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Endovascular Treatment of Anterior Communicating Artery Aneurysms: A Single-Center Experience from a Developing Country

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Abstract

Objective In recent years, endovascular methods have been developed to treat intracranial aneurysms. To date, results of endovascular treatment (EVT) for anterior communicating aneurysms (ACoAs) have never been investigated in Iran. Thus, we sought to assess the mid-term angiographic and clinical outcomes of patients with ACoAs who underwent EVT in a tertiary center.

Materials and Methods Electronic health documents of patients with ACoAs who underwent EVT from March 2019 to July 2021 were retrospectively reviewed. Demographic and clinical characteristics of patients, procedural and clinical complications along with immediate and 12 months' postprocedural angiographic and clinical results were included in the analysis. Aneurysm occlusion status was classified based on the Raymond–Roy Occlusion Classification (RROC), and clinical outcomes were assessed using the modified Rankin Scale (mRS).

Results Of 38 patients with 38 ACoAs, 32 patients (84.21%) presented with subarachnoid hemorrhage of whom 23 (60.52%) had ruptured ACoAs. EVT included simple coiling in 29 patients (76.32%), balloon-assisted coiling in 6 (15.79%), and stent-assisted coiling in 3 (7.89%). Immediate and 12-month postprocedural angiograms demonstrated complete/near-complete occlusion (RROC I and II) in 32 (84.21%) and 35 patients (97.22%), respectively. Periprocedural complications occurred in five patients (13.15%), and the mortality rate was 5.26%. Thirty-two patients (84.21%) had favorable outcomes (mRS 0–2) at the last follow-up.

Conclusion EVT is a safe and beneficial procedure with favorable mid-term clinical and angiographic outcomes for ACoAs. Our results can lay the foundation for further studies in developing countries and are satisfactory enough for neurointerventionists to put EVT on the therapeutic agenda of ACoAs.

Keywords
- anterior communicating artery
- endovascular treatment
- intracranial aneurysm
- clinical outcome
- angiographic outcome

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Introduction

The most common location of intracranial aneurysms, observed in 35% of cases, is the anterior communicating artery. Based on the macroscopic morphologic classification, saccular aneurysms occur in up to 90% of cases of anterior communicating artery aneurysms (ACoAs).[1] A majority of unruptured ACoAs are asymptomatic and found incidentally; while subarachnoid hemorrhage (SAH) is deemed to be the most common symptom in case of a rupture occurs.[2] Surgical clipping was the first method used for treating ACoAs. With the results of the International Subarachnoid Aneurysm Trial published in 2002, the treatment of intracranial aneurysms has preferentially shifted toward endovascular treatment (EVT).[3]

Endovascular coiling, used for the first time by Guglielmi et al in 1990, has been used since then as an effective technique of intracranial aneurysm embolization, and more clinical experience in the use of endovascular techniques, has led to a decline in the rate of complications.[4] Stent-assisted coiling (SAC) and balloons-assisted coiling (BAC) embolization has been proposed as alternatives to achieve the endovascular reconstruction of complex aneurysms.[5,6] The advent of newer techniques such as flow diversion and the introduction of catheters that are easier to maneuver have made endovascular embolization of ACoAs safer and more feasible.[7] EVT for ACoAs also has difficulties and can be technically demanding. Intraprocedural rupture and thrombus formation are vexed complications of coiling of ruptured intracranial aneurysms increasing morbidity and mortality.[6]

Even though a wealth of studies have shown the favorable results of EVT for ACoAs,[8] the rate of aneurysm occlusion following endovascular methods, especially in centers recently adopting EVT, has been insufficiently investigated. Herein, we sought to review and evaluate the angiographic and clinical outcomes of patients with ACoAs who underwent EVT in a tertiary center for the first time in Iran.

Materials and Methods

Study Design and Population

This retrospective study was performed on patients with ACoAs undergoing EVT from March 2019 to July 2021 in our referral center. All procedures for ruptured aneurysms were performed within 2 days of admission. Glasgow Coma Scale was assessed at the admission and a computed tomography angiography was performed for each patient. Conventional and rotational digital subtraction angiographies were used to assess aneurysms' sizes and configurations. Patients' electronic data were assessed retrospectively including their basic clinical and angiographic characteristics, early angiographic and clinical results, such as patient's age, sex, presence of SAH, ruptured or unruptured aneurysm, aneurysm size, and procedural and clinical complication. SAH grading and the presence of focal neurological deficits to grade the clinical severity of SAH were assessed using the modified Fisher scale[9] and modified World Federation of Neurosurgical Societies (WFNS),[10] respectively. Written consent was obtained from each participant or their guardians. This study was approved by our institutional ethics committee with the ethical code number: IR.BMSU.REC.1401.008.

Antiplatelet Treatment

Dual-antiplatelet therapy including (1) clopidogrel (75 mg/day) and acetylsalicylic acid (ASA) (325 mg/day) or (2) ticagrelor (90 mg/twice a day) and ASA (80 mg/day) was used for 7 to 14 days prior to EVT in patients with unruptured aneurysms and resumed for 3 to 6 months. ASA (80–240 mg/day) continued for 12 months following the intervention. Those who had ruptured aneurysms took (1) clopidogrel (300 mg) and ASA (325 mg) or (2) ticagrelor (180 mg) and ASA (325 mg) before undergoing anesthesia. In patients treated with stent deployment, eptifibatate (180 μg/kg) was administered intravenously before using the stent and the above-mentioned dose was repeated after 10 minutes. Infusion of eptifibatate (2 μg/kg/min) was resumed promptly after the EVT for at least 6 to 12 hours in patients taking clopidogrel and 4 to 6 hours in those taking ticagrelor.

Endovascular Treatment

All patients underwent EVT under general anesthesia through femoral artery access. Note that 3,000- or 5,000-unit bolus of heparin was administered after the 6F sheath was inserted into the right femoral artery, followed by a maintenance dosage of 1,000 units per hour. A guiding wire (Avigo or Transend) was inserted and navigated to the aneurysm lumen and then a microcatheter (Echelon or Headway) was introduced to deploy coils (Axium, GDC, and Cosmos coils) to obliterate aneurysm lumen.

SAC (LVIS stent) or BAC (Scepter c) was performed for wide-necked aneurysms.[5,11] An aneurysm with a neck diameter of 4 mm or bigger or a dome-to-neck (D-N) ratio of less than 2 was regarded as a wide-necked intracranial aneurysm.[12] In the case of using BAC, we used a coaxial or triaxial system to advance the balloon and a coiling microcatheter into the affected aneurysm. A Synchro-14 microwire (Stryker) was utilized afterward so as to position the balloon across the aneurysm neck. The balloon was then blown up to secure the microcatheter and avert coil prolapse into the parent vessel throughout the final coil placement.[13] In the case of SAC, the neurointerventionist jailed the microcatheter after device deployment.[14]

Clinical and Angiographic Follow-Up Studies

Clinical outcomes were evaluated by an expert interventional neurologist at the discharge visit. The latest follow-up, 1 year after the intervention, was conducted according to in-person visit or telephone interview with the patients or their relatives in case of inability to communicate properly. The modified Rankin Scale (mRS) score was used to evaluate the clinical outcome of patients at discharge and the last follow-up visit. Favorable and poor clinical outcomes were considered mRS scores of 0 to 2 and 3 to 6, respectively. Regarding the angiographic outcomes, patients underwent cerebral angiography immediately after the intervention and 12 months thereafter to assess the aneurysm's occlusion status. Raymond–Roy Occlusion Classification (RROC)[15] was used to

Table 1 Demographic characteristics of patients who underwent endovascular treatment for ACoAs

Variable	Total ($n = 38$)	Ruptured ($n = 23$)	Unruptured ($n = 15$)	p-Value
Age (y)	57.29 ± 11.48	58.04 ± 12.21	56.13 ± 10.56	0.623
Gender (male)	15 (39.47%)	8 (34.78%)	7 (46.67%)	0.464
Tobacco smoker	21 (55.26%)	11 (47.82%)	10 (66.67%)	0.100
SAH	32 (84.21%)	23 (100%)	9 (60%)	**0.002**
Modified Fisher grade	1.53 ± 1.17	2.09 ± 1.12	0.66 ± 0.61	$<$ **0.001**
Modified WFNS	1.74 ± 1.26	2.22 ± 1.44	1.00 ± 1.27	**0.002**
Aneurysm dome size (mm)	9.76 ± 4.03	9.51 ± 4.35	10.13 ± 4.03	0.652
Aneurysm neck size (mm)	3.76 ± 1.14	3.63 ± 1.25	3.96 ± 1.14	0.395
Dome-to-neck ratio (mm)	2.57 ± 0.54	2.59 ± 0.53	2.53 ± 0.54	0.749
Endovascular treatment				0.591
- Simple coiling	29 (76.32%)	18 (78.27%)	11 (73.34%)	
- Balloon-assisted coiling	6 (15.79%)	4 (17.39%)	2 (13.33%)	
- Stent-assisted coiling	3 (7.89%)	1 (4.34%)	2 (13.33%)	

Abbreviations: ACoAs, anterior communicating aneurysms; SAH, subarachnoid hemorrhage; WFNS, World Federation of Neurosurgical Societies.
Note: Data are the number of patients (%) or mean ± standard deviation (SD). Statistically significant differences are shown in bold ($p < 0.05$).

identify the immediate and follow-up angiographic outcomes. In this regard, RROC I is defined as complete obliteration, RROC II as residual neck, and RROC III as a residual aneurysm.

Statistical Analysis

Descriptive statistics on individuals' characteristics for categorical variables were expressed as percentages and quantitative data were presented as mean ± standard deviation. Statistical analysis was performed with an independent sample *t*-test for quantitative variables and chi-square or Fisher's exact test for categorical variables. All statistical analyses were performed using SPSS software version 26 (SPSS Inc., Chicago, Illinois, United States). Statistical significance was defined as a *p*-value less than 0.05.

Results

Patients' Characteristics

Totally, 38 patients with 38 ACoAs, including 23 ruptured aneurysms underwent EVT. There were 23 females and 15 males (39.48%) with a mean age of 57.29 ± 11.48 years among whom 21 (55.26%) were smokers. A staggering 32 patients (84.21%) presented with SAH owing to a ruptured aneurysm of whom 23 were ruptured ACoAs ($p = 0.002$). The discovery of nine patients with unruptured ACoAs was on account of SAH from another intracranial aneurysm, and the remaining six were found fortuitously. The mean modified Fischer scale and modified WFNS for our patients were 1.53 ± 1.17 and 1.74 ± 1.26, respectively. The mean modified Fisher grade in the ruptured group was 2.09 ± 1.12, while it was 0.66 ± 0.61 in the unruptured group ($p < 0.001$). Similarly, there was a significant difference in the modified WFNS between the ruptured (2.22 ± 1.44) and unruptured (1.00 ± 1.27) groups ($p = 0.002$). The mean aneurysm dome and neck sizes were 9.76 ± 4.03 and 3.76 ± 1.14, respectively, with a mean D-N ratio of 2.57 ± 0.54. Simple coil embolization was the most common intervention ($n = 29$, 76.32%), followed by BAC ($n = 6$, 15.79%) and SAC ($n = 3$, 7.89%). There was no significant difference between patients with ruptured and unruptured ACoAs in terms of age, sex, aneurysm dome size, neck size, D-N ratio, and the type of endovascular intervention (►**Table 1**).

Angiographic Outcomes

EVT was successfully performed in all patients. Immediate postprocedural angiograms showed complete/near-complete occlusion in 32 patients (84.21%), including 22 (57.90%) complete obliterations (RROC I) and 6 (15.79%) with a residual neck (RROC II). Of 36 patients who underwent follow-up cerebral angiography at 12 months postoperatively, 28 had RROC I, 7 had RROC II, and only 1 had RROC III. Of 10 aneurysms with a residual neck (RROC II), 5 showed complete obliteration in the 12-month postprocedural angiogram and 5 others remained in the same status (RROC II). Of six patients with residual aneurysm (RROC III), the follow-up angiogram showed complete obliteration (RROC I) in one and neck remnant (RROC II) in two aneurysms. Only one aneurysm remained in RROC III after 1 year of follow-up that was retreated by simple coiling without any complication. There was no significant difference between ruptured and unruptured ACoAs regarding their occlusion status at discharge or follow-up (►**Table 2**).

Clinical Outcomes and Periprocedural Complications

Of 38 patients, 27 (71.05%) had favorable outcomes at discharge, including 14 patients (60.86%) with ruptured and 13 (86.67%) with unruptured aneurysms ($p = 0.145$). Over a 12-month follow-up, 32 patients (84.21%) demonstrated favorable clinical outcomes, including all patients (100%) with unruptured and 17 (73.91%) with ruptured ACoAs ($p = 0.029$). Procedural-related complications occurred in 5 patients (13.15%). The most common complication was intrastent thrombosis, which occurred in 4 cases

Table 2 Clinical and angiographic outcomes of patients with ACoAs at discharge and follow-up

Variable	Total ($n = 38$)	Ruptured ($n = 23$)	Unruptured ($n = 15$)	*p*-Value
Immediate RROC				0.944
- I	22 (57.90%)	13 (56.52%)	9 (60%)	
- II	10 (26.31%)	6 (26.08%)	4 (26.67%)	
- III	6 (15.79%)	4 (17.40%)	2 (13.33%)	
Follow-up RROC[a]				0.693
- I	28 (77.78%)	16 (76.19%)	12 (80%)	
- II	7 (19.44%)	4 (19.04%)	3 (20%)	
- III	1 (2.78%)	1 (4.77%)	0 (0%)	
Favorable outcome at discharge	27 (71.05%)	14 (60.86%)	13 (86.67%)	0.145
Favorable outcome at follow-up	32 (84.21%)	17 (73.91%)	15 (100%)	**0.029**
Complications				0.153
- Intrastent thrombosis	4 (10.52%)	4 (17.39%)	0 (0%)	
- Intraoperative rupture	1 (2.63%)	1 (4.34%)	0 (0%)	

Abbreviations: ACoAs, anterior communicating aneurysms; RROC, Raymond–Roy Occlusion Classification.
Note: Data are the number of patients (%) or mean ± standard deviation (SD). Statistically significant differences are shown in bold ($p < 0.05$).
[a]Out of 36 patients, 2 patients expired in the ruptured group during the follow-up.

(10.5%). Thrombosis was resolved by intravenous administration of Integrilin without any new neurological deficits. Intraoperative aneurysm rupture occurred solely in one patient. We controlled the bleeding by reversing the heparin, coiling the aneurysm, and inserting an external ventricular drain thereafter. Nonetheless, the patient expired 14 days later on account of extensive brain damage. There was another expired case in our study who died due to coronavirus disease 2019 (COVID-19)-related pneumonia. Although all five complications were exclusively observed in patients with ruptured aneurysms, no significant differences were noted between the two groups ($p = 0.153$).

Discussion

The anterior communicating artery is the most prevalent site for intracranial aneurysms.[1] ACoAs are usually asymptomatic and incidental, but in case of being symptomatic, SAH is the most common presentation of ACoAs due to aneurysm rupture.[2] Treatment for ACoAs has always been a contentious matter and surgical clipping was deemed to be the conventional method to treat ACoAs.[16] Since the introduction of detachable coils by Guglielmi et al, EVT has been growing in popularity and it has become the preferable therapeutic method in the majority of cases harboring ACoAs.[4] The advent of newer techniques such as BAC, SAC, and flow diverters have enabled neurointerventionists to deal with more complex ACoAs[17]; however, opting for the suitable endovascular method should be based on the indication, resources and facilities, and expertise of the neurointervention team.[18]

In our study, EVT for ACoAs was successfully performed for all the cases. Having reviewed the pertinent literature, we found that the rate of failure in EVT has been reported between 0 and 11.1%.[6,19,20] Complete/near-complete aneurysm obliteration (RROC I and II) was achieved in a staggering 32 patients (84.21%) and 35 (97.22%) immediately and at the last follow-up, respectively, which was comparable to previous studies.[21–24] A recent systematic review by Yarahmadi et al[6] reported that the immediate complete and near-complete angiographic occlusion was 89.2% (95% confidence interval [CI] 86.4–91.2%). Immediate therapeutic success depends on multiple factors; that is to say that treating ACoAs with a D-N ratio less than 1.7, ruptured aneurysmal sac, irregular shape, superior or posterior dome orientation, and wide neck and large dimensions of the aneurysm usually yields less desirable outcomes.[25]

The functional status of the patients was assessed at discharge and the last follow-up and classified into two groups: (1) favorable outcome (mRS 0–2) and (2) poor outcome (mRS 3–6). At discharge 27 patients (71.05%) showed favorable outcomes, and by the last follow-up, the number of patients with mRS less than 3 had reached 32 (84.21%) which corresponds to data in the literature.[8,22] Notably, all patients with unruptured aneurysms were in satisfactory clinical status, whereas six patients from the ruptured group depicted poor outcomes.

The rate of total periprocedural complications varies between 2.6 and 16.1% among studies.[26,27] The most prevalent complications were thrombosis[6,26,28] observed in up to 11.2% of patients, and intraoperative aneurysm rupture in up to 6.1% of patients.[6,19,28] Less prevalent complications were coil prolapse[29] and procedure-related vasospasm.[30] Intraprocedural complications tend to be associated with higher risks of periprocedural and in-hospital mortality and long-term morbidities.[19] Increased experience in applying endovascular methods has led to a reduction in treatment complications.[4] Our periprocedural complication rate of 13.15% was also consistent with earlier endovascular studies.[26,27] Four patients, who had ruptured aneurysms at admission, encountered thrombotic events during the procedure. Having

administered intravenous Integrilin, all the intrastent thrombosis resolved without rendering any new deficits.

In line with previous studies with mortality rates ranging from 10 to 31%,[22,26,31,32] we have reported a mortality rate of 5.26% in our study. One individual experienced an intraoperative aneurysm rupture and expired within 2 weeks following the endovascular intervention on account of extensive brain damage, while the other one died due to COVID-19 pneumonia 4 months postoperatively. The rate of retreatment in previous studies on EVT of ACoAs pales in comparison with that of our study. One patient who was treated by simple coiling and aneurysm remnant on immediate and final angiograms (RROC III) underwent retreatment by simple coiling (2.63%). Our low retreatment rate can be attributable to our moderately low sample size and a shorter follow-up duration compared to previous studies varying between 5.5 and 13.2%.[6,22,25,26,33]

To the best of our knowledge, this is the first study on patients with ACoAs treated by endovascular intervention from a tertiary center in Iran. In this retrospective study, baseline characteristics along with clinical and angiographic outcomes of 38 ACoAs undergoing three types of EVT have been provided. The main shortcoming of our study was the retrospective design. Furthermore, relatively shorter follow-up compared to previous studies has deterred us from assessing the retreatment rates, obliteration, and functional status in the long run. Beyond and above that, the lack of a control group treated by microsurgical clipping as the conventional method could have hindered us from drawing a firm conclusion and encouraging other centers to adopt endovascular methods. Therefore, larger prospective studies with longer follow-ups, especially in developing countries, ought to be conducted so as to substantiate our findings and transcend our limitations.

Conclusion

The results of the current study have led us to infer that EVT is a safe and beneficial procedure with favorable mid-term clinical and angiographic outcomes for ACoAs. Our pilot experience can lay the foundation for further studies, especially in developing countries, and are satisfactory enough for neurointerventionists to put EVT on the therapeutic agenda of ACoAs. However, larger prospective comparative cohort studies are highly proposed so as to lead to a firm conclusion, particularly for centers considering EVT for ACoAs.

Ethics Approval

This study was approved by our institutional ethics committee with the ethical code number: IR.BMSU.REC.1401.008.

Informed Consent

Written informed consent was obtained from patients for the publication of this paper.

Authors' Contributions

S.S. contributed to writing the paper, data collection, interpretation, and leadership responsibility for the research activity planning and execution, including mentorship external to the core team. A.R.B., M.E., and M.A.A.M. contributed to data collection and interpretation. A.V.L. and G.T. contributed to the study concept or design and interpretation.

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Conflict of Interest

None declared.

References

1 Keedy A. An overview of intracranial aneurysms. McGill J Med 2006;9(02):141–146
2 Fang S, Brinjikji W, Murad MH, Kallmes DF, Cloft HJ, Lanzino G. Endovascular treatment of anterior communicating artery aneurysms: a systematic review and meta-analysis. AJNR Am J Neuroradiol 2014;35(05):943–947
3 Molyneux A, Kerr R, Stratton I, et al; International Subarachnoid Aneurysm Trial (ISAT) Collaborative Group. International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomized trial. J Stroke Cerebrovasc Dis 2002;11(06):304–314
4 Guglielmi G, Vinuela F, Sepetka I, Macellari V, Kerr RS. Electrothrombosis of saccular aneurysms via endovascular approach: part 1: electrochemical basis, technique, and experimental results. Journal of Neurosurgery 1991;75(01):1–7
5 De Leacy RA, Fargen KM, Mascitelli JR, et al. Wide-neck bifurcation aneurysms of the middle cerebral artery and basilar apex treated by endovascular techniques: a multicentre, core lab adjudicated study evaluating safety and durability of occlusion (BRANCH). J Neurointerv Surg 2019;11(01):31–36
6 Yarahmadi P, Kabiri A, Bavandipour A, Jabbour P, Yousefi O. Intraprocedural complications, success rate, and need for retreatment of endovascular treatments in anterior communicating artery aneurysms: a systematic review and meta-analysis. Neurosurg Rev 2022;45(05):3157–3170
7 Moon K, Albuquerque FC, Ducruet AF, Crowley RW, McDougall CG. Balloon remodeling of complex anterior communicating artery aneurysms: technical considerations and complications. J Neurointerv Surg 2015;7(06):418–424
8 Moon K, Park MS, Albuquerque FC, Levitt MR, Mulholland CB, McDougall CG. Changing paradigms in the endovascular management of ruptured anterior communicating artery aneurysms. Neurosurgery 2017;81(04):581–584
9 Sano H, Satoh A, Murayama Y, et al; members of the 38 registered institutions and WFNS Cerebrovascular Disease & Treatment Committee. Modified World Federation of Neurosurgical Societies subarachnoid hemorrhage grading system. World Neurosurg 2015;83(05):801–807
10 Frontera JA, Claassen J, Schmidt JM, et al. Prediction of symptomatic vasospasm after subarachnoid hemorrhage: the modified fisher scale. Neurosurgery 2006;59(01):21–27, discussion 21–27
11 Vivanco-Suarez J, Wallace AN, Dandapat S, et al. Stent-assisted coiling versus balloon-assisted coiling for the treatment of ruptured wide-necked aneurysms: a 2-center experience. Stroke Vasc Intervent Neurol 2023;3(01):e000456

12 Zhao B, Yin R, Lanzino G, Kallmes DF, Cloft HJ, Brinjikji W. Endovascular coiling of wide-neck and wide-neck bifurcation aneurysms: a systematic review and meta-analysis. AJNR Am J Neuroradiol 2016;37(09):1700–1705
13 Wallace AN, Samaniego E, Kayan Y, et al. Balloon-assisted coiling of cerebral aneurysms with the dual-lumen Scepter XC balloon catheter: experience at two high-volume centers. Interv Neuroradiol 2019;25(04):414–418
14 Chalouhi N, Jabbour P, Singhal S, et al. Stent-assisted coiling of intracranial aneurysms: predictors of complications, recanalization, and outcome in 508 cases. Stroke 2013;44(05):1348–1353
15 Mascitelli JR, Moyle H, Oermann EK, et al. An update to the Raymond-Roy Occlusion Classification of intracranial aneurysms treated with coil embolization. J Neurointerv Surg 2015;7(07): 496–502
16 Hernesniemi J, Dashti R, Lehecka M, et al. Microneurosurgical management of anterior communicating artery aneurysms. Surg Neurol 2008;70(01):8–28, discussion 29
17 Liu J, Song J, Zhao D, et al. Risk factors responsible for the volume of hemorrhage in aneurysmal subarachnoid hemorrhage. Neurol India 2016;64(04):686–691
18 Limbucci N, Leone G, Renieri L, et al. Expanding indications for flow diverters: distal aneurysms, bifurcation aneurysms, small aneurysms, previously coiled aneurysms and clipped aneurysms, and carotid cavernous fistulas. Neurosurgery 2020;86(Suppl 1): S85–S94
19 Fan L, Lin B, Xu T, et al. Predicting intraprocedural rupture and thrombus formation during coiling of ruptured anterior communicating artery aneurysms. J Neurointerv Surg 2017;9(04):370–375
20 Finitsis S, Anxionnat R, Lebedinsky A, et al. Endovascular treatment of ACom intracranial aneurysms. Report on series of 280 patients. Interv Neuroradiol 2010;16(01):7–16
21 Moret J, Pierot L, Boulin A, Castaings L, Rey A. Endovascular treatment of anterior communicating artery aneurysms using Guglielmi detachable coils. Neuroradiology 1996;38(08):800–805
22 Catapano JS, Karahalios K, Rumalla K, et al. Endovascular treatment of ruptured anterior communicating aneurysms: a 17-year institutional experience with coil embolization. J Neurointerv Surg 2022;14(10):1018–1021
23 Elias T, Ogungbo B, Connolly D, Gregson B, Mendelow AD, Gholkar A. Endovascular treatment of anterior communicating artery aneurysms: results of clinical and radiological outcome in Newcastle. Br J Neurosurg 2003;17(03):278–286
24 Turjman F, Massoud TF, Sayre J, Viñuela F. Predictors of aneurysmal occlusion in the period immediately after endovascular treatment with detachable coils: a multivariate analysis. AJNR Am J Neuroradiol 1998;19(09):1645–1651
25 Tarulli E, Sneade M, Clarke A, Molyneux AJ, Fox AJ. Effects of circle of Willis anatomic variations on angiographic and clinical outcomes of coiled anterior communicating artery aneurysms. AJNR Am J Neuroradiol 2014;35(08):1551–1555
26 Brzegowy P, Kucybała I, Krupa K, et al. Angiographic and clinical results of anterior communicating artery aneurysm endovascular treatment. Wideochir Inne Tech Malo Inwazyjne 2019;14(03): 451–460
27 Harris L, Hill CS, Elliot M, Fitzpatrick T, Ghosh A, Vindlacheruvu R. Comparison between outcomes of endovascular and surgical treatments of ruptured anterior communicating artery aneurysms. Br J Neurosurg 2021;35(03):313–318
28 Cherian MP, Pranesh MB, Mehta P, et al. Outcomes of endovascular coiling of anterior communicating artery aneurysms in the early post-rupture period: a prospective analysis. Neurol India 2011;59 (02):218–223
29 Hur CW, Choi CH, Cha SH, Lee TH, Jeong HW, Lee JI. Eleven year's single center experience of endovascular treatment of anterior communicating artery aneurysms: Focused on digital subtraction angiography follow-up results. J Korean Neurosurg Soc 2015;58 (03):184–191
30 Kocur D, Zbroszczyk M, Przybyłko N, et al. Stand-alone coil embolization of anterior communicating artery aneurysms: efficacy and technical issues. Neuroradiol J 2016;29(05):361–367
31 Debono B, Proust F, Langlois O, et al. Ruptured anterior communicating artery aneurysm. Therapeutic options in 119 consecutive cases [in French]. Neurochirurgie 2004;50(01):21–32
32 Soares FP, Velho MC, Antunes ACM. Clinical and morphological profile of aneurysms of the anterior communicating artery treated at a neurosurgical service in Southern Brazil. Surg Neurol Int 2019;10:193
33 Jang CK, Chung J, Lee JW, Huh SK, Son N-H, Park KY. Recurrence and retreatment of anterior communicating artery aneurysms after endovascular treatment: a retrospective study. BMC Neurol 2020;20(01):287

