Endovascular Treatment of Cerebral Aneurysms During Acute (<72 Hours)
Subarachnoid Hemorrhage

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Summary

Objective: To evaluate the safety and efficacy of endovascular embolization of ruptured cerebral aneurysms during acute stage of subarachnoid hemorrhage (SAH).

Methods: Results in 40 consecutive patients (14 men, 26 women; mean age, 50.9 years; range, 34–72 years) with acutely ruptured cerebral aneurysms who were treated with endovascular coil embolization were evaluated. The mean length of angiographic follow-up was 8.8 months (range, 3–18 months).

Results: Forty-four aneurysms were treated endovascularly in 40 patients. The technical success rate was 97.7% (43 of 44). There were 2 (4.5%) cases of intraprocedural bleeding, which caused 1 death. There was 1 (2.5%) case of rebleeding causing death within 24 hours after endovascular embolization, and clinical outcome was good for 92.5% patients had Glasgow Outcome Scale scores of 4 or 5 at the end of the study period.

Conclusion: Endovascular coil embolization is a safe method for cerebral aneurysms that are difficult to treat surgically during acute SAH. Intraprocedural bleeding is the main adverse event associated with this treatment. Delayed rebleeding is possible after endovascular treatment.

Key words: Subarachnoid hemorrhage, cerebral aneurysm, acute, embolization

Akut Subaraknoid Kanama Sırasında (<72 saat) Serebral Anevrizmaların Endovasküler Tedavisi

Özet

Amaç: Kanamış serebral anevrizmaların subarakanoid kanamanın (SAK) akut devresinde embolizasyonunun etkinliği ve güvenirlüğünün değerlendirilmesi.

Yöntem: Kanamış anevrizmaları nedeniyle akut evrede endovasküler embolizasyon ile tedavi edilen 40 ayrı hastadaki (14 erkek, 26 kadın; ortalama yaştı 50,9 yıl; yaş aralığı 34-72 yaş) sonuçlar değerlendirilmeye alındı. Angiografik kontrol ile ortalama izleme süresi 8,8 aydı (izlem aralığı 3-18 ay). Sonuçlar: Endovasküler olarak 40 hastadaki 44 anevrizma tedavi edildi. Teknik başarı yüzdesi 97,7 oldu (44 girişimde 43). İşlem sırasında 2 olguda (%4,5) kanama gelişti ve bir olgu kaybetti. Endovasküler embolizasyondan 24 saat sonra gelişen yeniden kanama sonucu 1 olgu (%2,5) ölümne neden oldu ve çalışma sonucu itibari ile klinik sonuç geride kalan hastalarda (%92,5) Glasgow Sonuç Derecelendirmesi ile 4 ila 5 arasında olmak üzere çok iyi oldu.
INTRODUCTION

Since the publication of the results of the International Subarachnoid Aneurysm Trial (15), endovascular treatment has been proved to be as effective as surgical clipping in the prevention of rebleeding of ruptured aneurysm. However, the safety of the procedure during acute subarachnoid hemorrhage (SAH) is still unclear (1,2,4,6,10,11,14,20). In this retrospective study, we evaluated the safety and efficacy of endovascular embolization of ruptured cerebral aneurysms during acute stage of SAH and midterm follow-up results.

MATERIAL AND METHODS

Our study group included all 40 consecutive patients in whom endovascular coil embolization was used in the acute stage of SAH in Beijing Tiantan Hospital (Capital Medical University) in Beijing between February 2009 and October 2010. The group included 5 patients (12.5%) in whom stent placement was performed and 3 patients (7.5%) in whom balloon-assisted embolization was used. There were 14 men and 26 women with a mean age of 50.9 years (range, 34–72 years). There were 27 patients of Hunt-Hess grade I, 3 of grade II, 8 of grade III and 2 of grade IV (7).

The best and most feasible form of treatment (endovascular treatment or surgical clipping) was selected on a patient-by-patient basis in consensus between a neurosurgeon and an interventional neuroradiologist and depended on the clinical condition and comorbidities of the patient, the location and morphology of the ruptured aneurysm, the severity of the bleeding and possible parenchymal hematomas, and the clinical experience of the attending neurosurgeon and interventional neuroradiologist.

Endovascular treatment was usually favored over surgical clipping in older patients and in those in poor condition; in patients in very poor clinical condition (Hunt and Hess grade V), active endovascular treatment was delayed until signs of improvement were noted. When possible, coiling without the protection of a stent (ie, balloon-assisted coiling) was considered or attempted first. Surgical treatment was usually preferred for anterior circulation aneurysms, when the patient had a large parenchymal hematoma.

Postprocedural angiographic occlusion rate, technical success, follow-up images, and complications were independently evaluated by two neuroradiologists (Lv X, Lv M, with 5–8 years of experience in neurointervention). All patient records and follow-up angiograms for the patients in this series were evaluated in October 2010. The primary occlusion rate was classified as “total occlusion” (>95% occlusion rate), “neck remnant” (>80% occlusion rate with contrast medium filling only the neck area of the aneurysm), “partial occlusion” (distal filling of contrast medium in the aneurysm regardless of the occlusion rate), or “none” (unsuccessful coiling). Angiographic occlusion was considered to be adequate if either complete occlusion of the aneurysm or a small neck remnant with over 80% occlusion was achieved. The preoperative clinical condition of the patients was evaluated by using the Hunt and Hess classification, and the clinical outcome was measured by using the Glasgow Outcome Scale (8).

Aneurysm Characteristics
Forty-four aneurysms were treated in these 40 patients. Two-thirds of the patients were women, 7 aneurysms were located in the posterior circulation and 37 aneurysms were located in the anterior circulation, and 4 patients had multiple aneurysms. Six (13.6%) of the ruptured aneurysms were considered to be dissecting and 38 were saccular. All of the aneurysms had a neck width of more than 4mm or a dome-to-neck ratio of 1.5 or less. None of the ruptured aneurysms had been previously treated.

**Embolization Procedure**

Selective angiograms and three-dimensional angiograms were evaluated in detail before the embolization procedure. Diagnostic angiography and endovascular treatment of the aneurysm was performed within 72 hours for all of the patients. Unilateral femoral access was used in all interventions. A 90-cm guiding catheter (Envoy, Cordis, Fremont, Calif) was inserted into the relevant carotid or vertebral artery. A microcatheter (Echelon-10; M.T.I.-ev3, Fremont, Calif) was navigated into the aneurysm with the help of a standard (180-cm) micro-guidewire. Coil embolization was performed with the microcatheter placed and aneurysms were packed with either Microplex coils (Microvention) or GDC coils (Cordis) or with a combination of the two. Seven (15.9%) aneurysms were treated with stent, the microcatheter was first positioned in the aneurysm in 3 cases, and the stent was then deployed. In 4 cases, the microcatheter was navigated into the aneurismal sac through the stent interstices. Three aneurysms were treated with balloon-assisted “remodeling” technique.

**Medication**

All of the patients were treated with heparin during the procedure. Typically, heparin administration, with the aim of achieving measured activated clotting times of 220–250 seconds, was initiated after the first coil or coils had been deployed and the ruptured aneurysm was considered to be stable. Combination therapy with clopidogrel (a loading dose of 300 mg, and 75 mg daily for 1–3 months thereafter) and aspirin (a loading dose of 300mg, and 100 mg daily for 1–6 months) was started 2 hours before the procedure in all patients.

**Follow-up**

The mean duration of angiographic follow-up was 8.8 months (range, 3–18 months). The first angiographic control study, performed with conventional angiography, was usually performed at 3–18 months, depending on the primary result of the endovascular treatment.

**RESULTS**

Total 44 aneurysms were treated in 40 patients. The mean size of aneurysms was 5.6 mm (range, 2.5 to 12 mm). The technical success rate was 97.7% (43 of 44), and an adequate primary angiographic result was achieved in 41 (93.2%) aneurysms of the 44 aneurysms.

**Coil embolization**

Thirty-seven aneurysms were coiled. The locations were anterior cerebral artery (n=4), anterior communicating artery (Acoma) (n=5), posterior communicating artery (Pcoma) (n=22), basilar tip (n=1), posterior cerebral artery (n=2), middle cerebral artery (MCA) (n=1), internal carotid artery (n=2). Three Pcoma aneurysms were treated with balloon-assisted “remodeling” technique. Complete obliteration was achieved in 32 (86.5%) aneurysms, subtotal obliteration (>90%) was achieved in 3 with 2 treated more than 70%. Perioperative aneurysm perforation was detected in 2 (5.3%) of 38 patients. One patient with a M2 aneurysm of MCA experienced full recovery, while the other, who had a Pcoma anerysm, died immediately. There was 1 case (2.6%) of early lethal rebleeding, which ensued after complete occlusion of an Acoma aneurysm.
**Stent assisted technique**

Stent placement was used for 7 aneurysms in 6 patients. The locations of these aneurysms were Pcoma (n=1), vertebral artery (n=4), internal carotid artery (n=2). Five aneurysms were embolized completely with stent-assisted coiling with 2 VA aneurysms were treated with stent alone. There was no complication and rebleeding in cases treated by stent placement.

**Clinical Outcome**

The total mortality rate was 5% (2 of 40). After the primary phase, however, the risk of mortality and morbidity considerably decreased, as most of the patients made good recoveries. Thirty-seven (92.5%) of the 40 patients had a Glasgow Outcome Scale score of 4 or 5 at the end of the study period.

*Figure 1:* A, DSA 3-dimensional reformation shows a wide-necked (dome height, 5 mm; neck width, 4 mm) aneurysm in the right Pcoma. Note the secondary pouch of the aneurysm. B, fluoroscopic image obtained during the procedure shows that a Hyperform balloon has been inflated across the neck of the aneurysm. C, DSA image obtained after the procedure shows that the aneurysm is almost completely occluded with coils. Only a very small neck remnant is seen in the left margin of the aneurysm.
The present study describes the experience to date with coil embolization during the acute phase of SAH. Early treatment of ruptured aneurysms is recommended because of the high risk of subsequent rerupture\(^9,12\). We did not encounter the event of thromboembolic complications in our series. However, we do not know if this is attributable to anticoagulation treatment and the flexibility and relatively low radial force of the Neuroform or Enterprise stents, to minor endothelial injury, or to the properties of the cerebral vasculature. Acute SAH is a hypercoagulable state in which the tendency for thrombosis is high and necessitates anticoagulation and antiplatelet therapy during and after the procedure. However, we encountered an intraprocedural hemorrhagic rate of 4.5%, which is slightly higher than was reported in previous series of stent-assisted coil embolization of wide-necked cerebral aneurysms. Katsaridis et al\(^{10}\) reported a series of 44 patients, of which 33 were treated in the acute phase after SAH. They encountered no serious hemorrhagic complications and only one mild thromboembolic complication, although all embolizations were performed without pretreatment with antiplatelet drugs. Fifty-two of the 54 aneurysms included in that study were reported to be coiled, with a total occlusion rate in 51 (94%) aneurysms. In an article, Norbäck et al\(^{17}\) described a series of 239 patients treated with endovascular embolization in the acute stage (within 3 weeks of rupture) during a 4 year period. Complete occlusion was achieved in 126 patients (53%). Procedural complications occurred in 39 patients (16%). Favourable clinical outcome was observed in 57%, severe disability in 28% and poor outcome in 14% of the patients.

Aneurysm characteristics, primary angiographic results, and even the clinical condition of the patients at admission did...
not significantly correlate with the clinical outcome of the patients treated with stent-assisted coiling during acute stage of SAH\(^2\). Balloon-assisted embolization is a well-documented treatment option for wide-necked cerebral aneurysms\(^{3,13,16,21}\) and is also often a viable treatment option during acute SAH. Balloon-assisted embolization was used in 3 Pcoma aneurysms in our patients. But in some aneurysms, such as wide-necked and dissecting aneurysms, stent placement with or without coiling is a necessary option. In nonruptured aneurysms, deployment of a stent generally necessitates pre- and postprocedural treatment with clopidogrel and aspirin; however, these drugs are contraindicated in cases of acute SAH and a nonsecured aneurysm. The perioperative antiplatelet therapy necessitated by stent-assisted embolization may aggravate the clinical consequences that arise in the event of aneurysm perforation, which was not observed in our 7 patients treated by stent placement. A loading dose of 300mg of aspirin and clopidogrel have been shown to decrease the rate of thromboembolic events without an increase in the intraoperative bleeding rate and is advocated in the endovascular treatment of aneurysms, including during acute SAH\(^{19}\).

Early rebleeding after coil embolization has seldom been reported\(^5\). We experienced early rehemorrhage in 1 patient of ruptured small Acoma aneurysm of complete treatment with coil-embolization initially. There was no evidence of intraprocedural rupture and moreover complete occlusion with only two coils was obtained. Recently, Pyun et al.\(^{18}\) also reported 2 cases of early rebleeding after coil occlusion of small ruptured Acoma aneurysms. Extrusion of coil loop beyond the aneurysmal wall has been observed in their cases and they concluded that obvious extrusion of coil loop beyond the aneurysmal wall can be a sign of necessity for early follow-up study including plain radiography to track the change in the presumed extruded coil loop.

CONCLUSION

According to our results, endovascular techniques are feasible treatment option for ruptured cerebral aneurysms that are difficult to treat with surgical clipping during acute stage of SAH.

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