



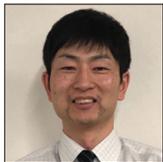
Original Article

## Current treatment options and prognostic factors for ruptured distal anterior cerebral artery aneurysms

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Received : 05 March 2021

Accepted : 31 March 2021

Published : 19 April 2021

**DOI**

10.25259/SNI\_223\_2021

**Quick Response Code:**



### ABSTRACT

**Background:** Distal anterior cerebral artery (ACA) aneurysms are rare, representing 1–9% of all intracranial aneurysms. The best treatment strategy for these aneurysms continues to be debated. We clarified the clinical features and treatment outcomes of patients with ruptured distal ACA aneurysms according to the treatment options at our institute.

**Methods:** Thirty-seven consecutive patients (26 women; mean age, 65.2 years) with ruptured distal ACA aneurysms who underwent surgical clipping or coil embolization between 2012 and 2018 were included in the study. Clinical presentations, radiographic findings, and outcomes were retrospectively reviewed and compared between patients who underwent either surgical clipping or coil embolization. Risk factors associated with poor outcomes (modified Rankin Scale 4–6) were analyzed using multiple regression analysis.

**Results:** Nineteen patients (51.4%) had World Federation Neurological Surgeons (WFNS) Grade IV–V, 18 (48.7%) had frontal lobe hematomas, and 13 (35.1%) had multiple aneurysms. Surgical clipping and endovascular coiling were performed in 28 (75.7%) and nine (24.3%) patients, respectively. Aneurysms located at the A4–5 portions were mainly treated by surgical clipping ( $P = 0.04$ ). There were no significant between-group differences in procedure-related morbidity and mortality; however, the complete occlusion rate was higher in the surgical group ( $P < 0.01$ ). Overall, a favorable neurological outcome at discharge (mRS 0–3) was obtained in 23 patients (62.5%). Multiple regression analysis revealed that WFNS Grade IV–V and frontal lobe hematomas were risk factors for poor outcomes (mRS 4–6).

**Conclusion:** Acceptable outcomes were obtained in 62.5% of cases, and there were no significant between-group differences in treatment results between clipping and coiling. A poor WFNS grade and intracerebral hematomas were risk factors for a poor prognosis.

**Keywords:** Coil embolization, Poor prognosis, Ruptured distal anterior cerebral aneurysm, Surgical clipping, Treatment outcome

### INTRODUCTION

Distal anterior cerebral artery (ACA) aneurysms are rare, representing between 1% and 9% of all intracranial aneurysms.<sup>[4,8,9,11,13,18]</sup> These aneurysms are associated with intracerebral hematoma, other aneurysms, and anomalies.<sup>[2-4,6,7,22]</sup> The best treatment strategy for these aneurysms continues

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to be debated because of difficulties inherent to both surgical clipping and coil embolization.<sup>[6,10,17,19,20]</sup> We clarified the clinical features and prognostic factors of ruptured distal ACA aneurysms in patients treated at our institute.

## MATERIALS AND METHODS

A total of 37 consecutive patients (26 women; mean age, 65.2 ± 13.2 years) with ruptured distal ACA aneurysms who underwent surgical clipping or coil embolization at our institute between 2012 and 2018 were included in the analysis. We retrospectively reviewed medical records and radiological studies. All patients were clinically assessed using the World Federation Neurological Surgeons (WFNS) grading scale at the time of admission. The clinical outcome was assessed at the time of discharge using the modified Rankin Scale (mRS), and a poor prognosis was defined as an mRS 4–6. Additionally, we analyzed risk factors of poor prognosis using multiple regression analysis.

We classified the aneurysms into three groups by location: infragenu including the A2 and inferior A3 segments, supragenu including the superior A3 and A4–5 segments, and genu including the area between the infragenu and supragenu. The treatment modalities for ruptured distal ACA aneurysms were selected according to various factors, including clinical status, the patient's age, and aneurysmal angiographic features. Surgical treatment was preferred for patients with mass-occupying hematomas or those needing decompressive surgery. Surgery was preferred for patients with supragenu aneurysms, whereas endovascular treatment was preferred for patients with infragenu aneurysms. The requirement for written informed consent was waived due to the retrospective nature of the study. This study was approved by the institutional review board of the Saitama Medical University International Medical Center (IRB: 18–124).

## RESULTS

Patients' characteristics — including clinical data, aneurysm location, and treatment method — are summarized in Table 1. Overall, there were 11 male and 26 female patients with a mean age of 65.2 years. Eighteen cases (48.6%) were WFNS Grades I–III, and 19 cases (51.4%) were Grades IV–V. Frontal lobe hematomas occurred in 18 patients (48.7%). The location of the aneurysm was infragenu in five patients (13.5%), genu in 29 patients (78.4%), and supragenu in three patients (8.1%). Five (13.5%) and 13 patients (35.1%) manifested azygos or bihemispheric ACA and multiple aneurysms, respectively. Surgical clipping was performed in 28 patients (75.7%) and endovascular coiling was performed in nine patients (24.3%). Acute hydrocephalus and symptomatic vasospasm were observed in seven (18.9%) and two patients (5.4%), respectively [Table 1].

**Table 1:** Demographics of 37 patients with ruptured distal ACA aneurysms.

Age, years±SD	65.2±13.2
Sex	
Male, <i>n</i> (%)	11 (29.7)
Female, <i>n</i> (%)	26 (70.3)
WFNS	
Grade I–III, <i>n</i> (%)	18 (48.6)
Grade IV–V, <i>n</i> (%)	19 (51.4)
Intracerebral hematoma, <i>n</i> (%)	18 (48.6)
Aneurysm Location	
Infragenu, <i>n</i> (%)	5 (13.5)
Genu, <i>n</i> (%)	29 (78.4)
Supragenu, <i>n</i> (%)	3 (8.1)
Azygos/bihemispheric ACA, <i>n</i> (%)	5 (13.5)
Multiple aneurysms, <i>n</i> (%)	13 (35.1)
Treatment modality	
Clip, <i>n</i> (%)	28 (75.7)
Coil, <i>n</i> (%)	9 (24.3)
Vasospasm, <i>n</i> (%)	2 (5.4)
Hydrocephalus, <i>n</i> (%)	7 (18.9)
ACA: Anterior cerebral artery, SD: Standard deviation, WFNS: World Federation Neurological Surgeons Grade	

The results of comparison between clipping and coiling are summarized in Table 2. There were no significant between-group differences in age, WFNS grade, intracranial hematoma, and aneurysm size and location. However, aneurysms located at the A4–5 portions (supragenu) were mainly treated by surgical clipping, and three of five patients with infragenu aneurysms were treated by coiling. Two patients (22.2%) had confirmed treatment-related infarctions in the coiling group, while brain contusions occurred in four patients (14.2%) in the clipping group. The complete occlusion rate was 96.4% in the clipping group and 44.4% in the coiling group ( $P < 0.01$ ). Both groups developed symptomatic vasospasm and hydrocephalus at statistically similar rates. Overall, 23 patients (62.5%) attained favorable neurological outcomes at discharge (mRS 0–3) [Table 2].

Comparisons according to the prognosis are summarized in Table 3. Age, aneurysm size and location, hydrocephalus, treatment modality, and surgical complications did not contribute to a poor prognosis. However, multiple regression analysis revealed that WFNS Grade IV–V and intracerebral hematomas were risk factors for a poor outcome (mRS 4–6) [Table 4].

## DISCUSSION

### Treatment outcomes

Lehecka reported the results of surgical clipping for ruptured distal ACA aneurysms at his institution before the 1980's, with surgical mortality of 1%, morbidity of 12%, and 78% of

**Table 2:** Comparison between clipping and coiling groups.

Variable	Clip (n=28)	Coil (n=9)	P-value <sup>†</sup>
Age, years±SD	64.1±1.9	68.6±5.7	0.335
WFNS			0.462
Grade I-III, n	13	5	
Grade IV-V, n	15	4	
Intracerebral hematoma, n	14	4	0.538
Aneurysm size, mm±SD	5.8±0.6	4.9±0.5	0.735
Aneurysm location			0.038
Infragenu, n	2	3	
Genu, n	23	6	
Supragenu, n	3	0	
Surgical complication			0.193
Bleeding, n	7	2	
Contusion, n	4	0	
Infarction, n	0	2	
Aneurysm obliteration			>0.01
Complete, n	27	4	
Neck remnant, n	0	4	
Dome, n	0	1	
Trapping, n	1	0	
Vasospasm, n	1	1	0.432
Hydrocephalus, n	6	1	0.444
Prognosis			0.241
Good (mRS0-3), n	16	7	
Poor (mRS4-6), n	12	2	

P-value<sup>†</sup>, variables showing significant difference by residual analysis (P<0.01). SD: Standard deviation, WFNS: World Federation Neurological Surgeons Grade

patients achieving favorable outcomes.<sup>[7]</sup> Since then, several authors have reported high technical success rates, high complete occlusion rates, and good neurological outcomes.<sup>[4,7,15,16,22,24]</sup> Conversely, Pierot *et al.* described endovascular management of eight cases of distal ACA aneurysms in 1996; coil embolization was successful in only 25% cases.<sup>[17]</sup> However, recent reports indicate that progressive developments in endovascular techniques and devices have led to higher rates of technical success with good neurological and angiographic outcomes.<sup>[7,10,16,21]</sup> In our study, the complete occlusion rate was higher in the surgical group, but there were no significant between-group differences in procedure-related morbidity and mortality, possibly due to the proper selection of treatment method. Park *et al.* reported good results at their institute. Their endovascular and clipping teams discuss which treatment was appropriate for each ruptured distal ACA aneurysm and decide on the treatment modality together.<sup>[15]</sup> In their report, the technical success rate was 100% for both clipping and coiling groups. The morbidity rate was 10.9% for clipping and 2.6% for coiling. The percentage of patients with Hunt and Hess Grade I-III at admission was 76.2%, and 23.8% were Grade IV or V. Good neurological outcomes were obtained in 58.7% of clipping cases and 63.2% of coiling cases. We observed

**Table 3:** Comparison between the good and poor prognosis groups.

Variables	Good	Poor	P-value <sup>†</sup>
Age, years±SD	62.2±2.6	70.1±2.5	0.04
WFNS			0.01
Grade I-III, n	16	2	
Grade IV-V, n	7	12	
Intracerebral hematoma			<0.01
Hematoma (+), n	7	11	
Hematoma (-), n	16	3	
Aneurysm size, mm±SD	5.1±0.5	6.3±0.8	0.108
Aneurysm location			0.263
Infragenu, n	2	3	
Genu, n	20	9	
Supragenu, n	1	2	
Hydrocephalus			0.07
Hydrocephalus (+), n	1	6	
Hydrocephalus (-), n	22	8	
Treatment modality			0.241
Clip, n	16	12	
Coil, n	7	2	
Surgical complication			0.559
Complication (+), n	9	5	
Complication (-), n	14	9	

P-value<sup>†</sup>, variables showing significant difference by residual analysis (P<0.01). SD: Standard deviation, WFNS: World Federation Neurological Surgeons Grade

**Table 4:** Multivariate analysis for poor prognostic factors.

Variables	Odds ratio (95% confidence interval)	P-value
Age (years)	1.08 (0.99–1.18)	0.054
Aneurysm size (mm)	1.12 (0.76–1.65)	0.556
WFNS Grade IV-V	9.60 (1.26–73.05)	0.029
Intracerebral hematoma	7.69 (1.09–54.13)	0.041
Hydrocephalus	6.21 (0.39–98.26)	0.195

WFNS: World Federation Neurological Surgeons Grade

similar acceptable results despite the high proportion of severe cases in our study. An adequate treatment modality must be selected for each patient to achieve better outcomes and to decrease the rate of procedure-related complications.

### Anatomical features

Several specific features of distal ACA aneurysms — such as aneurysm location, coexisting ACA anomalies, additional aneurysms, and intracerebral hematoma — have been reported. Lehecka *et al.* identified the locations of 277 ruptured distal ACA aneurysms. Thirty-eight (14%) were located in the A2 segment, 244 (81%) in the A3 segment, and 15 (5%) in the A4 and A5 segments.<sup>[7]</sup> The proportion of azygos ACA was 0.2%–11.6%, and the rate of coexistence

with other aneurysms was 27.9–52%.<sup>[3,7,22]</sup> Intracerebral hematomas were related to the rupture of distal ACA aneurysms in 17%–73% of patients.<sup>[2,7]</sup> Our results were similar to the previous reports concerning these additional factors.

### Treatment strategy

The most appropriate method for treating distal ACA aneurysms remains a controversial topic.<sup>[2,5,7,12-14,16,21-23]</sup> Endovascular treatment for ruptured distal ACA aneurysms is preferable for patients with an aneurysm dome/neck ratio >1.5, patients with poor or complicated clinical statuses, and those without intracranial mass-occupying hematomas.<sup>[15,22]</sup> Conversely, surgical treatment is generally preferred in patients with an aneurysm with branch artery incorporation and in patients with a large-volume intraparenchymal hematoma with increased intracranial pressure requiring primary decompressive surgery.<sup>[1,2,12,15,22]</sup> According to the previous reports, establishing hemostatic proximal control is difficult in surgical clipping for a ruptured infracallosal aneurysm, and it is difficult to maintain microcatheter control with coiling for a ruptured supracallosal aneurysm because of the long access route.<sup>[2,6,22]</sup> Carvi y Nievas reported that surgical treatment was preferable in distal ACA aneurysms located in the A3–5 segments (supracallosal), and endovascular treatment for ruptured infracallosal aneurysms, almost always resulted in a favorable outcome.<sup>[2]</sup> In the current report, we selected the treatment modality based on the aneurysm location, age, grade, and various other factors. However, we generally choose coiling for infragenu aneurysms and clipping for supragenu aneurysms. Proper treatment selection resulted in favorable results despite the large number of severe cases in this series.

### Prognostic factors

The previous studies have shown that the Hunt and Hess grade at admission, intracerebral hemorrhage, intraventricular hemorrhage, severe preoperative hydrocephalus, age, and rebleeding before treatment were significant predictors of poor clinical outcomes in patients undergoing either endovascular or microsurgical treatment of distal ACA aneurysms.<sup>[1,16,24]</sup> In univariate analysis, age and hydrocephalus showed significant differences; however, no significant differences were found in multivariate analysis. This may be due to the small number of cases. Regarding rebleeding, we treat ruptured distal ACA aneurysms immediately after ictus. We did not add rebleeding to the analysis since there were few cases of rebleeding before treatment. Only WFNS Grades IV-V and intracerebral hematoma were risk factors associated with poor prognosis in our study [Table 3].

### Limitations

Several limitations need to be considered while interpreting these results. This was a retrospective, nonrandomized, single-center study. This produced an inherent selection bias. In addition, our relatively small sample size may have generated unreliable statistically significant differences. Future, well-powered studies are necessary to further validate our results.

### CONCLUSION

Although this study included many cases with poor WFNS grades, we achieved good outcomes. There were no significant between-group differences in treatment outcomes between clipping and coiling. This might be due to our center's highly personalized process for designing each patient's treatment plan, fundamentally coiling for infragenu aneurysms, and clipping for supragenu aneurysms. Poor WFNS grade and intracerebral hematoma appear to be risk factors for a poor prognosis in patients with ruptured distal ACA aneurysms.

### Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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**How to cite this article:** Take Y, Kamide T, Kikkawa Y, Ikegami M, Teranishi A, Ehara T, *et al.* Current treatment options and prognostic factors for ruptured distal anterior cerebral artery aneurysms. *Surg Neurol Int* 2021;12:171.