STENT-ASSISTED COIL EMBOLIZATION OF POSTERIOR CIRCULATION ANEURYSMS USING SOLITAIRE AB: PRELIMINARY EXPERIENCE

Joachim Klisch, M.D.
Department of Diagnostic and Interventional Radiology and Neuroradiology, Helios General Hospital Erfurt, Erfurt, Germany

Cornelia Eger, M.D.
Department of Diagnostic and Interventional Radiology and Neuroradiology, Helios General Hospital Erfurt, Erfurt, Germany

Vojtech Sychra, M.D.
Department of Diagnostic and Interventional Radiology and Neuroradiology, Helios General Hospital Erfurt, Erfurt, Germany

Christoph Strasilla, M.D.
Department of Diagnostic and Interventional Radiology and Neuroradiology, Helios General Hospital Erfurt, Erfurt, Germany

Steffen Basche, M.D.
Department of Diagnostic and Interventional Radiology and Neuroradiology, Helios General Hospital Erfurt, Erfurt, Germany

Johannes Weber, M.D.
Department of Neuroradiology, University of Freiburg, Freiburg, Germany

Reprint requests:
Joachim Klisch, M.D., Department of Diagnostic and Interventional Radiology and Neuroradiology, Helios General Hospital Erfurt, Nordhäuser Strasse 74, 99089 Erfurt, Germany.
Email: joachim.klisch@helios-kliniken.de

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OBJECTIVE: To evaluate patients with wide-necked aneurysms of the posterior circulation who underwent Solitaire AB (ev3, Inc., Irvine, CA) stent-assisted coil embolization.

METHODS: Retrospective analysis of 10 patients (age range, 32–76 years; mean age, 59.1 years) with aneurysms of the basilar artery (basilar tip, n = 5; basilar trunk, n = 4; posterior cerebral artery, n = 1). Seven of the patients presented with an acute subarachnoid hemorrhage. Five aneurysms were small, 2 were large, and 3 were giant. All patients were treated by different applications (n = 14) of the Solitaire AB neurovascular remodeling device followed by a standard coiling procedure using bioactive coils.

RESULTS: Positioning of all Solitaire AB stents was easy and successful. No stent required retrieving and repositioning after full deployment. There were no thromboembolic complications, and no dissection/rupture or vasospasm occurred during stent placement. In all cases except 3, 100% lesion occlusion was observed after the initial treatment.

CONCLUSION: The initial technical and clinical results of Solitaire AB stent-assisted coiling of different types of wide-necked aneurysms in the posterior circulation are highly encouraging, and this technique may improve the endovascular treatment of these aneurysms.

KEY WORDS: Basilar artery aneurysms, Coil embolization, Solitaire AB stent

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Treatment of wide-necked posterior circulation aneurysms remains a therapeutic challenge with a higher risk of recanalization, regrowth, and rerupture (1–5, 7, 8, 9, 17, 19, 22, 26, 29, 33, 42, 43, 48). However, modern endovascular techniques have made the treatment more feasible. Balloon remodeling alone might not be sufficient to prevent coil protrusion into the parent vessel (10, 27). For these cases, intracranial stents can be used as a supporting implant. The ideal remodeling device for this endovascular treatment should be highly flexible, atraumatic, easily and accurately delivered, and easily seen on fluoroscopy. Ideally, the device should be fully retrievable, thus allowing repositioning. Several products have been approved for stent-assisted coiling. All of them are nitinol self-expanding stents with either open- or closed-cell designs. Clinical applications and the limitations of the available implants are described in various case series and approval studies (6, 7, 12–14, 17, 23, 25, 30–32, 35, 36, 40, 50).

ABBREVIATIONS: BA, basilar artery; **GOS**, Glasgow Outcome Scale; **H & H**, Hunt and Hess; **SAH**, subarachnoid hemorrhage

The Solitaire AB stent (Solitaire AB Neurovascular Remodeling Device, formerly Solo stent; ev3, Inc., Irvine, CA) is a laser-cut, self-expanding, and fully retrievable split-design nitinol device. The concept of its use was first reported by Henkes et al. in 2003 (15), and preclinical data of this stent were detailed by Doerfler et al. in 2005 (11).

The stent, with 4-mm diameter and 20-mm working length, is attached to a stainless steel push wire and can be placed across the aneurysm neck through a 0.021-in. microcatheter. The method of electrolytic detachment from the push wire is similar to that used for coils. Until detachment is started, the whole system is fully retrievable (Fig. 1).

Recently, Liebig et al. (28) and Yavuz et al. (49) reported their experience with this type of stent in 27 aneurysms. Stent deployment was

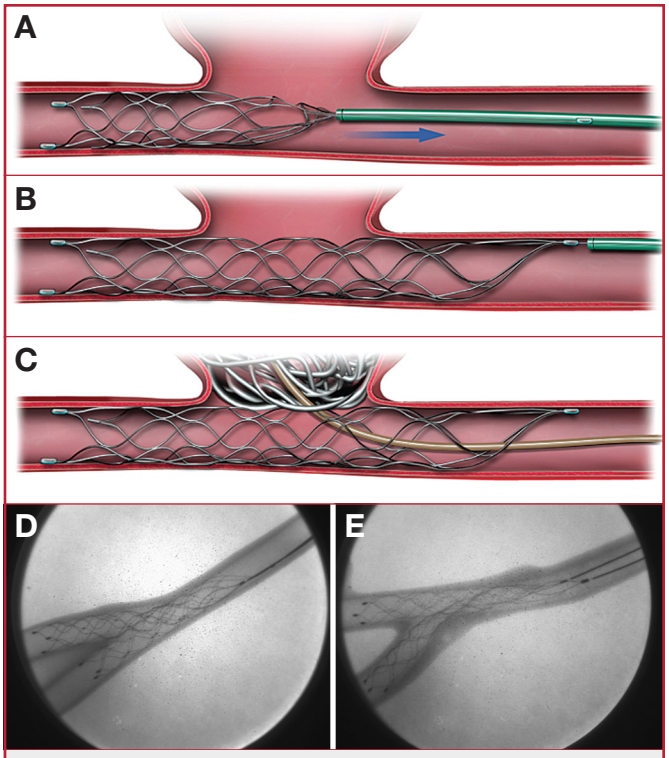

FIGURE 1. *Drawings (A–C) and videoscopic views (D and E) of deployment of the Solitaire AB stent. A, the stent should be advanced through the 0.021-in microcatheter until its distal radiopaque markers reach the end of the properly positioned microcatheter to ensure at least 4 mm on each side of the aneurysm neck after full deployment. To deploy the device, the microcatheter should be withdrawn in the proximal direction while maintaining the position of the stent. B, to ensure full deployment, the microcatheter must be proximal to the proximal radiopaque marker on the stent. In the case of retrieval or redeployment, the microcatheter should be advanced carefully (while maintaining the position of the stent) until the device is fully retrieved into the microcatheter. When placing embolic coils through the interstices of the stent (C), a microcatheter with a distal tip of 2.5 French or less should be used. A standard embolic coiling procedure should be performed using accepted embolic coiling practices. A Y stenting (D) or a "kissing" technique is possible (E). (Courtesy of ev3, Inc., Irvine, CA.)*

successful in all cases. Retrieval of the fully deployed stent was attempted in 3 cases with a 100% success rate. Morbidity and mortality were not remarkable in these small series. Because the combined total number of basilar artery (BA) aneurysms from both series was only 5 (1 basilar tip aneurysm, 4 basilar trunk aneurysms), this report is focused on our initial clinical experience with this new, fully retrievable, self-expanding neurovascular stent combined with bioactive coils for the treatment of wide-necked aneurysms of the posterior circulation.

PATIENTS AND METHODS

In February 2008, we decided to treat wide-necked aneurysms prospectively by the use of the Solitaire AB stent as first-line treatment if stent-protected coiling of an aneurysm was needed. Since that time point, we have performed endovascular treatment in 40 patients using the Solitaire AB for stent-assisted coiling. Between February and August 2008, we treated 10 patients (age range, 32–76 years; mean age, 59.1 years) harboring wide-necked aneurysms of the posterior circulation. Solitaire AB stents were used (n = 14) in combination with Nexus coils with interwoven polyglycolic/polylactic acid microfilament threads (ev3, Inc.) to reduce the reopening rate of coiled aneurysms. Seven patients had a subarachnoid hemorrhage (SAH) (Hunt and Hess [H & H] grade I, n = 3; H & H grade II, n = 2; H & H grade III, n = 1; H & H grade V, n = 1). Three patients with giant, partially thrombosed aneurysms had clinical signs suggesting compression of the brainstem. There was only 1 aneurysm without any neurological signs in a 73-year-old woman; however, she wanted to be treated. The clinical data of the patients treated are summarized in Table 1.

All patients (except those with SAH H & H grades III–V) were informed about the treatment; it was emphasized that the stent was approved for clinical use and that, to date, only limited data from the literature were available. The possibility of performing the treatment with an alternative stent (Neuroform 2 or 3, Boston Scientific, Natick, MA; Leo, Balt, Montmorency, France; Enterprise, Cordis Neurovascular, Miami Lakes, FL) or a flow diverter was specifically mentioned, including that these stents would be available if treatment with the Solitaire AB stent was deemed unsatisfactory. All patients gave their informed consent.

All imaging studies were interpreted by 2 neuroradiologists (JK, CE). Aneurysm dimensions were derived primarily from preprocedural computed tomographic angiographic or magnetic resonance angiographic axial source data, reconstructed image, or a calculation from angiographic images. Aneurysms were classified into categories on the basis of size and neck width: small aneurysms (<10 mm) with wide necks (>4 mm), large (>10 mm), and giant (>25 mm). A qualitative assessment of aneurysm occlusion was performed (JK, CE) using a 3-point Raymond scale (41): 1) *complete occlusion* was applied when no contrast could be visualized within the aneurysm; 2) *neck remnant* was used when residual filling was noted in the region of the aneurysm neck only, typically between the interstices of coils in this region; and 3) *residual aneurysm* was applied if any contrast was visualized extending beyond the immediate parent vessel-aneurysm interface into the aneurysm fundus. In all cases, aneurysm occlusion was interpreted on the basis of the image obtained immediately after placement of the last coil.

Five patients presented with a wide-necked aneurysm of the basilar tip, 4 patients presented with a wide-necked aneurysm of the basilar trunk, and 1 aneurysm was located at the P2 segment of the posterior cerebral artery. Five aneurysms were small, 2 were large, and 3 were giant.

Patients with SAH were heparinized to an activated clotting time of 250 to 300 seconds before deployment of the stent, and heparin administration was continued for 48 hours after the procedure. Patients were started on aspirin 500 mg if the control computed tomographic scan performed directly after the procedure revealed no complications, indicating that no neurosurgical intervention was warranted. Patients were continued with aspirin 100 mg after the procedure in combination with low-molecular-weight heparin starting 48 hours after the procedure. Those patients without SAH in the acute stage were premedicated with antiplatelet therapy consisting of 100 mg of aspirin and a loading dose of 300 to 450 mg of clopidogrel 1 to 7 days before the procedure. Clopidogrel (75 mg/d) was continued for an additional 8 weeks after the procedure and then stopped. Aspirin (100 mg/d) was continued and anticipated to be administered for the patient's lifetime. In addition, patients were heparinized to an activated clotting time of 250 to 300 seconds during the endovascular procedure.

TABLE 1. Overview of patients treated by Solitaire AB stent-protected coiling[a]

Patient no.	Age (y)	Type of aneurysm	Size/neck width (mm)	Microcatheter stent delivery	Microcatheter coil delivery	Stent dimensions (mm)/technique	Symptoms	No. of Nexus coils	Occlusion degree[b]	GOS score at discharge
1	70	BA trunk	9/5.5	Rebar 18	Echelon 10	4/20	SAH, H & H V	9	Complete	5
2	72	BA bifurcation	3/3	Rebar 18	Echelon 10	2 × 4/20/ Y stenting	SAH, H & H II	2	Complete	1
3	53	BA trunk	3/3	Rebar 18	Echelon 10	4/20	SAH, H & H III	4	Complete	3
4	76	GA/PT BA bifurcation	10 × 6/4 (perfused portion)	Rebar 18	Echelon 10	4/20	Mass effect with HP	11	Complete	2
5	37	BA bifurcation	5 × 7/5	Rebar 18	Echelon 10	4/20	SAH, H & H II	10	Neck remnant	5
6	42	BA bifurcation	9/5	Rebar 18	Echelon 10	2 × 4/20/ Y stenting	SAH, H & H I	10	Neck remnant	1
7	75	GA/PT BA trunk	6/6.5 (perfused portion)	Rebar 18	Echelon 10	2 × 4/20/stent-in-stent	SAH, H & H I	21	Complete	1
8	73	BA bifurcation	15/5	Rebar 18	Echelon 10	4/20	None	21	Complete	1
9	45	GA/PT BA trunk	10/8 (perfused portion)	Rebar 18	Echelon 10	2 × 4/20/ stent-in-stent	Mass effect with HP	14	Complete	2
10	48	PCA P2 left	11/6	Rebar 18	Excelsior SL 10	4/20	SAH, H & H I	7	Neck remnant	1

[a] GOS, Glasgow Outcome Scale; BA, basilar artery; SAH, subarachnoid hemorrhage; H & H, Hunt and Hess; GA, giant aneurysm; PT, partially thrombosed; PCA, posterior cerebral artery; HP, hemiparesis.
[b] According to Raymond classification.

The feasibility of delivery/deployment by a single user, radial force, visibility, ease of retrievability (if needed), ease of stent detachment, and aneurysm occlusion rate were documented. The posttreatment outcome was determined based on the Glasgow Outcome Scale (GOS) score at discharge (20): 1 (good recovery), 2 (moderately disabled), 3 (severely disabled), 4 (vegetative survival), or 5 (death).

Three cases of basilar tip aneurysm were treated by a single Solitaire AB stenting from the P1 segment to the BA followed by a standard coiling procedure using Nexus coils. In 1 case, a transbrachial approach was required because of excessive elongation of the supra-aortic vessels. In addition, 1 aneurysm of the left P2 segment was also treated by a single Solitaire AB stenting from the P3 to the P1 segment, followed by a standard coiling procedure.

We treated 2 of 5 patients with broad-necked basilar tip aneurysms by creating a stent-in-stent "Y" configuration at the BA apex. After visualization of the aneurysm, a larger inner-bore single 6-French guide catheter (Cordis Neurovascular) was navigated to the vertebral artery, and a digital subtraction road map was made. A Rebar 18 microcatheter (ev3, Inc.) was navigated past the aneurysm into the left P1 segment. The initial Solitaire AB stent placed was deployed from the left P1 segment into the BA. The Rebar 18 microcatheter was then advanced through the stent struts into the right posterior cerebral artery, and the second Solitaire AB stent was deployed through the struts of the previously placed Solitaire AB stent into the BA, where it overlapped the first stent. An Echelon 10 microcatheter (ev3, Inc.) was advanced into the BA apex aneurysm using a 0.014-in. microguidewire, and coil embolization proceeded in the usual manner by use of Nexus coils.

Four additional patients with basilar trunk aneurysms were treated in this series. Two aneurysms of the basilar trunk were giant and partially thrombosed with progressive signs indicating compression of the brainstem. They were treated by a stent-in-stent technique.

After control angiograms were obtained, the guide catheter and vascular sheath were withdrawn, and hemostasis was achieved using a vascular closure device. In a single case, manual compression was performed to occlude the puncture side after a transbrachial approach.

RESULTS

All patients were successfully treated using this technique with no procedural complications. No thromboembolic complications, arterial dissections/ruptures, or spasms occurred during stent placement. Two of the 7 patients treated in the acute stage of SAH died unrelated to the endovascular treatment; at presentation, the initial H & H grade of these patients was II and V, respectively. Seven patients left the hospital with a good clinical status; 1 patient with SAH H & H grade III was severely disabled (GOS score 1, n = 5; GOS score 2, n = 2; GOS score 3, n = 1; and GOS score 5, n = 2). There were no difficulties in delivering the stents. In addition, there was no necessity to retrieve and reposition the stent after its initial full deployment. The radiopacity of the 3 distal and 1 proximal markers, which promoted proper placement of the stent, was satisfactory. In all cases in which the stent was placed before coil embolization, an Echelon 10 or an Excelsior SL 10 microcatheter was easily navigated through the stent struts into the aneurysm sac. Based on the postembolization angiographic studies, total occlusion with no residual lumen filling (Raymond class 1) was achieved in 7 of 10 aneurysms (70%). In the remaining 3 aneurysms, there was more than 95% occlusion (Raymond class 2). No stent misplacement or dislodgement occurred during the procedure.

Three patients with broad-necked basilar tip aneurysms were treated by a single Solitaire AB stenting from the P1 segment to the BA and then by a standard coiling procedure using Nexus coils. In 1 patient with a broad-necked P2 segment aneurysm, stenting from the P3 segment to the P1 segment successfully excluded the aneurysm, followed by "near-complete" coiling of the aneurysm (Fig. 2). This single procedure led to a satisfactory preservation of the artery in each case. In 2 cases with basilar tip aneurysms involving the origin of the P1 segment without a sufficient posterior communicating artery, creating a stent-in-stent Y configuration at the BA apex was technically easy, supporting a very dense packing of coils (Fig. 3). Two of 4 additional patients with basilar trunk aneurysms were treated by a double stent-in-stent technique in 1 session to create a flow diverter (Fig. 4).

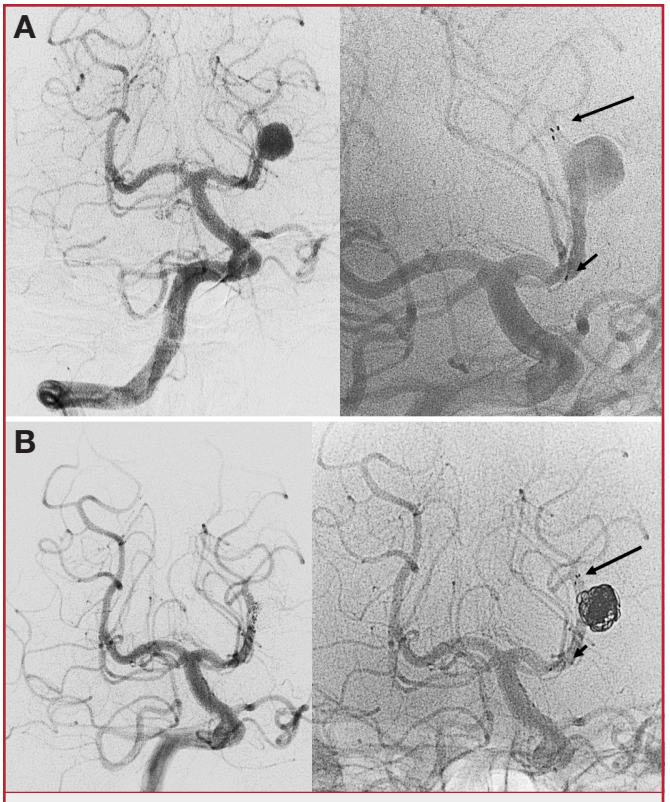

FIGURE 2. *Patient 10, a 48-year-old man who presented with subarachnoid hemorrhage (SAH), Hunt and Hess (H & H) grade I and Fisher grade 1, on day 3 after bleeding. After interdisciplinary discussion and clarification of risks, benefits, and alternatives, the patient was selected for endovascular treatment with stent-protected coiling.* **A**, *arteriogram of the right vertebral artery (posteroanterior view and angulated projection), showing a broad-based aneurysm of the P2 segment of the left posterior cerebral artery with a maximum diameter of 11 mm. The diameter of the P2 segment on the left side was estimated to be 2 mm.* **B**, *posttreatment arteriogram of the right vertebral artery (posteroanterior view and angulated projection). Note that the distal stent markers (arrows) are located near a bifurcation, and they will not ensure at least 4 mm on the distal side of the aneurysm neck after full deployment. Nevertheless, stent position was stable enough to perform "near-complete" coil occlusion of the aneurysm (arrowheads, proximal stent markers).*

DISCUSSION

Stent-protected endovascular occlusion of posterior circulation aneurysms with platinum coils has proven to be safe and effective. However, large and broad-necked aneurysms may be difficult to treat, despite recent technical advances. In cases of SAH, it is accepted that, of all clinical factors evaluated in the literature, H & H grade is the strongest predictor of good clinical outcome (38). Endovascular reconstruction of wide-necked aneurysms of the posterior circulation has been augmented by adjunctive techniques such as balloon and stent assistance (37, 47). In challenging, broad-necked BA or posterior cerebral aneurysms, balloon remodeling alone might not be sufficient to prevent coil protrusion into the parent vessel. For these cases, intracranial stents can be used. Nonetheless, limitations have also been reported, including a lack of retractability when partially deployed, low radial force, and some deployment difficulties (6, 13, 23). Periprocedural perforation of an aneurysm, aneurysm reruptures, or parent vessel damage can lead to a disastrous outcome if patients are taking an adequate antithrombotic regimen to prevent stent thrombosis and thromboembolic events (35, 36, 38). It is widely accepted that stent-assisted coiling should therefore be reserved for unruptured or for acutely ruptured aneurysms with no other therapeutic option. The treatment concepts should be addressed with an interdisciplinary approach.

In our series, the treatment of aneurysms in the posterior circulation demonstrates that the Solitaire AB stent is extremely flexible, is technically easy to deploy, and can be easily and safely

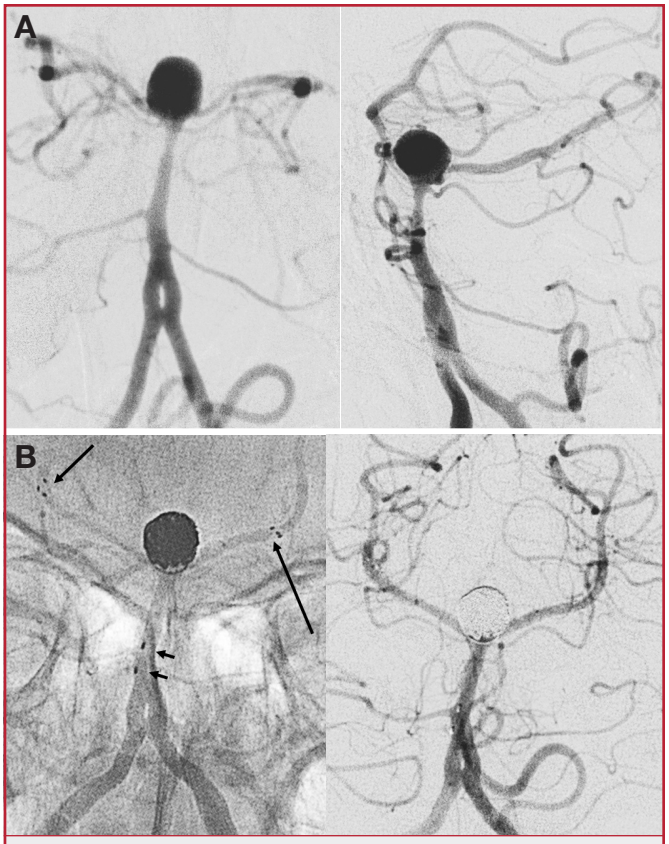

FIGURE 3. *Patient 6, a 42-year-old man who presented with SAH, H & H grade II, Fisher grade 1, on day 4 after bleeding. After interdisciplinary discussion, clarification of risks, benefits, and alternatives, the patient was selected for endovascular treatment with stent-protected coiling.* **A**, *arteriogram of the left vertebral artery (posteroanterior view and angulated projection), showing a broad-based aneurysm of the basilar tip with a maximum diameter of 12 mm. The diameter of the P1 segment on both sides was estimated to be 2.1 mm. Note that there are signs of vasospasm along the distal part of the basilar artery and the P1 segment on both sides. Before endovascular treatment, 2 mg of nimodipine was given via the guiding catheter.* **B**, *arteriogram of the left vertebral artery (unsubtracted view and subtracted view) after treatment with "Y stenting" of basilar artery to bilateral posterior cerebral artery and then standard coil embolization (arrows, distal stent markers; arrowheads, proximal markers). Reconstruction of the basilar tip was followed by complete occlusion of the aneurysm by bioactive coils. Note that the stents maintained patency of the formerly vasospastic vessels. The postprocedure hospital course was uneventful, with no rebleeding or thromboembolic complication. The patient did not need further endovascular treatment of vasospasm.*

maneuvered through severely tortuous and atherosclerotic vessels. Five of the patients treated were older than age 70 years. We used the Solitaire AB microstent without technical difficulty in 10 patients with wide-necked aneurysms. The Solitaire AB stents could be easily delivered through the Rebar 18 microcatheter and positioned to bridge the aneurysm neck in all cases. Noninvasive imaging by using magnetic resonance angiography and computed tomographic angiography is feasible in this stent system and may be useful for follow-up monitoring, but it is limited where Nexus bioactive coils are used (21).

Furthermore, this stent can be retrieved and repositioned by a single user, even after full deployment. The ease of handling the device enables new users and "switchers" to learn very quickly. Users will feel confident using this stent, as they will have full control of the stent's final position and final detachment.

That said, in our small series, it was not necessary to retrieve and reposition even a fully deployed stent. Retrievability of the stent system per se is a unique feature that makes the stent deployment more controllable and its use potentially safer. The stent has satisfactory visibility through the 3 distal markers and the proximal coil segment that remains attached to it. Placement is controlled by these markers on the microcatheter that are to be aligned with the 3-cm delivery coil at the end of the delivery system. Once positioned as desired, the stent is detached from the push wire using direct current application (1 mA for 60–120 seconds).

The visibility of the distal and proximal stent markers was excellent. However, visibility of the stent itself was not optimal even when high-quality fluoroscopy was used. These limitations of fluoroscopy in visualization of the stent are well known from other stent systems. Especially when used in combination with coils, distinguishing coil protrusion into the parent artery from the aneurysm coil mass superimposing on the stent may be problematic (35, 47, 48). Nevertheless, in our series, "complete" or "near-complete" occlusion of the aneurysms by the use of Nexus coils was feasible without significant prolapse of coils into the vessel lumen.

Although Doerfler et al. (11) stated that the stent prototype (Dendron GmbH, Bochum, Germany) can be manufactured in any diameter from 2.5 to 6.0 mm and any length from 10 to 35 mm, the stent diameter and length of the Solitaire AB stent is currently available with a stent dimension of 4 mm in diameter and 20 mm in working length. Therefore, the use in very small vessels (2- to 3-mm vessels) should be handled with prudence. However, in our experience, we detected no device-related vasospasm or thrombosis in stented vessels, even though the diameter of the stented P1 segment is approximately 2 mm.

Liebig et al. (28) reported on 4 BA aneurysms that were treated by the use of Solo stents (now Solitaire AB) with 6-mm diameter and 30-mm length or a Solo stent with 5-mm diameter and 20-mm length, respectively. One stent was retrieved, and the aneurysm was treated by the use of a different stent system; 1 basilar trunk aneurysm was treated by the use of a second stent (stent-in-stent technique). The occlusion rates of the coiled aneurysms were 90% to 99% in 3 cases and 100% in 1 case. In the series by Yavuz et al. (49), there was only 1 basilar trunk aneurysm, which was coiled after application of the Solo stent with "complete" occlusion, but there was no information about the stent dimension used in this case. These data from the Solo stents are in accordance with our findings in Solitaire AB stenting demonstrating a "complete" occlusion in 7 of 10 cases and "near-complete" occlusion in 3 of 10 cases.

The adequate radial force in the Solitaire AB stent reduces the possibility of displacement after deployment. Radial strength of

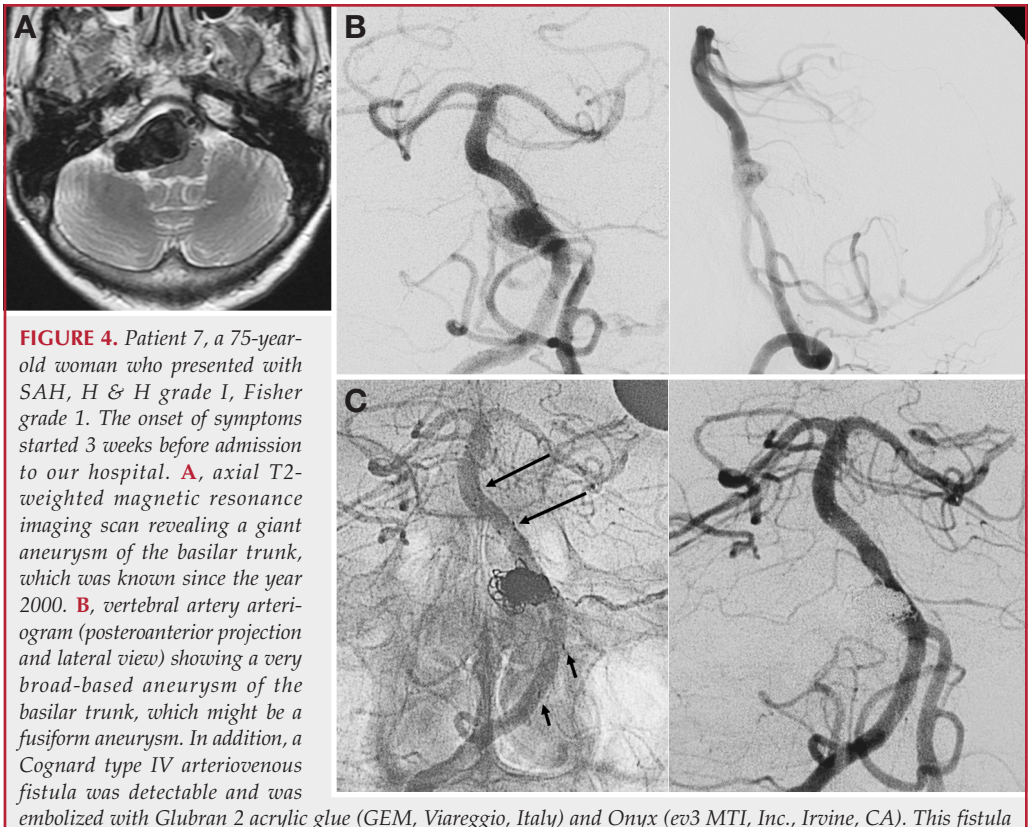

FIGURE 4. *Patient 7, a 75-year-old woman who presented with SAH, H & H grade I, Fisher grade 1. The onset of symptoms started 3 weeks before admission to our hospital.* **A**, *axial T2-weighted magnetic resonance imaging scan revealing a giant aneurysm of the basilar trunk, which was known since the year 2000.* **B**, *vertebral artery arteriogram (posteroanterior projection and lateral view) showing a very broad-based aneurysm of the basilar trunk, which might be a fusiform aneurysm. In addition, a Cognard type IV arteriovenous fistula was detectable and was embolized with Glubran 2 acrylic glue (GEM, Viareggio, Italy) and Onyx (ev3 MTI, Inc., Irvine, CA). This fistula was completely occluded before treatment of the aneurysm in the same session.* **C**, *vertebral angiogram after reconstruction of the basilar trunk with 2 stents (stent-in-stent technique) (arrows, distal markers; arrowheads, proximal markers) allowed nearly complete coil obliteration of the aneurysm via several different microcatheter approaches from the left and the right vertebral artery.*

a Solitaire AB was measured in vitro using the flat plate method. Radial strength of the Solitaire AB was 0.0106 N/mm of stent length, and that of the Enterprise stent was 0.0082 N/mm of stent length. Therefore, the Solitaire AB stent has approximately 30% more radial strength than the Enterprise. In all cases, placement of the Echelon 10 microcatheter combined with a 0.014-in. microguidewire through the stent into the aneurysm was achieved without any difficulty. Withdrawal of the microcatheter at the end of coil insertion was uneventful. The radial force and closed-cell design of the stent allowed excellent stabilization of coils between the stent and parent artery and prevented possible thromboembolic events.

Metal to lumen area ratio for the Solitaire AB is 5% to 7%, which means that Solitaire AB covers 5% to 7% of the vessel area with metal, when deployed in a vessel in the recommended size range. The gap between struts is approximately 4 mm long and up to 3 mm wide. Metal to artery ratio of the Solitaire AB is similar to that of the Enterprise. Our series showed that the Solitaire AB stent system can be deployed in a Y configuration dual technique as known from the Neuroform 2 stent design (Fig. 1D) (44). Solitaire AB cell length is also similar to that of Enterprise, but the Solitaire AB cell is approximately twice as wide as that of Enterprise. Therefore, the Solitaire AB cell area is twice as large as that of Enterprise. Because the Solitaire AB cell allows a 3-mm-diameter circle to pass through it, it lends itself very nicely to Y stenting. If a 4-mm stent is put through the interstices of a stent, it will be open to a 3-mm diameter while passing through the interstices of the first stent. In such Y stenting, the Enterprise stent can also be used as the second stent if the first one deployed is a Solitaire AB. Other commercially available stents will allow a diameter of only up to 1.5 mm to remain open in a Y stenting case. A Y stenting deployment performed in an in vitro model is shown in Figure 1D. In this regard, Solitaire AB provides the best of the open- and closed-cell design features. In a single case of Y stenting, the procedure was uneventful, although there was a severe vasospasm of the BA and the P1 segment on both sides (Fig. 3) already present before the procedure. The "kissing" stent technique, described by Henkes et al. (16, 39), is different from the Y (stent-through-stent) technique, but it presumably was not used in their study; nevertheless, deployment in this manner is technically feasible (Fig. 1E).

In our series, there was no need to use the stent design for constructing an artificial neck in a BA terminal aneurysm, although this strategy of endovascular treatment ("waffle cone technique") seems to be promising (18). In addition, stent-protected coil embolization can be performed as a staged maneuver, as we have shown in very broad-based/fusiform aneurysms at the basilar trunk. There were no technical problems in the delivery of a second stent (stent-in-stent technique), e.g., dislocation of the first stent. Detachment of the first stent after complete positioning of the second stent might be helpful in stabilizing the system during stent catheterization; this makes a difference in all stents available today. The stent-in-stent technique may result in a flow diverter model (24, 47). We did not need a third stent to stabilize the BA.

Because Solitaire AB has a relatively large cell, it offers an easy catheter access. The largest catheter that can pass through the cell of a single Solitaire AB is 3 mm in diameter. The pore size of the Solitaire AB would allow up to an 8-French catheter

to pass through, which is larger than most devices used in neurovascular intervention. Therefore, Solitaire AB will pose no restrictions on the size of catheter that can pass through it. If 2 stents are deployed across the neck, the ability to catheterize through the cell depends on the cell size of a single stent and the relative positions of the overlapping stents. Although the relative positions of cells from 2 overlapping stents will be arbitrarily distributed, a larger single stent cell increases the probability that a catheter will go through the double stent wall. Solitaire AB offers an advantage in such situations over Enterprise, Neuroform, or Leo Plus stents. Again, whether a catheter can travel through a double stent wall is not fully predictable. It depends on the relative locations of the cells in the 2 stents. It is possible that the catheter will go through certain locations but will be unable to go through others in any overlapping stent deployment. Whereas it cannot be ensured that the cells will have enough opening after a certain number of stents, the Solitaire AB will allow more stents to be deployed before the gap is too small compared with other commercially available stents. In our opinion, one of the major advantages of the Solitaire AB stent system is the ability to deploy the stent and safely place a remodeling balloon within it to perform stent- and balloon-assisted coil insertion or treatment with the Onyx embolic agent (ev3, Inc.) without detaching the stent (34). The stent can be detached after the treatment is completed. This technique eliminates the risk of inaccurate stent positioning if balloon placement is needed in the stent immediately after its deployment.

The posterior cerebral artery territory is relatively resistant to ischemia because the posterior cerebral artery has a rich collateral system, with the anterior choroidal artery and the superior cerebellar artery for the deep territory and the anterior and middle cerebral arteries for the superficial territory. Ischemic complications, however, do occur in the case of vessel occlusion. Accordingly, preservation of the parent artery must be one of the primary goals for the endovascular treatment of posterior cerebral artery aneurysms. Therefore, stent-assisted coiling, as performed in patient 10, is recommended if the aneurysm seems to be at high risk for surgical intervention because of the location at the P2 segment (37, 38, 42, 51).

Giant BA aneurysms are some of the most challenging vascular pathological lesions (45, 46). Anatomic features that create challenges in the therapeutic approach include size, shape, neck dimensions, branch involvement, intraluminal thrombosis, and location. The treatment objectives are protection from bleeding, reduction of size for mass effect relief, and prevention of thromboembolic complications.

Endovascular therapy has evolved as a safe and effective treatment option for selected aneurysms; however, the endovascular treatment of these giant aneurysms is difficult. As described in this report, aneurysms of this size have a body and fundus that exceed the size of the parent artery incorporating almost invariably a significant proportion of the parent vessel in a saccular aneurysm. The presence of a wide neck in relation to the parent vessel has been associated with incomplete occlusions and higher recanalization rates after coiling. In these cases, often the exact anatomy of the neck could not be clarified by angiographic technique.

The Solitaire AB stent has a closed-cell design cut from a nitinol tube together with a stainless steel pusher wire. The closed-strut design addresses problems that can result from the dislocation of single cells in an open-strut mesh or from interference with coils and guidewires. However, in 2 cases of giant and partially thrombosed basilar trunk aneurysms, the first stent did not preserve the BA during the whole procedure; therefore, a second stent-in-stent was mandatory in 1 treatment session. This structure may be similar to a flow diverter (Fig. 4). In those cases, the presence of thrombus inside the aneurysm is associated with higher recanalization rates secondary to migration and compaction of the coils into the wall thrombus and inadvertent embolic events during coil deposition. To obtain a stable coil basket, we used Nexus coils with interwoven polyglycolic/polylactic acid microfilament threads intended to reduce the reopening rate of coiled aneurysms. However, the efficacy of bioactive coils remains controversial and is being studied in randomized trials. With the use of antiplatelet therapy, which is routinely initiated 1 to 7 days before the elective procedure and started immediately after the therapy in the case of acute SAH, no thromboembolic complications occurred in the present study. The overall total occlusion rate was 70% immediately after treatment with Solitaire AB stent-supported coil embolization.

Endovascular coil embolization of posterior circulation aneurysms is an effective treatment in the short term but is associated with recurrence, which requires close surveillance, may need retreatment, and can, albeit very rarely, lead to rehemorrhage. Therefore, the use of biologically active coils such as Nexus in combination with stenting will permit a higher rate of permanent obliteration of these aneurysms.

CONCLUSION

The Solitaire AB stent was successfully used clinically in 10 patients with broad-based aneurysms of the posterior circulation. Treatment without a stent or other remodeling technique in these patients might have been impossible or would have yielded an unsatisfactory result. The stent proved to be highly flexible and could be positioned to bridge the neck of the aneurysm, even in tortuous vessels.

All of these findings are consistent with the experimental and animal in vivo data that have recently been published regarding the former Solo stent. Our preliminary results demonstrate that this new device shows promise as an aneurysm-bridging stent because it can be accurately and reliably positioned in small intracranial vessels. In addition, this electrolytically detachable stent is fully retrievable and thus provides greater control compared with currently available self- or balloon-expandable stents.

Disclosure

Joachim Klisch, M.D., is a consultant to ev3, Inc., Irvine, CA. The other authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

Klisch et al. report on their preliminary experience using the Solitaire device for stent-assisted coiling of posterior circulation aneurysms. This stent is fully retrievable, which may occasionally be advantageous when compared with the self-expanding stents that are currently available in North America. The feasibility of "Y stenting" is an advantage over the Enterprise stent but not the Neuroform stent. This stent has relatively large struts, which offers the potential advantage of easier aneurysm catheterization but could increase the risk of coil protrusion into the parent artery. One of the questions that has arisen about using self-expanding stents intracranially relates to the potential for stent kinking on severe curves. It will be very interesting to see how this stent compares on this issue. Stent use in subarachnoid hemorrhage remains problematic. We suspect that further advances in intracranial stents will depend on strategies that prevent stent thrombosis and decrease the need for antiplatelet medications.

Michael C. Hurley
Bernard R. Bendok
Chicago, Illinois

The authors retrospectively evaluated 10 patients who had wide-necked aneurysms treated with a new retrievable intracranial stent system, the Solitaire AB. Obviously, the advantage of this stent is that it is totally retrievable and certainly can be repositioned. Other stents on the market that can be resheathed to a certain extent offer the same advantage.

The utility of stent technology in wide-necked aneurysms certainly has been well described and worked out, and this new device has some additional advantages. In our own experience, stent positioning has not been problematic, but in a small number of cases, this would be a useful technology to apply.

Robert H. Rosenwasser
Philadelphia, Pennsylvania

FUTURE MEETINGS—CONGRESS OF NEUROLOGICAL SURGEONS

The following are the planned sites and dates for future annual meetings of the Congress of Neurological Surgeons:

2009	New Orleans, LA	October 24–29
2010	San Francisco, CA	October 23–28
2011	Washington, DC	October 1–6
2012	Chicago, IL	September 29–October 4
2013	San Francisco, CA	October 19–24