



Clinical Study

Stent-assisted coiling strategies for the treatment of wide-necked basilar artery bifurcation aneurysms

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ABSTRACT

Stent-assisted coiling is now the preferred treatment option for wide-necked basilar artery bifurcation aneurysms (BABA). However, the optimal choice of specific treatment strategies is still not well documented. In this paper, based on the “two-neck” theory of BABA, we classified the stent-assisted coiling treatment of BABA into three types: unilateral stent-assisted coiling, unilateral stent plus contralateral microcatheter or microwire-assisted coiling, and bilateral stent-assisted coiling. We assessed the feasibility and effectiveness of different stent-assisted coiling strategies for the treatment of BABA. Twenty-three BABA patients treated with stent-assisted coiling between May 2003 and September 2012 were included. Of the 23 aneurysms, 16 were treated with unilateral stent-assisted coiling, two were treated with unilateral stent and microcatheter or microwire-assisted coiling, and five were treated with bilateral stent-assisted coiling. All 23 BABA were successfully embolized, with a technical success rate of 100%. According to the Raymond classification, the immediate procedural outcome was grade I in nine patients, grade II (neck residue) in four patients and grade III (body filling) in 10 patients. The rate of procedure-related complications was 4.3% (1/23), where intra-operative hemorrhage occurred during coiling due to rupture of the aneurysm. Of the 23 patients, 16 (69.6%) had angiographic follow-up. The mean follow-up duration was 13.5 months (range 1–46 months). Angiographic follow-up showed complete occlusion in 10 patients (62.5%), improvement in two patients (12.5%), stability in three patients (18.7%), and recanalization in one patient (6.25%). The various stent-assisted coiling strategies available at present are feasible and effective for the treatment of wide-necked BABA.

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1. Introduction

Basilar artery bifurcation aneurysms (BABA) account for about 5% of all intracranial aneurysms. Clipping of these aneurysms is extremely challenging for neurosurgeons due to their deep location and complex anatomy. Thalamic perforator injury during surgery and intra-operative rupture often leads to severe clinical complications. Reported combined mortality and morbidity rates are as high as 26% in some microsurgery series of BABA [1]. Endovascular therapy has become the first choice for BABA treatment owing to its minimal invasiveness and relatively low procedure-related complication rate [2]. However, it is often difficult to use coils alone to treat BABA aneurysms, which frequently have wide necks or involve the origin of bilateral posterior cerebral arteries, and sometimes even the initial segment of the superior cerebellar artery.

Since the first use of the intracranial Neuroform stent (Boston Scientific, Fremont, CA, USA) in 2002, various stent-assisted coiling techniques have been widely applied to the treatment of

wide-necked intracranial aneurysms [3]. Stent-assisted coiling can prevent coils from protruding into the parent artery, reconstruct the parent artery, and promote endothelial cells to cover the aneurysm neck. In addition, stents change the local hemodynamic status, thus facilitating thrombosis within the aneurysm to achieve the goal of treatment. To date, there have been few systematic evaluations of the treatment of BABA with stent-assisted coiling. We retrospectively reviewed the clinical data of 23 BABA patients who were treated with stent-assisted coiling at our hospital between May 2003 and September 2012. We aimed to evaluate the feasibility and effectiveness of stent placement for this kind of aneurysm using different stenting strategies. In addition, the selection of stenting strategy, technique details and clinical outcomes were analyzed.

2. Materials and methods

2.1. Patient population

Twenty-three BABA patients who received stent-assisted coiling at our hospital between May 2003 and September 2012 were included in this study. There were 11 men and 12 women with a

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mean age of $51.2 \pm$ standard deviation of 15.6 years (range 22–71). Of the 23 aneurysms, six were unruptured. Of the 17 patients with ruptured BABA, 10 were admitted because of acute subarachnoid hemorrhage (<28 days). According to the Hunt-Hess classification, five patients had grade I subarachnoid hemorrhage, two had grade II, two had grade III, and one had grade IV.

2.2. Imaging examination

The BABA diagnosis was confirmed by cerebral angiography as a true sac aneurysm in all 23 patients. The aneurysm diameter was large (10–25 mm) in three patients, and small (<10 mm) in 20 patients [4]. All the aneurysms were wide-necked as defined by neck width >4 mm or dome to neck ratio <2.

2.3. Treatment procedures

All procedures were performed under general anesthesia with endotracheal intubation and systemic heparinization. Digital subtraction angiography (DSA) and three-dimensional reconstruction were performed to clarify the aneurysm size, morphology, and the relationship to the bilateral posterior and superior cerebellar artery origins, and the diameter of the aneurysm neck and body were measured. Over a guide wire, a 6 French ENVOY guiding catheter (Cordis, Miami, FL, USA) was placed in the distal vertebral artery. Delivery and release of various stents were performed according to the standard procedures recommended by the manufacturers. Stent-assisted endovascular coiling was employed in all 23 BABA patients, of whom 16 were treated with unilateral stent-assisted coiling, two were treated with unilateral stent and microcatheter or microwire-assisted coiling, and five were treated with bilateral stent-assisted coiling (Y-configuration stenting technique).

2.4. Anticoagulation and antiplatelet management

All patients received systemic heparinization after placement of the sheath. The activated clotting time was maintained at 2–3 times the baseline throughout the procedure. Low molecular-weight heparin (40 mg, every 12 hours, hypodermic injection) was administered immediately after the procedure and continued for 3 days.

For patients with unruptured aneurysms and patients with remote hemorrhage, oral clopidogrel (75 mg/day) and enteric-coated aspirin (300 mg/day) were administered for at least 3 days before surgery. For patients who had acute subarachnoid hemorrhage (<28 days), a loading dose of clopidogrel and aspirin (300 mg each) was administered orally by gastrointestinal tube or per rectum 2 hours before stenting. All patients were continued on aspirin and clopidogrel post-operatively for 6 weeks, followed by aspirin (100 mg/day) alone which was maintained indefinitely. After the platelet aggregation test became available at our hospital in June 2010, the dosage of enteric-coated aspirin was changed from 300 mg/day to 100 mg/day peri-operatively.

2.5. Imaging follow-up and evaluation

All patients were advised to be clinically evaluated 1, 3, 6, and 12 months after the treatment and yearly thereafter. Angiographic follow-up was also recommended, including magnetic resonance angiography (MRA) at 3 months and digital subtraction angiography (DSA) at 6 months post-operatively. The angiographic results were independently interpreted by two authors (Q.H. and P.Y.), and were classified into four categories: (1) cured, defined as no contrast filling into the aneurysm sac; (2) improved, defined as decreased contrast filling into the aneurysm sac; (3) stable, defined as

unchanged contrast filling into the aneurysm sac; and (4) recanalized, defined as increased contrast filling into the aneurysm sac.

3. Results

3.1. Immediate post-operative results

Successful stent placement was achieved in all patients, resulting in a technical success rate of 100%. A total of 28 stents were implanted into the parent arteries, including 19 Enterprise stents (Cordis), six Neuroform stents, two BX stents (Cordis), and one Solitaire stent (ev3 Endovascular, Irvine, CA, USA), with Enterprise and Neuroform stents most frequently used, accounting for 67.9% and 21.4% respectively. According to the Raymond classification [5], the immediate post-procedural outcome was grade I in nine patients (39.1%), grade II in four patients (17.4%), and grade III in 10 patients (43.5%).

3.2. Complications

There was only one procedure-related complication in this series, when an intra-operative hemorrhage occurred during coiling due to rupture of the aneurysm, which was immediately controlled by additional coil packing. Post-operative CT scan revealed extensive subarachnoid hemorrhage and lumbar cistern drainage was commenced, but the patient died 6 days after procedure. This was the only technique-related death rate in this series (4.3%).

3.3. Imaging follow-up

Sixteen patients (69.6%) were followed up angiographically, including 13 patients who had DSA and three patients who had MRA. The mean follow-up period was 13.5 months (range 1–46 months). The imaging outcomes were; cured in 10 patients (62.5%), improvement in two patients (12.5%), stability in three patients (18.7%), and recanalized in one patient (6.25%). The recanalized patient received re-coiling and achieved complete occlusion. The modified Rankin Scale score was 0–1 in the 22 surviving patients. No hemorrhage or new neurological dysfunction occurred during the follow-up period.

4. Discussion

The basilar bifurcation region is deeply located with abundant branches. The necks of aneurysms occurring in this region often involve the bilateral posterior cerebral arteries or even the superior cerebellar artery, including the initial segment of these arteries a part of the aneurysm. Although the course of such an aneurysm is continuous with that of the basilar artery and it is straightforward for a microcatheter to enter the aneurysm, coverage of the aneurysm neck and preservation of the side branches still remains difficult for neurosurgeons and neurointerventional therapists. With advances in endovascular treatment techniques in recent years, stent-assisted coiling has become an ideal option for the treatment of BABA [6,7].

In our series, procedure-related complications occurred in only one (4.3%) of the 23 patients who received stent-assisted coiling, which is considerably lower than the overall complication rate (20%) and recurrence rate (35%) as reported by Henkes et al. who used coiling alone for the treatment of BABA. To our knowledge, the complication and recurrence rates of balloon-assisted embolization of BABA have not yet been reported. Sluzewski and his colleagues reported that the complication and recurrence rates of balloon-assisted embolization of intracranial wide-necked

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