Blood blister–like aneurysms of the ICA are rare but clinically important causes of acute SAH. These lesions comprise ~0.5–2.0% of ruptured intracranial aneurysms and have unusually high morbidity and mortality rates compared with typical ruptured saccular aneurysms of the ICA. The optimal treatment of BBAs remains uncertain. The reported outcomes of most surgical series of BBAs have been poor because of the relatively high incidence of premature rupture during the dissection and postoperative rebleeding compared with saccular aneurysms. Endovascular coiling is also difficult and is normally not sufficient by itself to prevent recurrence or rebleeding of BBAs. Recently, Park et al. reported on a series of 7 patients with BBAs who underwent deconstructive endovascular treatment.
graphic outcomes in 9 consecutive patients with BBAs

In the present study we evaluate the clinical and angiographic outcomes in 9 consecutive patients with BBAs who underwent reconstructive endovascular treatment.

Methods

This retrospective study was approved by our institutional review board and informed patient consent was not required. Nine consecutive patients with ruptured BBAs underwent treatment with reconstructive endovascular methods at 2 institutions between January 2006 and November 2007. The patients included 2 men and 7 women, 42–57 years of age (mean 50 years) (Table 1). The BBAs were diagnosed on the basis of the following criteria: 1) typical location at the nonbranching supraclinoid ICA; 2) typical appearance as a hemispherical small bulge or an irregular bleb-like protrusion on initial angiography and/or rapidly growing sac on very short-term follow-up angiography obtained within 1 week; and 3) the absence of any other angiographic cause of SAH. In 3 cases, a rapidly growing aneurysm sac highly suggestive of a BBA was documented on follow-up angiograms obtained 2–4 days after the first images were obtained. The other 6 patients received their diagnosis and treatment at the same time. Reconstructive endovascular treatment was performed in these patients because of poor collateral blood supply, extreme proximity of the BBA to the origin of the anterior choroidal artery, or both.

Procedure for Reconstructive Endovascular Treatment of BBA

All procedures were conducted with the patient in a state of general anesthesia or deep sedation. The activated coagulation time was maintained 2–3 times above the baseline value during the procedure and for 24–48 hours afterwards. Antiplatelet medication was not given before the procedure. Immediately after completion of the procedure, dual antiplatelet therapy with aspirin and clopidogrel bisulfate was initiated.

Stent-Assisted Coil Embolization Alone or Followed by the SWS Procedure

A microcatheter was navigated to the distal branch of the middle cerebral artery using a guidewire, which was then exchanged with a 300-cm-length exchangeable guidewire. The microcatheter was retrieved and a self-expanding Neuroform stent (Neuroform, Boston Scientifics or Envoy, Cordis) was inserted using the SWS technique (Fig. 1). A microcatheter was navigated to a distal branch of the middle cerebral artery using a guidewire. The guidewire was exchanged with a 300-cm-length exchangeable guidewire and the microcatheter was retrieved. A balloon-expandable covered stent (Jostent Graftmaster, Abbott Vascular Devices) was advanced over the prepositioned guidewire and deployed across the BBA.

Clinical and Angiographic Follow-Up

Clinical assessment was performed on admission with the Hunt and Hess grading system and the patients were evaluated for complications during and after treatment. The clinical outcome was evaluated at discharge and clinical follow-up according to the GOS score. Each patient’s clinical status at the last clinical follow-up was defined as the final outcome. Angiographic follow-up was performed after treatment at 1–4 weeks, 2–4 months, 6–12 months, and 18–24 months postoperatively.

Results

Stent-assisted coiling or SWS was initially attempted in 6 patients with BBAs, and in 3 covered stents were attempted. In 4 of the 6 patients who received SAC embolization, a second stent insertion using the SWS procedure was tried in the same session and was successful in 3 patients. Therefore, 3 patients received initial treatment with SWS and 3 with SAC embolization alone.

The 3 patients treated with the SWS technique had excellent outcomes with GOS scores of 5 and showed complete resolution of the BBAs on follow-up angiography. At the last follow-up a radiolucent gap between the coil mass and the reconstructed ICA lumen was revealed on angiography (Fig. 1). Smooth reconstruction of the affected ICA segments was also demonstrated, which had been noted as luminal irregularities on initial angiography.

Of the 3 patients in whom covered stenting was initially attempted, excellent outcomes were achieved in 2 (GOS Score 5). These 2 patients also showed complete resolution of the BBA with reconstruction of the affected ICA segment. The third patient died of ICA rupture during the procedure.

All 3 patients who received SAC embolization alone showed BBA regrowth on short-term follow-up angiography but without rebleeding. Two of the 3 recurrent BBAs were re-treated by coiling followed by a second overlapping stent insertion, and as a result, these patients belonged to the SWS group. Excellent outcomes were achieved in both of these patients (GOS score of 5) and complete resolution of the BBAs with smooth reconstruction of the affected ICA segment was revealed on follow-up imaging.
Endovascular treatment of blood blister–like aneurysm

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>BBA Location</th>
<th>H &amp; H Grade</th>
<th>Initial Tx</th>
<th>Tx-Related Complications</th>
<th>Clinical Course &amp; Re-treatment</th>
<th>Status at Last FU Angiogram</th>
<th>GOS Score</th>
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<tr>
<td>1</td>
<td>49</td>
<td>M</td>
<td>rt III</td>
<td>SAC</td>
<td>none</td>
<td>regrowth &amp; coiling (1 wk); regrowth &amp; SWS (3 mos)</td>
<td>CR (24 mos)</td>
<td>5 (26 mos)</td>
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<td>2</td>
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<td>lt III</td>
<td>SAC</td>
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<td>regrowth &amp; SAC + SWS (2 mos)</td>
<td>CR (6 mos)</td>
<td>5 (8 mos)</td>
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<tr>
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<td>lt I</td>
<td>SAC</td>
<td>none</td>
<td>regrowth &amp; covered stent (2 mos)</td>
<td>CR (3 mos)</td>
<td>5 (5 mos)</td>
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<tr>
<td>4†</td>
<td>57</td>
<td>F</td>
<td>lt III</td>
<td>SAC + SWS</td>
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<td>no regrowth</td>
<td>CR (6 mos)</td>
<td>5 (15 mos)</td>
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<tr>
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<td>F</td>
<td>rt III</td>
<td>SAC + SWS</td>
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<td>no regrowth</td>
<td>CR (6 mos)</td>
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<tr>
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<td>no regrowth</td>
<td>CR (3 mos)</td>
<td>5 (4 mos)</td>
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<td>9</td>
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<td>lt III</td>
<td>covered stent</td>
<td>ICA rupture</td>
<td>death</td>
<td>NA</td>
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* NR = not applicable
† This case was published previously by Kim BM et al., 2007.

One of the 2 BBAs re-treated with the SWS procedure also revealed a radiolucent gap between the coil mass and the reconstructed ICA lumen (Fig. 2). The remaining patient with a recurrent BBA underwent covered stent insertion and therefore belonged to covered stent group. The patient also had an excellent outcome (GOS Score 5) and complete resolution of the BBA with reconstruction of the affected ICA segment was revealed on follow-up imaging (Fig. 3).

Excluding the case of ruptured ICA, a total of 11 sessions for inserting bare or covered stents was performed in the 8 surviving patients. There were no BBA ruptures during SWS placement or SAC embolization. In 1 (9%) of the 11 sessions, a small amount of in-stent thrombosis without flow restriction was detected but this spontaneously resolved and did not require further management (Fig. 2).

Discussion

The BBA is an atypical type of ruptured aneurysm and typically appears as a small, hemispherical bulge or irregular bleb at the nonbranching sites in the suprACL...

Blood blister–like aneurysms are very difficult to treat reconstructively not only with surgical clipping but also with endovascular coiling. Although Sim et al. re-reported good results in 10 BBAs treated with the surgical method, they documented a higher incidence of premature rupture. Moreover, the outcomes in most surgical reports...
are poor.10,11 Recently Park and colleagues12 reported on 7 consecutive patients with BBAs, among whom 4 patients underwent repeated treatment by coiling, balloon-assisted coiling, or SAC; in all cases the BBAs regrew with or without rebleeding. Eventually, 2 of the 4 patients underwent ICA trapping. Thereafter, the next 3 patients with BBAs were initially treated with ICA trapping after the balloon occlusion test.

In our series, 8 of 9 patients with BBAs who underwent reconstructive endovascular method with ICA preservation had excellent outcomes. The 5 SWS-treated BBAs (3 initially treated and 2 treated again after SAC alone) and the 3 covered stent–treated BBAs (2 initially treated and 1 treated again after SAC alone) showed complete resolution with smooth reconstruction of the affected ICA segment. Moreover, in 4 of the 5 SWS-treated BBAs, imaging studies revealed a radiolucent gap between the coil mass and the ICA lumen, which may be presumed, in our opinion, as representative of neointima formation.

If BBAs are presumed to be a specific type of dissection or pseudoaneurysm, then treatment should not be focused only on the BBA sac, but also on the affected wall of the ICA around the BBA. Therefore, as in the ruptured intracranial vertebral artery dissection, trapping of the ICA may be a possible treatment option. However, when collateral flow is insufficient or the anterior choroidal artery originates too close to the BBA, trapping the ICA may be difficult and should be preceded by bypass surgery. Endovascular trapping also may not be completely safe from rebleeding during the procedure. There was 1 case of contrast media leakage during the 5 endovascular ICA trapping procedures.12 Furthermore, sufficient collateral supply on preoperative angiographic evaluation cannot always protect the patient from postoperative ischemic complication. In the latest report about BBA treatment, patients in whom the ICA was sacrificed had significantly poorer outcomes due to ischemic complications than the patients in whom the ICA was preserved.9 In their case series, the 4 patients with good collateral vessels and the 3 with poor collateral vessels on preoperative angiographic evaluation eventually suffered a severe infarction due to vasospasm. As a result, ischemic complications lead to death in 6 patients and a poor outcome in the remaining patient. Therefore, the authors suggested that the results of preoperative tests to evaluate patient tolerance of elective carotid artery closure are invalid in situations of acute SAH and furthermore, that if the management of an SAH-induced vasospasm is difficult, the
management of a carotid occlusion in the face of acute SAH is doubly so.9 Fiorella et al.4 recently reported on 10 cases of intracranial pseudoaneurysm, including 2 BBAs, 1 treated with a single Neuroform stent and the other with triple overlapping of Neuroform stents; both completely resolved. Our results in combination with the results of Fiorella et al. suggest that reconstruction of the affected ICA wall may be of critical importance in the treatment of BBA. Intuitively, a covered stent may be considered an ideal tool for ICA reconstruction with BBA occlusion. However, several limitations inherent in the use of covered stents are present with the current technology, and their application in BBAs may risk additional injury to the fragile BBA and ICA wall.7 Among our patients, ICA rupture occurred during the procedure in 1 of the 3 who initially underwent treatment with a covered stent, and this patient died as a result.

Blood blister–like aneurysms are difficult to treat with coil embolization and even with SAC embolization because of their small size, wide neck, and location. Appropriate steam shaping of the microcatheter tip and balloon-in-stent technique may help overcome the difficulty of coiling the BBA. Appropriate shaping of the microcatheter tip and positioning of the balloon within the stent help to prevent catheter kickback during embolization, and the balloon positioned across the BBA may be used to “batten down the hatch” if BBA rupture occurs during the procedure. However, although complete occlusion of a BBA was initially achieved by SAC embolization, this was insufficient to prevent the BBA from reforming both in our experience and in Park and colleagues’ report.12 The use of at least 2
overlapping stents fully covering the affected segment of ICA with the BBA seems crucial to prevent regrowth of the BBA. Overlapping double stents may double the strut density and thickness of the stent, thus reinforcing blood flow remodeling and arterial wall support. These effects may help reconstruct the fragile neck of the BBA and prevent its regrowth. Furthermore, the greater the strut density and stent thickness, the more easily neointima formation is promoted. In 4 of the 5 BBAs we treated with the SWS technique, a radiolucent gap representative of neointima formation between the coil mass and ICA lumen was seen on angiography.

It is not always feasible to insert a second stent for the SWS procedure immediately after SAC embolization. In our patients, 1 of the 4 attempts to insert the second stent immediately after embolization failed. However, the second stent insertion in 2 of the re-treated cases was easier and successful. Therefore, if the second stent insertion is not possible immediately after embolization alone, a very short-term angiographic follow-up is mandatory. If BBA regrowth is detected, SWS, covered stent placement, or ICA sacrifice with or without bypass may be considered as possible treatment options depending on the patient’s anatomical factors and medical conditions.

Conclusions

In our patients, SWS and covered stenting were effective to prevent rebleeding and BBA regrowth without sacrificing the ICA. Stent-within-a-stent or covered stent placement can be considered as an alternative treatment option for BBAs in selected patients in whom ICA sacrifice is not feasible. Stent-assisted coil embolization alone, however, seems insufficient to prevent BBA regrowth.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

References


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