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Midterm outcomes of intracranial aneurysms with bleb formation with densely coiling of the aneurismal neck or entire aneurysm

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Abstract

To evaluate whether the efficacy and safety of embolization of the aneurysmal neck were better than those of embolization of the entire aneurysm. Previous studies found that embolization of the aneurysmal neck can be used for treating ruptured intracranial aneurysm with bleb formation.

In all, 163 patients with ruptured aneurysms with bleb formation who underwent endovascular embolization at the Shanghai Municipal Jing'an District Central Hospital from January 2014 to August 2015 were divided into the embolization of aneurysmal neck group (neck group; 87 cases) and embolization of entire aneurysm group (aneurysm group; 76 cases). A retrospective analysis of clinical data, follow-up Glasgow Outcome Scale (GOS) score, and occurrence of complications was performed. The impacts of different embolisms on the prognosis were compared.

The median follow-up time in the neck and aneurysm groups was 17 months (9.62) and 16.5 months (9.54), respectively ($P = .799$). No differences were found in recurrence, postoperative GOS score, and GOS score at the last follow-up between the 2 groups. The numbers of coils and surgical complications in the neck group were smaller than those in the aneurysm group ($P < .001$ and $P < .030$, respectively). After adjusting for age and sex, the embolization method was found to be an independent predictor for surgery-related complications (odds ratio 2.419, 95% confidence interval 1.111–5.269, $P = .026$).

The numbers of coils and surgery-related complications were smaller when embolizing the aneurysmal neck than the entire aneurysm, showing potential advantages of embolization of the aneurysmal neck.

Abbreviations: DSA = digital subtraction angiography, GOS = Glasgow Outcome Scale, TIA = transient ischemic attack.

Keywords: cerebral vasospasm, endovascular embolization, false bleb formation, intracranial aneurysm, retrospective analysis

1. Introduction

Intracranial aneurysm refers to cerebrovascular disease characterized by an abnormal bulging of a cerebral artery wall, which occurs in 2% to 3% of the general population.[1] Aneurysm rupture is the main cause of nontraumatic subarachnoid hemorrhage (SAH)[2] and cerebral vasospasm, often leading to severe morbidity or even death. Microsurgical clipping and endovascular embolization are the main treatments of intracranial aneurysms. Because of the low mortality, low morbidity, less complications,[3,4] and shorter length of hospital stay, endovascular embolization is increasingly used for treating intracranial aneurysms.[5,6]

One of the types of intracranial aneurysm is aneurysm with false bleb formation. After the aneurysm is ruptured, a hematoma is formed around the break, and the center of the hematoma is liquefied. Under sustained shocks of pressure, the liquefied hematoma connects with the true aneurysm to form aneurysm with false bleb formation.[7,8] The artery walls of an aneurysm with false bleb formation are covered with fibrous connective tissue with the formation of thrombosis in it, thereby making it easy to bleed because of rerupture.[9] Aneurysm with bleb formation is difficult to treat and prone to causing complications such as cerebral vasospasm and bleeding. Previous studies have shown that endovascular coil embolization of the aneurysmal neck can be used for treating ruptured intracranial aneurysm with bleb formation,[10] but its efficacy is still unclear compared with that of endovascular coil embolization of the entire aneurysm.

Therefore, this study retrospectively analyzed the clinical and follow-up data of patients who underwent aneurysm embolization at the Shanghai Municipal Jing'an District Central Hospital from January 2014 to August 2015, and also compared the prognostic impact of embolization between aneurysmal neck and entire aneurysm on patients with intracranial aneurysm.

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2. Methods

2.1. Patients

A retrospective analysis of the clinical data was performed for the patients who underwent aneurysm embolization at the department of interventional radiology of the Jing'an Branch of the Affiliated Huashan Hospital and the Department of Radiology Affiliated Huashan Hospital of Fudan University from January 2014 to August 2015. This study was approved by the ethics committee of the Shanghai Municipal Jing'an District Central Hospital, but was exempted from the need of informed consent. The inclusion criteria were: patients 18 to 80 years old; patients suffering from intracranial aneurysms with bleb formation detected by imaging, with an aneurysm diameter of 5 to 15 mm; and patients with a Glasgow Coma Scale (GCS) score >8 and a Hunt–Hess score ≤ 3. The exclusion criteria were: patients who received emergency surgery; patients having other cerebral vascular diseases; patients with a history of aneurysm embolization or clipping operation; or patients having other severe diseases. In all, 163 patients who met the inclusion criteria were included, of which 87 had embolization of the aneurysmal neck (neck group) and 75 had embolization of the entire aneurysm (aneurysm group). The general data of the patients are shown in Table 1. The Hunt–Hess and GCS[11] scores were used to evaluate the surgical risk and preoperative consciousness state of the patients, respectively.

2.2. Intervention

The method of embolization was as previously described.[10] In the case of embolization of the aneurysmal neck, the true lumen of the aneurysm underwent compact embolization, whereas the bleb formation underwent loose embolization (Fig. 1). However, in the case of embolization of the entire aneurysm, both the true lumen of the aneurysm and the bleb formation underwent compact embolization (Fig. 2).

2.3. Outcomes and follow-up

The digital subtraction angiography (DSA) evaluation criteria of the degree of embolization were: complete embolization without development in aneurysm and aneurysmal neck; residual aneurysmal neck with development in aneurysmal neck but not in aneurysm; partial embolization with development both in the aneurysmal neck and in the aneurysm; and relapse that was defined by the increased volume of the aneurysm or residual of aneurysmal neck found at DSA follow-up.[12] The surgery-related complications included cerebral infarction, aneurysm hemor-

Table 1

Clinical characteristics.

	Groups		
	Embolization of the aneurysmal neck (n = 87)	Embolization of the entire aneurysm (n = 76)	*P*
Sex			.566
Male	25 (28.74%)	25 (32.89%)	
Female	62 (71.26%)	51 (67.11%)	
Age	52.6 ± 9.8	50.1 ± 11.4	.128
Clinical manifestation			.457
SAH	68 (78.16%)	64 (84.21%)	
CH	3 (4.23%)	0	
Admission GCS			.397
11	1 (1.15%)	0.00	
12	1 (1.15%)	0.00	
13	5 (5.75%)	8 (10.53%)	
14	14 (16.09%)	16 (21.05%)	
15	66 (75.86%)	52 (68.42%)	
Admission Hunt–Hess			.243
I	72 (82.76%)	69 (90.79%)	
II	14 (16.09%)	7 (9.21%)	
III	1 (1.15%)	0	
Location of vascular lesions			.794
ACA	27 (31.03%)	22 (28.95%)	
MCA	5 (5.75%)	4 (5.26%)	
PCA	4 (4.60%)	6 (7.89%)	
ICA	50 (57.47%)	45 (59.21%)	
BA	1 (1.15%)	0	
Width of aneurysmal neck			.449
Wide neck	30 (34.48%)	22 (28.95%)	
Narrow neck	57 (65.52%)	54 (71.05%)	
Methods of treatment			.339
Double microcatheter	8 (9.20%)	6 (7.89%)	
Adjunctive therapy	20 (22.99%)	11 (14.47%)	
Embolization alone	59 (67.82%)	59 (77.63%)	
Number of coils*	6 (4.11)	7 (4.13)	<.001

ACA = anterior cerebral artery, BA = basilar artery, CH = cerebral hemorrhage, GCS = Glasgow Coma Scale, ICA = internal carotid artery, MCA = middle cerebral artery, PCA = posterior cerebral artery, SAH = subarachnoid hemorrhage.

* Number of coils used in a single patient. Presented as median (range).

Figure 1. A 57-year-old female complaining of sudden-onset headache showed SAH on head CT scan. (A) Cerebral DSA revealed an irregular-shaped aneurysm. (B) The true lumen of the aneurysm was completely occluded and the distal sac was loosely occluded. (C) The immediate angiography after embolization showed the complete occlusion of the aneurysm. (D) Follow-up angiography 14 months after embolization showed no residual or recurrent aneurysm. CT = computed tomography, DSA = digital subtraction angiography, SAH = subarachnoid hemorrhage.

rhage, cerebral vasospasm, and secondary hydrocephalus, both during the operation and postoperative hospital stay. Postoperative Glasgow Outcome Scale (GOS) (on the second day after the operation) and follow-up GOS (GOS score at the last follow-up) were used to evaluate the degree of rehabilitation of the patients after the operation.[13]

2.4. Statistical methods

Normally distributed continuous variables were presented as means ± standard deviation, and non-normally distributed variables were presented as median (range). The *t* test was used for normally distributed continuous variables; otherwise, the Mann–Whitney *U* test was used. Chi-square or Fisher exact test was performed for categorical variables. Logistic regression was used for multivariate analysis. $P < .05$ was considered to be statistically significant.

3. Results

3.1. Clinical characteristics

In all, 163 patients were included in this study, including 87 with embolization of the aneurysmal neck and 76 with embolization of the entire aneurysm. No differences were found in age, sex, clinical characteristics (SAH and cerebral hemorrhage), admission GCS score, admission Hunt–Hess score, location of vascular lesions, width of aneurysmal neck, and treatments between the 2 groups (all $P > .05$). Compared with the aneurysm group, the number of coils was smaller in the neck group ($P < .001$) (Table 1).

3.2. Clinical outcomes

The median follow-up time of the neck and of aneurysm groups was 17 months (9.62) and 16.5 months (9.54) ($P = .799$),

Figure 2. A 52-year-old male with headache, nausea, and vomiting showed SAH on head CT scan. (A) Cerebral DSA revealed an aneurysm with bleb formation. (B) Both the true lumen of the aneurysm and distal sac were completely occluded. (C) The immediate angiography after embolization showed the complete occlusion of the aneurysm. (D) Follow-up angiography 13 months after the operation showed no residual or recurrent aneurysm. CT = computed tomography, DSA = digital subtraction angiography, SAH = subarachnoid hemorrhage.

respectively. No differences were found in recurrence, postoperative GOS score, and GOS score at the last follow-up ($P > .05$). Compared with the aneurysm group, the surgery-related complications were less in the neck group ($P = .030$). Six cases of cerebral infarction occurred in both the neck (6.90%) and aneurysm (7.89%) groups. Two cases of bleeding aneurysm occurred in each group. Only 5 patients were combined with cerebral vasospasm (5.75%) in the neck group, whereas 13 such cases were found (17.11%) in the aneurysm group. No secondary edema of the brain was found in the neck group, but 2 cases were found in the aneurysm group (2.63%) (Table 2). After adjusting for age and sex, it was confirmed that the embolization method was an independent predictor of surgery-related complications (odds ratio [OR] 2.419, 95% confidence interval (CI) 1.111–5.269, $P = .026$) (Table 3).

4. Discussion

This study retrospectively analyzed the clinical data of patients who received different methods of aneurysm embolization from January 2014 to August 2015 to compare the prognostic impact between embolization of the aneurysmal neck and embolization of the entire aneurysm in patients with intracranial aneurysm with false bleb formation. The results showed that the number of coils was smaller in the neck group, consistently with the embolization approach. Moreover, the occurrence of postoperative complications was also lower in this group.

No differences were found in recurrence and GOS scores between the 2 groups during follow-up, suggesting that nonembolized blebs did not affect the prognosis of the patients. This also suggests that under the premise that the coils

Table 2

Clinical outcomes.

Factors	Groups		P
	Embolization of the aneurysmal neck (n = 87)	Embolization of the entire aneurysm (n = 76)	
Results of embolization			.922
Complete embolization	76 (87.36%)	66 (86.84%)	
Residual of aneurysmal neck	11 (12.74%)	10 (13.16%)	
Surgery-related complications	13 (14.94%)	22 (28.95%)	.030
Cerebral infarction	6 (6.90%)	6 (7.89%)	
Aneurysm bleeding	2 (2.30%)	2 (2.63%)	
Cerebrovascular spasms	5 (5.75%)	13 (17.11%)	
Secondary hydrocephalus	0	2 (2.63%)	
Results of DSA follow-up			.253
Without recurrence	85 (97.70%)	71 (93.42%)	
With recurrence	2 (2.30%)	5 (6.58%)	
Postoperative GOS			.940
3	3 (3.45%)	2 (2.63%)	
4	11 (12.64%)	9 (11.84%)	
5	73 (83.91%)	65 (85.53%)	
Latest follow-up GOS			.923
3	3 (3.45%)	2 (2.63%)	
4	9 (10.34%)	7 (9.21%)	
5	75 (86.21%)	67 (88.16%)	

DSA = digital subtraction angiography, GOS = Glasgow Outcome Scale.

Table 3

Multivariate analysis of the surgical complications.

	β	OR	95% CI		P
Sex (female vs male)	0.135	1.145	.493	2.658	.753
Age	0.014	1.014	.978	1.051	.446
Scope of embolization (entire vs aneurysmal neck)	0.884	2.419	1.111	5.269	.026

CI = confidence interval, OR = odds ratio.

were assured to be stable during embolization, the focus should be on densely packing the cavity of the true aneurysm and aneurysmal neck to reduce recurrence or the risk of rerupture. In addition, reducing the number of coils can shorten the surgical time, reduce the workload of health care staff, and decrease the costs.

Cerebral vasospasm is the most severe complication of aneurysmal SAH, which leads to insufficiency in local blood flow and oxygen supply and results in cerebral ischemia or cerebral infarction.[14] A recent multicenter study also confirmed that the clinical outcomes were worse for patients with aneurysmal SAH who suffered from cerebral vasospasm ($P = .039$).[15] The present study found that the frequency of cerebral vasospasm in the neck group was much lower than that in the aneurysm group (5.8% vs 17.1%). The reason could be that during embolization, the stimulation from guide wires and catheters on the cerebral vascular system could lead to cerebral vasospasm, but reducing the number of coils during the embolization of the aneurysmal neck decreased the stimulation on the cerebral vascular system, thereby reducing the occurrence of cerebral vasospasm. Therefore, embolization of the aneurysmal neck may improve the safety of aneurysm embolization. Cerebral vasospasm is 1 of the reasons for transient ischemic attack (TIA).[16] TIA can lead to cognitive impairment in older people.[17] During the follow-up, this study did not explore whether the reduction of cerebral vasospasm could improve the long-term GOS of the patients, but TIA caused by cerebral vasospasm could affect the cognitive function of the patients. However, it needs to be confirmed in the long term.

Secondary hydrocephalus is also 1 of the common complications of SAH. The occurrence rate of secondary hydrocephalus caused by the rupture of intracranial aneurysm is 7% to 48%,[18] and can result in cognitive dysfunction and neurological impairment. In the present study, 2 cases (2.6%) of secondary hydrocephalus occurred in the aneurysm group, but no case was found in the neck group. The possible reason could be the smaller number of coils and less subsequent cerebrovascular damage.

Studies have shown that aneurysm recurrence mainly occurred after 1 to 2 years of coil embolization, but re-rupture and bleeding might occur after an even longer time,[12,19] suggesting the necessity of long-term follow-up of these patients. Differences in cerebrovascular events were not observed in this retrospective study, which might be due to the small sample size, short follow-up time, and low occurrence rate of complications after endovascular embolization. In addition, the pathogenesis of various cerebrovascular complications is complex, influencing factors were varied, and cases were limited. Thus, it was difficult to perform an effective statistical analysis for the relationship between the occurrence of aneurysm and various indicators.

5. Conclusions

In summary, this study found that embolization of the aneurysmal neck could be efficacious for the treatment of

aneurysms with ruptured bleb. Moreover, reducing the number of coils effectively reduced the occurrence of postoperative complications, especially cerebral vasospasm. However, further evaluation of its efficacy and safety in prospective studies is required.

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