A(2), B(1), C(3), D(1), E(2), F(0)
Intra or delayed bleeding (N=6)	A(1), B(1), C(4), D(0), E(0), F(0)
Thromboembolism (N=2)	A(2), B(0), C(0), D(0), E(0), F(0)
Partial embolization (N=2)	A(1), B(0), C(1), D(0), E(0), F(0)
Postop. hemorrhagic infarction (N=1)	A(0), B(1), C(0), D(0), E(0), F(0)

A : neck of aneurysm<4 & anterior projection, B : neck of aneurysm (4 & anterior projection, C : neck of aneurysm<4 & posterior (superior) projection, D : neck of aneurysm (4 & posterior (superior) projection, E : neck of aneurysm<4 & inferior projection, F : neck of aneurysm (4 & inferior projection, N=number of patients

2) Unsuccessful embolization (Table 4). Unsuccessful embolization for ACoA aneurysms was per-formed in 37patients of 123patients (30.1%). Table 4 shows that there is no specific morphology that relates to an unsu-ccessful embolization. But, inferiorly projecting aneurysms (12/18patients, 67%) were related to recanalization of ane-urysm. This phenomenon probably relate to the sheer pressure of the aneurysm sac.

Factor analysis for successful embolization and recanalization

Univariate analysis summarizes the chi-square and t-test results for the primary outcomes (Table 5). For successful embolization, projection and morphological classification show significant associations (using 0.05 as the significance criterion). For recanalization, projection, Hunt and Hess grade, size, morphological classification and neck size (continuous) show significant associations.

Multivariate analysis for successful embolization shows anteriorly projecting aneurysms are more likely to be successfully coiled than posteriorly or inferiorly pointing lesions (odds ratio; 3.7, 95% credit interval; 1.2~11.0 and odds ratio 4.3, 95% credit interval 1.5~12.1, respectively) (Table 6).

As morphological class worsens (A~D), chances of successful coil occlusion significantly decrease (odds ratio; 0.67, 95% credit interval 0.5~0.8)

Multivariate analysis for recanalization shows that inferiorly projecting aneurysms are significantly more likely to recanalize

Table 5. Statistical Analysis, univariate analysis for primary outcomes

Covariates	Outcome	
	Successful embolization	Recanalization
Categorical		
Sex**	0.166	0.114
Projection**	0.004	***<0.001
Neck size**	0.089	***0.053
Fundus neck ratio**	0.779	***0.243
Age*	0.362	0.911
Hunt and Hess*	***0.232	***0.022
Fisher group*	0.070	***0.080
Size*	***0.080	***0.005
Morphological class*	***<0.001	***<0.001
Continuous		
Age	0.117	0.214
Neck size	0.284	0.012
Fundus neck ratio	0.692	0.318

*Mantel-Haenszel chi-square, **Pearson chi-square, ***Exact test. This table summarizes the chi-square and t-test results for the primary outcomes. For successful, projection and morphological class show significant associations (using 0.05 as the significance criterion). For recanalization, projection, Hunt and Hess grade, size, morphological class and neck size (continuous) show significant associations

Table 6. Statistical Analysis, multivariate analysis for successful embolization

Effect	Odds ratio estimates		
	Point estimate	95% Wald confidence limits	
Projection (ant vs post)	*3.679	1.232	10.989
Projection (inf vs post)	0.858	0.284	2.591
Projection (ant vs inf)	*4.287	1.521	12.081
Fisher group	*2.318	1.046	5.136

This table shows aneurysms with anterior projection are 3.7times more likely to have a successful embolization than those aneurysms with posterior projection and 4.3times more likely to have a successful embolization than those aneurysms with inferior projection. Also, each one unit increase in fisher group results in a 103% increase in the odds of successful embolization. ant : anterior, inf : inferior, post : posterior

than anteriorly or posteriorly pointing lesions (odds ratio 47.5, 95% credit interval 6.1~371.8 and odds ratio 5.9, 95% credit interval 1.3~27.3) (Table 7). Aneurysms with larger necks (>4mm) are significantly more likely to recanalize than those with small necks (<4mm) (odds ratio 2.0, 95% credit interval 1.1~3.5), and as morphological class worsens (A~D), chances of recanalization significantly increase (odds ratio 2.4, 95% credit interval 1.6~3.7)

Discussion

Since the introduction of GDC embolization, endovascular treatment for ACoA aneurysms has become the reference standard treatment alternative[1,3,6]. In our study, endovascular treatments for ACoA aneurysms were performed in 123patients in the last 4years. Successful embolization for ACoA aneurysms was performed in 86 of 123patients (69.9%). Complete or near aneurysm occlusion was observed in 102patients (82.9%); a neck remnant was observed in 6patients (4.8%); partial embolization was done in 3patients (2.4%); and embolization was attempted in 12patients (9.7%). Mortality related coil embolization was in 4patients (3.2%). However, our study shows some problems such as a considerable rate of unsuccessful embolization (37patients, 39.1%) with relatively high recanalization rate (32.7%), small portion of large and giant aneurysm (only 7 aneurysms, 5.6%), and selection bias of patient selection before endovascular approach : exclusion of very small (less than 3mm) and complex morphology (broad-based with the incorporation of normal vessels).

Wide neck of aneurysm

Wide-neck aneurysms were difficult to treat with coils because the coils tend to prolapse into parent artery. This was the main obstacle in successful embolization[1,2,4,6-8,12,15,17-19,21,22,24,28-31,34,35,40]. This problem can often be overcome with use of two adjunctive techniques, i.e., balloon remodeling and stent-assisted coil embolization[1,11,22]. However, this technique is limited in ACoA aneurysms because current endovascular techniques have difficulty in delivering stents or balloons through the small and tortuous anterior communicating artery. This limitation may be overcome with experience, and advances GDC emblolization techniques such as 3-dimensional basket coil, more flexible microcatheter and microwire, and advanced neurophysiological mornitoring system[1,21,37]. The creation of a basket with coils is a technique that especially seems to reduce the incidence of coil herniation into parent vessel and to allow better packing of aneurysm[1)]

Projection of aneurysm sac and recanalization

The phenomenon of recanalization after coil embolization for aneurysm usually results from poorly organized or unorgarnized intraaneurysmal thrombus. These were covered only by thin transparent membrane. These findings suggest that the coil-thrombus complex at orifices of aneurysms subjected to hemodynamic forces of axial blood flow fail to form a normal endothelial cell layer[3,15,31,36)]

It is well known that the endovascular treatment of large and giant aneurysms frequently fails to obtain a total and durable occlusion of aneurysm sac. Larger or giant aneurysms usually have wider necks than small aneurysms, which increase the risk of coil herniation and may show a higher rate of recanalization[2,30,32,38]. Fortunately, compared with their high frequency among small aneurysms, large and giant aneurysms of ACoA are uncommon. Cognard et al. insisted that ratio between the size of sac and size of neck did not correlate with frequency of recurrence[6].

Recanalization after coil embolization in ACoA aneurysms is likely related to projection of the aneurysm. In our study,

Table 7. Statistical Analysis, multivariate analysis for recanalization

Effect	Odds Ratio Estimates Point Estimate	95% Wald Confidence Limits	
Projection (ant vs post)	0.125	0.014	1.088
Projection (inf vs post)	*5.916	1.280	27.342
Projection (inf vs ant)	*47.478	6.063	371.807
Neck size	*1.970	1.119	3.466
Fisher group	*0.229	0.067	0.778

This table shows those aneurysms with inferior projection are 5.9times more likely to have recanalization than those aneurysms with posterior projection and 47.5times more likely to have recanalization than those aneurysms with anterior projection. Also, each one unit increase in neck size increases the odds of recanalization by 97%. Finally, each one unit increase in fisher group results in an 87% reduction in the odds of recanalization. ant : anterior, inf : inferior, post : posterior

inferior projecting aneurysms (16/18patients, 67%) were related to recanalization of aneurysm. This phenomenon is probably due to frequently described "inflow aneurysms", that is, the blood-flow water-hammer effect and concomitant sheer pressure of aneurysm sac[6,13-16,23,25,26,28]. This phenomenon based on the premise that aneurysm growth and rupture is a function of turbulent rotatory intraaneurysmal circulation producing maximal shear stress at the inflow zone, which usually resides at the distal neck of aneurysm. There is relatively less risk at the outflow zone, which resides at the proximal neck of the aneurysm.

Limitation of endovascular treatment for ACoA aneurysms

Comparison between endovascular and microsurgical approaches should be made with caution because of the wide heterogenous component in study design, patients, and aneurysms. Most patients treated with coil embolization were poor surgical candidates because of poor medical condition, anatomic considerations, or failed surgical exploration[20]. However, endovascular treatment for ACoA aneurysms had some definite disadvantages comparing other location of aneurysms. Disadvantages of endovascular treatment for ACoA comparing other location of aneurysm were that first, many ACoA aneurysms had a small size (less than 3mm), which are easily embolized, second, ACoA aneurysms had a many portion of complex aneurysm, and adjacent anomaly of anterior cerebral artery, third, in aspect of endovascular technique, decreased controlability and trackability due to involving artery of morphology with acute angle during endovascular procedure[27,30]. Moret et al. reported that endovascular treatment of ACoA aneurysms may be precluded because of difficulty in distinguishing the aneurysm neck or because of the small size of the aneurysm sac. They also reported that the main causes of failure to embolize were loops in the cervical and intracranial vessel in spite of using the cervical approach when necessary, and acute angle change of posterior projection of the aneurysm[27,30].

Compared with endovascular treatment, surgical approach for ACoA aneurysms also has some disadvantages. It may be difficult because of complex arterial relationship, perforator preservation, frequent association of aneurysm with ACoA anomaly, and more frequent potential cognitive dysfunction[6,9,27,30]. Microsurgical clipping remains the treatment of choice for much of portion of ACoA aneurysms is valid up to now. Compensatory endovascular and microsurgical approaches are needed for optimal treatment of ACoA aneurysms patients[3,27].

Conclusion

Endovascular treatment of ACoA aneurysms was performed without clinical complication in 86 of 123patients (69.9%) in our experiences. Procedure related complications (7.3%) and mortality (3.2%), which were mainly caused by intra or delayed bleeding and ischemic problem were acceptable. Even though clinical outcome in our study showed encouraging data, considering that first, our study did not include very small (less than 3mm) and complex aneurysms. And second, showed relatively high recanalization and attempted rate (successful embolization rate; 69.9%). And third, morphological analysis in our study demonstrated that small neck was major factor in successful embolization, and, inferiorly projecting aneurysms are highly related to recanalization of aneurysm sac, only endovascular treatment of ACoA aneurysms had a limitation up to now.

In our opinion, even though advanced modern techniques evolve rapidly, compensatory surgical approach with endovascular approach is needed for successful treatment of ACoA aneurysms. The continuous refinement of our tools and the better understanding of pathophysiology of the disease associated with ever-improving outcome information, will further the reassessment of our therapeutic recommendations in the future.

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