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ORIGINAL ARTICLE

Stent-assisted coiling of unruptured intracranial aneurysms: Long-term follow-up in 164 patients with 183 aneurysms

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Summary
Purpose: Stent-assisted coiling (SAC) is increasingly used to treat complex unruptured intracranial aneurysms (UIA) including wide-necked and fusiform IA. However, few data are available over the long-term results of this technique. We report our 9-year-experience of SAC of UIA.
Methods: A retrospective review of our prospectively maintained database identified all patients treated by SAC for an UIA in 2 institutions. The clinical charts, procedural data and angiographic results were reviewed.
Results: Between 2004 and 2012, we identified 164 patients with 183 UIA. There were 115 women and 49 men with a mean age of 46 years. Embolization was successful in all patients. Procedural morbidity and mortality rates were 2.2% and 0% respectively. Immediate anatomical outcome included 54 complete occlusion (29.5%), 43 neck remnants (23.5%) and 86 incomplete occlusions (47%). Imaging follow-up was available in 137 patients (mean = 26 months, range 3 to 99 months) and it showed 104 complete occlusions (75.9%), 23 neck remnants (16.8%) and 10 incomplete occlusions (7.3%). At follow-up, only 3 patients developed a significant intrastent stenosis, one of which was induced by radiosurgery. One of these patients had a symptomatic thrombo-embolic complication 3 years after stent placement.
Conclusion: SAC of complex UIA is effective and associated with low complication rates. Even if immediate anatomical results are relatively unsatisfying, mid- and long-term follow-up show a major improvement with a high rate of adequate occlusion that is stable over time. Moreover, the long-term clinical and angiographic tolerance of intracranial stents is excellent.

Introduction

Self-expandable intracranial stents have enlarged the indications of the endovascular treatment (EVT) of intracranial

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aneurysms (IA). Indeed, most IA are now amenable to EVT including complex ones such as wide-necked and fusiform IA [1—8]. These stents are not only used as a scaffold for coils but they also contribute to aneurysm healing and thrombosis by redirecting the blood flow towards the parent artery rather than the sac [9—11]. Several authors have shown that SAC achieves a high rate of complete occlusion at mid-term follow-up [12] and could stabilize or even improve the results of coiling over time [13]. However, few data are available about the long-term results of this technique including stability of aneurysm occlusion and stent tolerance [14]. The aim of our study was to report our 9-year-experience of SAC for the treatment of UIA.

Material and methods

Patients and aneurysms characteristics

The study protocol was approved by our institutional Ethical Committee.

Between January 2004 and November 2012, we retrospectively identified in our prospectively maintained database all patients treated by SAC for UIA in 2 institutions.

All patients underwent conventional angiography of both carotid arteries and vertebral arteries. Then, 3D-rotational angiography was obtained to depict the aneurysm morphology. These UIA were classified as saccular or fusiform and as small (< 10 mm), large (between 10 and 24 mm) or giant (≥ 25 mm). For saccular UIA, the neck was classified as wide (neck width > 4 mm or dome to neck ratio < 1.6) or small (neck width ≤ 4 mm and dome to neck ratio ≥ 1.6).

Endovascular procedures

In all patients, EVT was performed under general anesthesia and systemic heparinization. The adequacy of systemic anticoagulation was monitored by repeated measurements of the activated clotting time (ACT). A baseline ACT was obtained prior to the 5000 IU bolus infusion of heparin and hourly thereafter. The bolus infusion was followed by a continuous drip (1500 to 2500 IU/hr), with the purpose of doubling the baseline ACT. At the end of the procedure, systemic heparinization was maintained for 24 hours in most patients. All procedures were performed by 2 senior interventional neuroradiologists (BL, BM). When stenting was planned prior to the procedure, a loading dose of 300 mg of clopidogrel and 320 mg of aspirin was administered one day before and on the day of EVT. When stenting was decided during the procedure, intravenous abciximab was administered a few minutes before stent deployment with a bolus of 0.25 mg/kg followed by a continuous perfusion of 0.125 μg/kg/minute for 12 hours. The following stents were used: Enterprise® stents (Cordis, Miami Lakes, Florida), Leo® stents (Balt, Montmorency, France) and Solitaire® stents (Covidien/ev3, Irvine, California). Catheterization of the aneurysm was performed either before or after stent deployment depending on morphological characteristics. The guidewire was placed in the aneurysmal sac only if it was not possible to gently advance the microcatheter within the aneurysm by orientating it with the guidewire at its tip. Clopidogrel was maintained for one month whereas aspirin was administered for at least 6 months according to angiographic tolerance of the stent. After EVT, control DSA was performed including working, frontal and lateral views. Patients were then transferred to the intensive care unit, and fluid balance, neurological status and blood pressure were carefully monitored.

Immediate outcome

Clinical outcome

Procedural and early post-procedural (within 48 hours) complications were recorded. The clinical course was recorded including worsening of symptoms and death.

Anatomical outcome

Patients were evaluated by angiography at the end of the procedure. Two senior neuroradiologists reached a consensus regarding aneurysm occlusion and stent tolerance. Anatomical outcome was classified as complete occlusion (no contrast filling the aneurysm), neck remnant (residual contrast filling the aneurysmal neck) and incomplete occlusion (residual contrast filling the aneurysmal body). Stent tolerance was classified as good (no stenosis or stenosis < 50%), moderate stenosis (stenosis of 50%), severe stenosis (stenosis between 50% and 99%) or occlusion (no flow within the stent)

Patients follow-up

Clinical follow-up

Based on clinical charts review, we recorded delayed complications. Retreatments and aneurysm ruptures were also recorded. Clinical outcome at the longest available follow-up was evaluated according to the modified Rankin scale (mRS) [15].

Imaging follow-up

Our imaging follow-up protocol includes a DSA at 6 and 12 months, A contemporarily Magnetic Resonance Angiography (MRA) at 12 months is also performed and serves as a baseline comparative non-invasive technique. Then patients are followed up only by MRA every 2 years. Both time-of-flight and contrast-enhanced MRA are performed. Imaging follow-up duration was defined as the delay between SAC and the most recent DSA or MRA.

Imaging analysis

Two senior neurointerventionalists with a 5- and 4-year-experience in interventional neuroradiology reviewed all imaging exams. They reached a consensus regarding aneurysm occlusion and stent tolerance. The latest available imaging follow-up was compared with the immediate result after EVT.

Recanalization was considered as minor when no further treatment was required and as major when retreatment was performed.