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Stent-assisted coiling embolization of middle cerebral artery trifurcation wide-necked aneurysms

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Abstract. – OBJECTIVE: The aim of this study was to examine the effects of stent-assisted coiling embolization of middle cerebral artery (MCA) trifurcation wide-necked aneurysms in clinical practice.

PATIENTS AND METHODS: 57 patients with MCA trifurcation wide-necked aneurysms underwent stent-assisted coiling embolization using a solitaire AB stent. All 57 patients completed the surgery successfully. Embolization efficacy was graded according to the modified Raymond scale.

RESULTS: There were 52 cases of complete embolization, 4 cases of residual aneurysm neck, and 1 case of residual aneurysm body. 50 patients participated in a 6-36-month follow-up. There has not been observed any aneurysm rupture and hemorrhage. 50 patients received digital subtraction angiography (DSA) re-examination; 46 patients presenting complete embolization had no aneurysm relapses; 3 patients had residual aneurysm neck demonstrated; 1 patient had no aneurysm neck and others 2 were in stable condition. Finally, the patient with residual aneurysm body showed no sign during follow-up reexamination.

CONCLUSIONS: Stent-assisted coiling embolization of intracranial wide-necked aneurysms using the solitaire AB stent was safe and effective.

Key Words:
Aneurysm, Middle cerebral artery trifurcation, Embolization, Stent.

Introduction

The middle cerebral artery (MCA) aneurysm is a common type of intracranial aneurysm (20-30%), with approximately 85% of MCA aneurysms occurring in the MCA trifurcation[1]. There are some difficulties in endovascular treatment for MCA aneurysms with wide neck and complicated shape. The complication rate and recurrence rate are relatively very higher. However, since the superficial anatomy of the aneurysm, many hospitals still use craniotomy clipping as the preferred treatment. Dotter and Judkins[2] first proposed the concept of endovascular stent in 1964, and Dotter tested the experimental applications in 1969. In 1999, Regli et al[3] reported a comparative study of endovascular treatment and craniotomy clipping for the treatment of MCA aneurysms. The stent was used to reconstruct the tumor-carrying artery, and fixed with a spring ring in the aneurysm without protrusion into the parent artery or shift. Thus, the coverage rate of the aneurysm and the rate of dense embolization can be significantly improved. In recent years, the technique has been applied to the treatment of extracranial carotid artery disease[4].

Patients and Methods

Patients Information

Between January 2012 and June 2015, 57 patients with wide-necked MCA trifurcation aneurysms were treated with stent-assisted coiling. This study included 57 patients (26 males and 31 females) aged 34-75 years. This study was approved by the Ethical Committee of Anhui Provincial Hospital (Hefei, Anhui, China) and all patients involved signed informed consent. There were 50 cases of ruptured and 7 cases of non-ruptured aneurysms. All diagnoses were confirmed by digital subtraction angiography (DSA). Hunt-Hess grades before surgery were as follows: 7 cases of Grade I, 32 cases of Grade II, and 11 cases of Grade III. Fisher grades of patients with ruptured aneurysms as determined by CT were as follows: 11 cases of Grade I, 27 cases of Grade II, and 12 cases of Grade III. All aneurysms were wide-necked aneurysms, including 24 cases of absolute wide-necked aneurysms (aneurysm width ≥

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4 mm) and 33 cases of relative wide-necked aneurysms (neck-to-body ratio > 1/2). There were 40 cases of small aneurysms (< 10 mm) and 17 cases of large aneurysms (10-20 mm).

Preoperative Preparations

Based on the intraoperative DSA results, the Solitaire AB stent-assisted coiling method was chosen. For patients with non-ruptured aneurysms, antiplatelet therapy (oral aspirin 300 mg/d and clopidogrel 75 mg/d) was provided 3 days before surgery. For emergency cases with ruptured aneurysms, oral aspirin 300 mg/d and clopidogrel 75 mg/d were administrated 2 h before surgery.

Interventional Therapy

The patients received tracheal intubation for anesthesia. Femoral artery puncture was performed by the Seldinger technique. After indwelling of the 6 F arterial sheath, systemic heparinization was performed. Selective cerebral angiography was performed first, followed by rotational angiography and 3D reconstruction for the internal carotid artery on the side of the aneurysm. The 6 F guiding catheter was inserted into the petrous internal carotid artery. We analyzed the relationship between aneurysms and tumor-bearing aneurysms based on the imaging data and accordingly selected craniotomy or interventional therapy. For all wide-necked MCA trifurcation aneurysms in this group, interventional therapy was performed. The best working angle, permitting the visualization of the aneurysm neck and the tumor-bearing aneurysm, was selected based on 3D images. The diameter and size of the aneurysms requiring stenting were measured, following which the appropriate stent and coil were selected. The micro-catheter was molded based on the shape of the tumor-bearing aneurysm and the aneurysm neck, as well as the anatomic relationship between the aneurysm neck and the MCA, and the ratio of the neck width to the aneurysm body width. The stent type was selected. Using the best working angle, the stent catheter was indwelled in the distal aneurysm-bearing artery; then the micro-catheter was indwelled into the cavity of the aneurysm. The stent was delivered to the fore-end of the stent catheter and not detached. In this study, the Solitaire AB stent (EV3, 4 mm/15 mm and 4 mm/20 mm), electrolytic detachment coil (Microvention), and mechanical detachment coil (EV3) were used. The type of coil was selected based on the shape of the aneurysm. The diameter of the first coil was made slightly larger than the aneurysm diameter to allow the coil to protrude into the aneurysm-bearing artery; the coil was pushed into the aneurysm neck by post-stent placement. Coils of appropriate sizes were filled based on the remaining space in the aneurysm to achieve complete embolization. Finally, the stent was completely detached and the micro-catheter was removed. Intra-operative imaging showed the embolization of the aneurysm, allowing for identification of thrombus presence.

Postoperative Treatment

Routine post-operative treatment was provided to prevent vasospasm, dilation, and coagulation. After surgery, the patients were orally administrated with clopidogrel 75 mg/d for 4-6 weeks and aspirin 300 mg/d for 6 months. Symptomatic treatment was provided for common complications of subarachnoid hemorrhaging.

Statistical Analysis

All the data were expressed as mean ± SD. Results were evaluated by one-way ANOVA using SPSS13.0 software (SPSS Inc., Chicago, IL, USA) and followed by Dunnett's *t*-test. A value of $p<0.05$ was considered as statistically significant.

Results

All 57 patients underwent successful stent-assisted coiling without any complications. Immediate imaging after embolization was graded according to the modified Raymond scale: 52 cases of complete embolization, 4 cases of residual aneurysm neck, and 1 case of residual aneurysm body were identified. 50 patients underwent a follow-up period of 6-36 months, with no aneurysm rupture and hemorrhage observed. During this, all 50 patients received a DSA reexamination; 46 patients originally presenting complete embolization had no relapse of the aneurysm; 3 patients originally presented residual aneurysm neck, 1 showed absence of aneurysm neck and the other 2 showed stable condition upon reexamination. Finally, 1 patient with residual aneurysm showed no aneurysm presence upon reexamination. All 46 patients had no stent displacement, as shown in Figure 1.

Discussion

The MCA is the terminal branch of the internal carotid artery that supplies most of the brain, and

can be classified into 3 types based on the location of the aneurysm: proximal, trifurcation, and distal, with trifurcation aneurysm being the most common. MCA trifurcation aneurysms usually present complex shapes and were predominantly wide-necked aneurysms[5]. Over 90% of MCA aneurysms were ruptured upon patient admission, with common manifestations including subarachnoid hemorrhage. Also, cerebral aneurysm may cause intracranial hematoma and focal neurological deficits; therefore, craniotomy and clipping were considered serious treatments. The current efficacy of MCA aneurysm interventional therapy is not satisfactory. It has been reported that the rate of complete embolization by simple coiling in narrow-necked and wide-necked aneurysms were 57-85% and 15-35%, respectively[6]. With the development of embolization materials and improvement of embolization technology, notably special stents for intracranial aneurysms and detachable coil materials, good embolization in complex MCA aneurysm cases is now possible, ensuring both the density of aneurysm embolization and patent aneurysm-bearing artery. Therefore, interventional embolization usage had been increasing significantly[7-9]. In comparison to craniotomy and clipping, interventional embolization was characterized by only small injuries in the contralateral vessels thus, potentially achieving a relative disability lower rate. In this study, all 57 patients with MCA trifurcation wide-necked aneurysms underwent endovascular embolization with satisfactory efficacy and no serious complications. All patients who had aneurysms ≤ Hunt-Hess grade III presented no significant space-occupying intracranial hematoma. For patients with hematoma in the frontal or temporal lobes > 20 ml or midline shift > 5 mm, or patients with Hunt-Hess ≥ grade IV, we recommended craniotomy and clipping of the aneurysms with evacuation of hematoma. The patients with non-ruptured aneurysms were treated with antiplatelet therapy (oral aspirin and clopidogrel) 3 days before surgery; the patients with ruptured aneurysms were treated with antiplatelet therapy (oral aspirin and clopidogrel) 2 h before surgery. Heparin was administered immediately after femoral artery catheterization, with the initial dosage based on patient weight and then decreased 50% every hour until the end of surgery. A positive-pressure intravenous drip was performed to prevent catheter thrombosis. Based on our experience, injection of heparin through the guiding catheter and microcatheter before and after indwelling of the stent could further decrease the incidence of intra-operative thrombosis and post-operative micro-thrombus. Intra-arterial thrombolysis was performed immediately after intra-operative thrombosis, and anticoagulation/antiplatelet therapy provided after surgery. The anatomic structures of the aneurysm, aneurysm-bearing artery, and aortic arch were imaged using 3D-DSA. The feasibility of embolization was assessed and the embolization protocol was customized to ensure good efficacy. Post-stent placement and semi-placement were performed based on the shape of the aneurysm[9,10], the stent and coil were chosen based on the anatomic structures of the aneurysm and aneurysm-be-

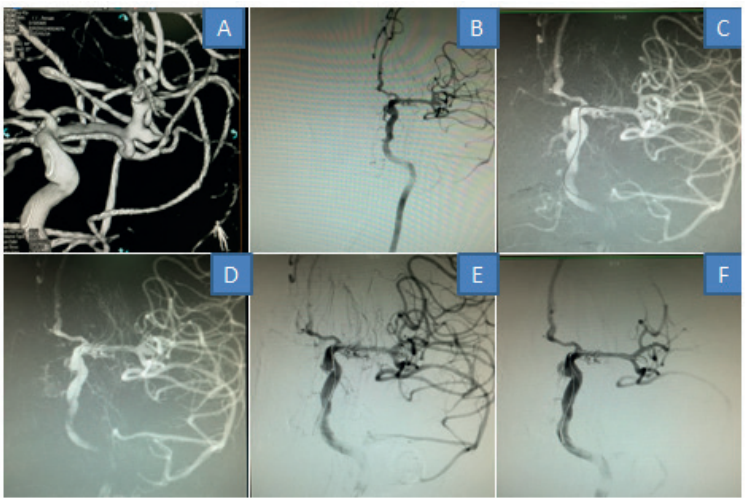

Figure 1. ***A-B.*** Artery bifurcation aneurysms on the left side of the brain. ***C,*** Spring coil micro catheter in place ***D.*** Stent catheter in place ***E-F.*** After embolization, the tumor was found to be dense and embolization

aring artery. The proximal and distal end of the stent was 4-5 mm larger than the diameter of the aneurysm; the diameter of the first coil should be slightly larger than the diameter of the aneurysm so as to form a 3D coil. The coil protruded into the aneurysm-bearing artery, then was pushed in the aneurysm neck by the post-stent placement, ensuring better coverage of the aneurysm neck and preventing detachment or displacement of the coil due to large stent mesh. Finally, coils of appropriate size were filled based on the remaining space in the aneurysm to achieve complete embolization. Since MCA trifurcation was tortuous, repeated operation may cause vasospasm, thus the degree of anesthesia should be considered, the filling of the coil should be gentle, the location of the microcatheter should be adjusted, and a coil of appropriate size and material should be selected based on filling resistance. Papaverine could be injected through the microcatheter on cases of mid-surgery cerebral vasospasm, with the surgical procedure stopped until vasospasm remission was confirmed by imaging. In this study, the Solitaire AB stent was used for the treatment of wide-necked aneurysms; this stent was an intracranial self-expanding electrolytic stent and could be reused if not detached after complete placement[11]. Thus, the degree and location of stent placement could be precisely controlled to adjust the support of the coil and microcatheter by the stent. This ensured successful interventional embolization and decreased the incidence of complications. 50 patients received DSA follow-up. The results showed that the relapse rate of stent-assisted coiling embolization was low. It was reported that stent-assisted coiling embolization of intracranial wide-necked aneurysms using the Solitaire AB stent was safe and effective[12,13].

Conclusions

In this study, 57 patients with MCA trifurcation aneurysms received individualized endovascular interventional therapy. All patients underwent successful surgery with satisfactory efficacy. This study suggested that stent-assisted coiling embolization was safe and effective for patients with complex MCA trifurcation aneurysms based on pre-operative conditions and intra-operative imaging.

Conflict of interest

The authors declare no conflicts of interest.

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