Safety and Efficacy of Endovascular Treatment for Ruptured Small Anterior Communicating Artery Aneurysms by Selecting an Appropriate Supporting Point and Microcatheter Tip Shaping Determined by the Course of the Blood Vessel

Takao Hashimoto, Tomoo Ohashi, Daisuke Watanabe, Hiroaki Namatame, Hirofumi Okada, Yujiro Tanaka, Norio Ichimasu, Daichi Kato, Takayoshi Hoshino, Osamu Utsugi, Michihiro Kohno

Abstract

Background and purpose: Endovascular treatment for ruptured cerebral aneurysms ≤ 3 mm in diameter is controversial because it is associated with a high risk of rupture during the procedure. The aim of this study is to evaluate safety and efficacy of endovascular treatment by selecting an appropriate supporting point and shaping of microcatheter in accordance with the blood vessel running for ruptured small anterior communicating aneurysms.

Material and Methods: Thirteen patients with ruptured small anterior communicating artery aneurysms who underwent endovascular treatment at our hospital or affiliated hospitals during the past 10 years were included. There were 3 men and 10 women, with a mean age of 69.8 (40-94) years. The mean major axis diameter was 2.5 (1.9-3.0) mm. All endovascular treatment procedures were performed by selecting an appropriate supporting point and shaping of microcatheter in accordance with the vessel running.

Technical success rate, immediate angiographical results, periprocedural complication within 30 day, and follow-up result were retrospectively assessed.

Results: Technical success rate was 100% (13/13). No periprocedural complication occurred. There were 4 cases of complete occlusion, 8 of neck remnant, and one of body filling. Patients were followed-up for a mean 57.3 (6-112) months, and no rebleeding or recurrent aneurysm was noted.

Conclusions: Endovascular treatment for ruptured small anterior communicating artery by making an appropriate supporting point and shaping of microcatheter in accordance with the blood vessel running seems be safe and efficacy to prevent rebleeding of aneurysm.

Key words: ruptured aneurysm, small, anterior communicating artery, embolization

INTRODUCTION

The International Subarachnoid Aneurysm Trial showed that endovascular treatment is effective to manage ruptured cerebral aneurysms [1]. However, the efficacy of this procedure to treat small aneurysms has not been evaluated. Endovascular treatment of small cerebral aneurysms is technically challenging, and reportedly, the incidence of complications is high [2, 3]. However, studies have shown that appropriate
Table 1. Summary of patients with ruptured small anterior communicating artery aneurysms

| Case | Age | Sex | H&K Grade | Fisher Group | Size (mm) longer axis | Projection of dome | Embolization ratio | GOS |
|------|-----|-----|-----------|--------------|----------------------|--------------------|-------------------|-----|
| 1    | 75  | F   | III       | 2            | 2.3                  | superior           | CO                | GR  |
| 2    | 73  | F   | IV        | 4            | 2.0                  | inferior           | BF                | SD  |
| 3    | 60  | M   | II        | 3            | 3.0                  | anterior           | CO                | GR  |
| 4    | 40  | M   | III       | 3            | 3.0                  | anterior           | CO                | GR  |
| 5    | 53  | F   | III       | 3            | 2.9                  | inferior           | NR                | GR  |
| 6    | 47  | F   | IV        | 3            | 3.0                  | superior           | NR                | SD  |
| 7    | 81  | F   | V         | 4            | 1.9                  | anterior           | NR                | MD  |
| 8    | 94  | F   | III       | 3            | 3.0                  | superior           | NR                | SD  |
| 9    | 82  | F   | III       | 4            | 2.5                  | inferior           | NR                | MD  |
| 10   | 50  | M   | II        | 3            | 2.0                  | inferior           | CO                | GR  |
| 11   | 83  | F   | IV        | 3            | 2.5                  | anterior           | NR                | MD  |
| 12   | 82  | F   | II        | 3            | 3.0                  | superior           | NR                | D   |
| 13   | 88  | F   | III       | 4            | 2.0                  | superior           | NR                | SD  |

H&K: Hunt & Kosnik, CO: complete occlusion, NR: neck remnant, BF: body filling
GOS: Glasgow outcome scale, GR: good recovery, MD: moderate disability,
SD: severe disability, D: death

Figure 1. How to shape the microcatheter. The microcatheter should be adjusted based on the direction of aneurysm projection. a: By carefully steam-shaping the microcatheter according to the location of the supporting point (allow), it does not come off aneurysm neck. b: If necessary, it should also be shaped securely according to the front-running blood vessel, has two supporting points (arrow) which will increase microcatheter stability.

selection of devices and careful instrumentation ensure successful treatment without major complications [4, 5]. The treatment of anterior communicating aneurysms with manipulation of microcatheters is technically more challenging than the treatment of other types of aneurysms[6, 7], and catheter manipulation is particularly difficult in patients with small aneurysms. To date, endovascular treatment has not been reported to treat small ruptured anterior communicating artery aneurysms. We report the technique, treatment outcomes, and limitations of this approach for the management of anterior communicating aneurysms measuring ≤3 mm in diameter.

MATERIALS AND METHODS

Patients

Endovascular treatment for ruptured cerebral aneurysms was performed in 326 patients at our hospital or affiliated hospitals over the past 10 years. Among these 326 patients, 97 were diagnosed with anterior communicating artery aneurysms, and 13 consecutive patients among these 97 presented with aneurysms measuring ≤3 mm in diameter. The technical success rate, immediate post-treatment angiography results based on Raymond classification [8], periprocedural (30-day) complications, and follow-up results were retrospectively assessed by 2 neurosurgeons (not interventionalists).

This study included 3 men and 10 women, with a mean age of 69.8 (range 40-94) years. The preoperative Hunt and Kosnik grade was II in 3 patients, III in 6 patients, IV in 3 patients, and V in 1 patient. The mean major axis aneurysm diameter was 2.5 (range 1.9-3.0) mm. The aneurysms projected superiorly in 5, inferiorly in 4, and anteriorly in 4 patients (Table 1).

Endovascular procedure

The endovascular procedure to treat cerebral aneurysms was performed by interventionalists in >100 patients in this study.
Figure 1. A 75-year-old woman with a 1-week history of headache. A diagnosis of subarachnoid hemorrhage of Hunt and Kosnik grade III and Fisher group 2 was made. A: Lt ICAG A-P view. Vasospasm is observed in the Lt A1, 2 and Lt M1, 2 (white arrows). B: Lt ICAG LAO 45 view. A superiorly projecting aneurysm measuring 2.3×1.7 mm is seen (arrow head). C: The microcatheter was formed into an S shape in accordance with the front-running blood vessel. The microcatheter tip was positioned at the aneurysm neck, with two supporting points (black arrows) on the superior wall of the terminal part of the internal carotid artery and the inferior wall of the distal part of A1. D, E: Complete occlusion was achieved with two coils, i.e., ED coil ExtraSoft 1.5×3 and 1.5×1. The GOS 3 months later indicated GR.

A femoral artery approach was used under general anesthesia. After puncturing the femoral artery, heparin was infused intravenously (2,000-3,000 U) to maintain an activated clotting time of >200 s. The procedure was performed using the 6F ENVOY (Codman, USA) guiding catheter, the Excel- sior SL-10 (Stryker, USA) microcatheter, and the GT 12 90° (MicroVention, USA) microguidewire. All coils used were soft coils, including the GDC-10 UltraSoft and the Target NANO (Stryker, USA), the ED coil ExtraSoft (Kaneka Medix, Japan), the DeltaPlush (Codman, USA), and the AXIUM (Codvidien, USA). The guiding catheter was inserted as much distally as was possible to ensure easy maneuverability of the microcatheter. Steam-shaping of the microcatheter tip was performed using 3-dimensional rotational angiography. When the microcatheter is pushed back, it strikes the contralateral arterial wall and serves as a supporting point. The shape was determined by the anatomical course of the A1 segment of the anterior cerebral artery to achieve stable localization of the microcatheter tip near the aneurysm neck (Figure 1). The microcatheter tip was guided close to the aneurysm neck and not into the aneurysm. Small-sized soft coils were chosen and were gradually inserted while reducing catheter tension.

RESULTS

Embolization was completed using a simple technique without major complications in any patient. Complete occlusion was observed in 4, neck remnant in 8, and body filling in 1 case. Notably, the ratio of the neck remnant was high. No periprocedural (30-day) complications were observed. The Glasgow outcome scale recorded 3 months postoperatively showed the following results: 5 patients showed good recovery, 3 patients showed moderate disability, 4 patients showed severe disability (SD), and 1 patient died (D) (Table 1). Groups SD and D consisted of elderly patients and serious cases. All patients were followed-up for 6-112 (mean 57.3) months, and no rebleeding or recurrent aneurysm was observed.

Microcatheter maneuverability is technically demanding in patients with superiorly projecting aneurysms. Therefore, shaping the microcatheter tip based on the anatomical course of the internal carotid artery to the A1 segment and projection of the aneurysm was needed (Figure 2). Shaping...
A 60-year-old man was rushed to the emergency department because of a headache. He was diagnosed with subarachnoid hemorrhage of Hunt and Kosnik grade II and Fisher group 3. a: Lt ICAG A-P view. An anteriorly projecting aneurysm is seen at the Lt A1-2 junction. b: Lt ICAG RAO 35, CAU 45 view. An aneurysm measuring 3.0×2.8 mm is seen (arrow head). c: The A-P view shows that a microcatheter could be inserted straight into the aneurysm, but the view from a working angle shows misalignment of A1 and the axis of the aneurysm. Therefore, the microcatheter was shaped to make a 45° angle and guided to put the supporting point (arrow) on the inferior wall in front of the aneurysm. d, e: Complete occlusion was achieved with three coils, i.e., GDC 10 Ultra Soft 2.5×4 and ED coil Extra Soft 2×3 and 1.5×2. The GOS rating at 3 months indicated GR.

the microcatheter tip based on the supporting points was required in cases where the aneurysmal axis was not aligned with the A1 segment (Figure 3). The microcatheter tip was positioned at the aneurysm neck and was stabilized by steam-shaping. The use of flexible and undersized coils contributed to the successful treatment in these patients.

DISCUSSION

Endovascular treatment is used as widely as surgical clipping for ruptured cerebral aneurysms and has shown good efficacy in the management of this condition [1]. However, the role of endovascular treatment is controversial for the management of small aneurysms measuring ≤3 mm in diameter owing to the difficulty with microcatheter maneuverability and a high risk of intraprocedural aneurysm rupture [9, 10].

The risk of intraprocedural aneurysm rupture is higher for aneurysms measuring ≤3 mm in maximum diameter. The incidence rate of intraprocedural rupture of very small aneurysms was 2-fold higher (7.7%) than that of large aneurysms in a study performed by Van Rooij et al. [11], and was 5-fold higher (11.7%) in a study performed by Nguyen et al. [3]. A meta-analysis showed that the intraprocedural rupture rate was 8.3%, with a permanent morbidity rate of 1.4% and a mortality rate of 2.4% [10].

Lim et al. reported the structural limitations of 8 types of microcatheters and 3 types of detachable coils. The detachment zone is known to be stiff, and the authors observed that the length of the zone was approximately 0.5-0.8 mm and that the stiff detachment zone protruded approximately 0.2-1 mm from the microcatheter tip when the detachment point was adjusted under fluoroscopic visualization. The distance between the distal end of the microcatheter distal markers and the detachment zone of the coil was approximately 1.2-2.8 mm. The microcatheter should be maneuvered carefully and should be placed near the aneurysm neck to prevent intraprocedural rupture of very small aneurysms. The microcatheter should be cautiously maneuvered and drawn gradually during alignment of the coil with the detaching part to avoid injury by the stiff detachment zone. A thorough understanding of the structure of each coil is
Embolization of small aneurysms is often completed using a few coils, and small coils effectively prevent intra-procedural rupture. Therefore, loose packing of the coils into the aneurysm may be often. A study reported by Hwang et al., showed that coil embolization of 43 aneurysms measuring ≤ 3 mm in diameter achieved total occlusion in 16 (37%), subtotal occlusion in 22 (51%), and partial occlusion in 5 (12%) cases. After a follow-up of >6 months, 9 (41%) of the 22 aneurysms that showed subtotal/partial occlusion were stable and unchanged and 10 (45%) showed complete occlusion. Only 1 aneurysm required re-treatment. Endovascular treatment of small aneurysms is reported to be associated with a low rate of long-term recanalization, and even loose packing of the aneurysm achieves progressive occlusion, eventually yielding favorable results [13]. A few studies have reported no association between loose packing and recanalization [9, 14, 15].

Our case series was limited to anterior communicating artery aneurysms. Complete occlusion was observed in 4 (31%) cases, neck remnant in 8 (61%) cases, and body filling in 1 (8%) case. Rebleeding and recurrence did not occur, and long-term outcomes were favorable. These results concur with previous studies describing small aneurysms.

Endovascular treatment for anterior communicating artery aneurysms is reportedly superior to clipping with respect to the occurrence of higher cortical dysfunction [16, 17, 18]. Clipping of posteriorly projecting anterior communicating artery aneurysms is associated with an increased risk of serious ischemic complications; therefore, endovascular treatment is preferred in such cases [6]. However, microcatheter maneuverability tends to be difficult because the anterior cerebral artery shows a markedly curved, angular, and meandering course, and runs steeply as a branch originating from the internal carotid artery [6, 7]. In a study reported by Moret et al., the microcatheter could not be guided into the aneurysm during endovascular treatment in 9% of anterior communicating aneurysms because of the markedly tortuous and meandering course of the artery [7]. In our case series, the guiding catheter was inserted as much distally as was possible to improve maneuverability of the microcatheter. Additionally, the microcatheter was shaped to correspond to the anatomical contour of the anterior cerebral artery to achieve stability of the microcatheter. Stable positioning of the microcatheter tip near the aneurysm neck and not within the aneurysm reduces the stress on the aneurysm during coil insertion. Additionally, this approach prevents issues associated with the detachment zone. Thus, microcatheter tip shaping is important to achieve stability of the device. Thus, intraprocedural rupture was avoided, and we observed favorable results in our study.

LIMITATIONS

The retrospective study design and the small number of patients included serve as drawbacks of this study. However, endovascular treatment for only ruptured small anterior communicating artery aneurysms has not been reported. Large-scale studies are required in the future to gain a better understanding in this context.

CONCLUSIONS

Endovascular treatment using an appropriate supporting point and microcatheter tip shaping (determined by the anatomical course of the vessel) is safe and effective to treat ruptured small anterior communicating artery aneurysms and prevents rebleeding.

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical Approval: Ethical approval was not required because of the retrospective study design.

Informed Consent: Informed consent was obtained from all patients involved in this study.

References

1. Molyneux AJ, Kerr RS, Yu LM, Clarke M, Sneade M, Yarnold JA, 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 randomised comparison of effects on survival, dependency, seizures, rebleeding, subgroups, and aneurysm occlusion. Lancet. 2005; 366: 809-817.
2. Sluzewski M, Bosch JA, van Rooij WJ, Nijsen PC, Wijnalda D. Rupture of intracranial aneurysms during treatment with Guglielmi detachable coils: incidence, outcome, and risk factors. J Neurosurg. 2001; 94: 238-240.
3. Nguyen TN, Raymond J, Guilbert F, Roy D, Bérubé MD, Mahmoud M, et al. Association of endovascular therapy of very small ruptured aneurysms with higher rates of procedure-related rupture. J Neurosurg. 2008; 108: 1088-1092.
4. Tone O, Tomita H, Tamaki M, Akimoto H, Shigeta K, Sampetrean O, et al. Coil embolization for ruptured cerebral aneurysms of 2x3 mm diameter. Interv Neuroradiol. 2006; 12: 97-100.
5. Suzuki S, Kurata A, Ohmomo T, Sagiuchi T, Niki J, Yamada M, et al. Endovascular surgery for very small ruptured intracranial aneurysms. Technical note. J Neurosurg. 2006; 105: 777-780.
6. Proust F, Debono B, Hannequin D, Gerardin E, Clavier E, Langlois O, et al. Treatment of anterior communicating artery aneurysms : complementary aspects of microsurgical and endovascular procedures. J Neurosurg. 2003; 99: 3-14.
7. Moret J, Pierot L, Boulin A, Castaings L, Rey A. Endovascular treatment of anterior communicating artery aneurysms using Guglielmi detachable coils. Neuroradiology. 1996; 38: 800-805.
8. Raymond J, Roy D. Safety and efficacy of endovascular treatment of acutely ruptured aneurysms. Neurosurgery. 1997; 41: 1235-1245.
9. Kwon HJ, Park JB, Kwon Y, Ahn JS, Kwun BD. Long-term clinical and radiologic results of small cerebral aneurysms embolized with 1 or 2 detachable coils. Surg Neurol. 2006; 66: 507-512.
10. Brinjikji W, Lanzino G, Cloft HJ, Rabinstein A, Kallmes DF. Endovascular treatment of very small (3 mm or smaller) intracranial aneurysms: report of a consecutive series and a meta-analysis. Stroke. 2010; 41: 116-121.
11. van Rooij WJ, Keeren GJ, Peluso JP, Sluzewski M. Clinical and angiographic results of coiling of 196 very small (< or=3 mm) intracranial aneurysms. Am J Neuroradiol. 2009; 30: 835-839.
12. Lim YC, Kim BM, Shin YS, Kim SY, Chung J. Structural limitations of currently available microcatheters and coils for endovascular coiling of very small aneurysms. Neuroradiology. 2008; 50: 423-427.
13. Hwang JH, Roh HG, Chun YI, Kang HS, Choi JW, Moon WJ, et al. Endovascular coil embolization of very small intracranial aneurysms. Neuroradiology. 2011; 53: 349-357.
14. Goddard JK, Moran CJ, Cross DT 3rd, Derdeyn CP. Absent relationship between the coil-embolization ratio in small aneurysms treated with a single detachable coil and outcomes. Am J Neuroradiol. 2005; 26: 1916-1920.
15. Gupta V, Chugh M, Jha AN, Walia BS, Vaishya S. Coil embolization of very small (2 mm or smaller) berry aneurysms: feasibility and technical issues. Am J Neuroradiol. 2009; 30: 308-314.
16. Tidswell P, Dias PS, Sagar HJ, Mayes AR, Battersby RD. Cognitive outcome after aneurysm rupture: relationship to aneurysm size and perioperative complications. Neurology. 1995; 45: 875-882.
17. Chan A, Ho S, Poon WS. Neuropsychological sequelae of patients treated with microsurgical clipping or endovascular embolization for anterior communicating artery aneurysm. Eur Neurol. 2002; 47: 37-44.
18. Fontanella M, Perozzo P, Ursone R, Garbossa D, Bergui M. Neuropsychological assessment after microsurgical clipping or endovascular treatment for anterior communicating artery aneurysm. Acta Neurochir (Wien). 2003; 145: 867-872.