Combined endovascular treatment of dissecting vertebral artery aneurysms by using stents and coils

PEDRO LLYLYK, M.D., JOSÉ E. COHEN, M.D., ROSANA CERATTO, M.D., ANGEL FERRARIO, M.D., AND CARLOS MIRANDA, M.D.

Department of Neurosurgery and Interventional Neuroradiology, Eneri, Clínica Médica Belgrano, Buenos Aires, Argentina

Object. With the recent development and refinement of endovascular stents, the significant potential for these devices in the treatment of wide-necked dissecting and fusiform aneurysms has become apparent. In this article the authors report on the use of stents and coils to treat dissecting and fusiform vertebral artery (VA) aneurysms.

Methods. Eight consecutive patients harboring eight dissecting aneurysms and one fusiform aneurysm of the VA were successfully treated using a procedure in which the authors inserted an intravascular stent and secondary endosaccular coils when needed. In all but one patient complete aneurysm occlusion was achieved, and in all cases there was no neurological complication. Follow-up angiography examinations were performed in all patients (mean duration of follow-up angiography review 13.1 months, range 3–42 months). The patients remained stable throughout the clinical follow-up period (mean 14.1 months, range 4–42 months). No rebleeding was recorded.

Conclusions. At present this combined approach represents a reliable and safe alternative for the treatment of VA dissecting aneurysms, especially in patients who cannot tolerate occlusion tests.

KEY WORDS • vertebral artery • dissecting aneurysm • stent • aneurysm embolization • coil
Patients were selected for stent placement on the basis of a number of factors, including failure of, or contraindication for, coil placement or surgery; poor neurological grade; or poor medical status. Primary coil placement was attempted in one patient (Case 4); however, the coils failed to remain within the aneurysm and, instead, herniated into the parent artery.

All patients were evaluated by two neurosurgeons, two vascular neurologists, and four neuroradiologists—all members of the endovascular team. All patients also underwent computerized tomography and/or magnetic resonance imaging and cerebral angiography preoperatively.

Four patients underwent balloon test occlusion and a hypotensive challenge to assess the risk for vessel thrombosis. One patient experienced neurological signs during the test and three patients tolerated the hypotensive challenge.

A detailed report on the first patient who was treated using this combined procedure has been already published.11 No patient was lost to follow-up monitoring.

**Evaluation of Stent Placement**

Stent insertion was recorded as optimal when the stent was positioned across the aneurysm orifice leaving a sufficient amount of overlap on each side; insertion was deemed suboptimal when the stent did not overlap on both sides of the opening, but still covered more than 66% of the aneurysm orifice.

**Evaluation of Embolization Procedures**

All treated aneurysms were evaluated on the basis of findings on selective DS angiograms and transcranial Doppler sonograms after treatment and at the follow-up examination. An occlusion grading system was used to evaluate treatment based on the extent of residual aneurysm. Aneurysm occlusion was based on a three-tiered scale composed of the following categories: complete occlusion (no residual neck or aneurysm could be seen on DS angiograms); neck remnant (only a small residual neck of ≤1 mm); or partial occlusion.

**General Operative Procedure**

Every patient was taken to the endovascular suite for cerebral angiography and endovascular treatment. General anesthesia was routinely indicated. Appropriate monitoring of brainstem evoked potentials, cerebral oxygen saturation, and invasive arterial pressure was performed. A unilateral or bilateral intraarterial approach was initiated following standard Seldinger puncture. Catheterization was used and a No. 8 French introducer sheath was placed in the right femoral artery while full heparin therapy was administered. Following our protocol, a 10,000-IU bolus dose of heparin was given immediately before the start of the therapeutic procedure and a 1500-IU maintenance booster was added every hour to provide an activated coagulation time longer than 250 seconds before stent placement. Patients scheduled for elective procedures received uncoated oral acetylsalicylic acid (500 mg every day) and oral ticlopidine (250 mg twice a day) for 3 days before the stent procedure, and patients undergoing emergency procedures for acute SAH underwent combined antiplatelet therapy on the day of surgery. All patients were kept on a regimen of both medications for 90 days, after which ticlopidine was no longer given.

Selective DS angiography was performed and the targeted lesion was routinely outlined in multiple projections by using rotational three-dimensional angiography. In selected cases we performed a functional balloon test occlusion immediately before treatment. This particular balloon was never used to determine proximal flow control during stent placement.

A guiding catheter system consisting of a No. 6 French Envoy guiding catheter coaxial to a No. 8 French Envoy catheter was advanced into the diseased VA by using a standard 0.035- or 0.038-in guidewire. We advanced an Excel, Prowler, or Rapid Transit microcatheter over a tapered 0.014-in-diameter, 150-cm-long guidewire and then with the aid of a magnetic device performed a microcatheter exchange, to insert the balloon-premounted stent delivery system (four cases). As an option, the microguide wire can be replaced by a 0.014-in-diameter 300-cm-long exchange microguidewire, after which the microcatheter...
can be withdrawn (4 cases). Adequate support was needed to guide the stent device over the microguidewire, and this was achieved by navigating the wire across the target and as far as the P1 and P segments.

In our current series, follow-up clinical and angiographic evaluations were planned at 1 month for patients with partially treated aneurysms and at 3 months and/or 6 months and 1 year for patients with completely occluded aneurysms. Clinical assessment of patients was determined using the National Institutes of Health Stroke Scale and the GOS.9

**Stent Selection and Description**

Careful stent sizing is very important. In general, the stent size should be chosen to match the diameter of the pertinent vessel and to correspond with the length of the lesion, occlusion, or aneurysm neck. In the first cases treated, we used devices currently applied in interventional cardiology such as the Angiostent, a balloon-expandable metallic stent made of platinum (one case), the self-expandable Wallstent (one case), and, later, the AVE GFX stent, made of stainless steel (six cases). More recently, we used a new generation of stents specifically designed for neuroradiology such as the AVE INR stent (two cases), which is a metallic, radiopaque stent with a more flexible design and a delivery-release catheter. The stent should be positioned across the lesion with enough overlap on each side of the target to anchor the device properly. The device is released by inflation of the balloon delivery system with 6 atm pressure. After stent release, the aneurysm lumen usually continues to fill with contrast medium. In that case, one may decide to pack the lumen with coils after positioning the tip of a microcatheter through the stent struts or elect to take a wait-and-see attitude before initiating a second procedure in nonhemorrhagic cases in which there is marked intraluminal stagnation of contrast medium. In Case 2, marked stagnation was achieved using two stents abutting each other at the aneurysm orifice.

**Sources of Supplies and Equipment**

For functional balloon test occlusion, we used Zeppelin balloon supplies provided by Micro Interventional Systems (Sunnyvale, CA). In one patient (Case 3), we used a 3.5 × 4-mm blind-ended balloon catheter, obtained from Interventional Therapeutics Corp. (South San Francisco, CA) to dilate arterial segments. The Nos. 6 and 8 French Envoy catheters and the Prowler and Rapid Transit microcatheters were purchased from Cordis Endovascular Systems (Miami, FL) and the Excel microcatheter from Boston Scientific (Natick, MA). The tapered 0.014-in-diameter, 150-cm-long Transend-14 guidewire, the 0.014-in-diameter, 300-cm-long Choice exchange microguidewire, and the magnetic device (The Magnet) used to perform microcatheter exchanges were acquired from SciMed Life Sciences (Maple Grove, MN).

The Angiostent was purchased from Angio Dynamics (Queensbury, NY), the Wallstent from Schneider (Osaka, Japan), and models AVE GFX and AVE INR stents from Arterial Vascular Engineering, Inc. (Santa Rosa, CA). The GDCs were purchased from Target Therapeutics (Fremont, CA).

**Results**

Of the nine aneurysms treated with stents, seven (77.8%) were subjected to additional endosaccular coil placement. The overall success rate in using stents to access the targeted lesion was 100% (nine of nine targets). No procedure was aborted because of inability to reach the target. In two instances the first stent that was selected was insufficient to reach the target; however, use of a triaxial catheter system, a more adequate selection of stent (length, size, or brand), and a more distal placement of the microguidewire contributed to improved navigation.

Stent release and positioning were considered optimal in seven lesions (77.8%) and suboptimal in two (22.2%). In the two patients (Cases 5 and 7) in whom placement was suboptimal, a second stent had to be positioned, abutting the first proximally, and the overall result was excellent. One patient (Case 2) was intentionally treated with overlapping stents that completely covered the aneurysm orifice.

**Cases With Additional Coil Placement**

In all seven patients who presented with SAH, stent placement across the aneurysm neck was followed by adjunctive GDC placement by using a microcatheter that was positioned within the aneurysm through an opening in the stent mesh. Placement of a microcatheter through the stent was relatively easy in most cases and was performed in all cases on the same operative day because of the high rebleeding rate of symptomatic lesions.

On angiograms obtained immediately postoperatively, complete occlusion was verified in all but two patients. In one patient (Case 1) a very small neck remnant could be detected; this remained stable as confirmed on follow-up angiograms and continues to be closely observed (Fig. 1). Another patient (Case 4) harbored a neck remnant that was subsequently retreated with GDC placement, resulting in a complete occlusion.

**Case Without Additional Coil Placement**

One patient (Case 2) harbored two aneurysms; complete occlusion was achieved for one of the aneurysms by using two overlapping stents and for the other aneurysm by using one stent. There was no need for placement of a GDC. Angiograms obtained immediately following the procedure did not confirm occlusion, but significant stagnation of contrast media could be observed. This observation was particularly noticeable in the aneurysm treated with overlapping stents (double full-length stent coverage of the aneurysm orifice). On follow-up DS angiograms, it was clear that complete occlusion of both aneurysms had been achieved (Figs. 2 and 3).

**Technical Complications and Postoperative Morbidity**

A total of 10 embolization procedures were performed for the treatment of nine aneurysms. No permanent procedural neurological or clinical complication occurred.

One patient (Case 3) underwent mechanical percutaneous transluminal angioplasty for severe symptomatic vasospasm in the BA on post-SAH Day 13. A 3.5 × 4-mm blind-ended balloon catheter was advanced upward through the lumina of both stents to the BA, and both P1 segments were successfully dilated.
Follow-Up Clinical Evaluation

Follow-up clinical data were obtained for patients 48 hours and 1, 3, 6, and 12 months postprocedure. Good short-term clinical outcomes (GOS Scores 4 and 5) were achieved in all patients. There was no rebleeding of any dissecting aneurysm and the patients’ clinical conditions have remained stable throughout the follow-up period (mean 14.1 months, range 4–42 months; Table 1). One patient (Case 2) originally suffered from mass effect–related symptoms. Postoperatively, these symptoms were ameliorated and a reduction in the mass effect was consistently observed on follow-up magnetic resonance images.

Follow-Up Angiography Evaluation

Follow-up angiography data were obtained for all patients at 1, 3, and 12 months postoperatively, and yearly thereafter. In the seven cases treated with adjunctive coils, postoperative occlusion remained unchanged on follow-up DS angiograms (mean angiography follow-up period 13.1 months, range 3–42 months).

Three patients (Cases 1, 3, and 5) have been observed clinically and angiographically for more than 12 months. This subset of patients has remained clinically stable.

Discussion

Wide-necked saccular, dissecting and fusiform aneurysms constitute a persistent surgical challenge and frequently cannot be treated using standard clipping and endovascular procedures because the aneurysm neck is inadequate to hold coils or a clip. The recent availability of flexible stents that can be navigated through tortuous proximal intracranial vessels prompted us to consider using a stent-assisted procedure for the endovascular treatment of a subset of wide-necked VA dissecting aneurysms that were not suitable for GDC treatment alone.

In this setting, the flexible stent can be used to create a neck in the aneurysm that can hold the GDCs in place, virtually avoiding coil protrusion and migration and allowing tighter packing of the aneurysm. Secondarily, the stent itself may disrupt aneurysm inflow, thereby inducing stasis and facilitating intraaneurysmal thrombosis. This mechanism may have played a major role in both aneu-

Fig. 1. Case 1. Upper Left: Initial diagnostic angiogram of the right VA (left oblique projection) obtained at admission revealing a dissecting aneurysm arising from the right VA. Upper Right: Angiogram of the VA obtained after stent and GDC placement demonstrating a small residual aneurysm neck. Lower Left: Magnified nonsubtracted fluoroscopic image obtained without addition of contrast medium disclosing the position of the implanted stent and coils. Lower Right: Follow-up angiogram of the right VA (left oblique projection) obtained 19 months postoperatively revealing persistent occlusion of the aneurysm and excellent blood flow through the BA and both posterior cerebral arteries.

Fig. 2. Case 2. Upper Left: Digital subtraction angiogram of the right VA (oblique view) revealing an incidental dissecting aneurysm. Upper Right: Digital subtraction angiogram of the right VA (oblique view) depicting the dissecting aneurysm after stent placement. Lower Left: Magnified nonsubtracted fluoroscopic image (oblique view) obtained without addition of contrast medium disclosing the position of the implanted stent. Lower Right: Follow-up angiogram obtained 3 months later verifying aneurysm obliteration.

In this study the median length of stay in the intensive care unit was 2 days and that in the intermediate care unit was 2 days (mean 4 days, range 3–9 days). This time period includes the admission for the patient (Case 4) who underwent a second procedure.
Stents and coils for dissecting aneurysms

Aneurysms in the patient in Case 2, excluding the need for adjunctive coil placement. The strategy used to treat fusiform aneurysms consisted of double-mesh coverage of the aneurysm orifice to promote a more dramatic change in intraluminal flow.

Stent interstices are wide enough to allow adequate bloodflow through collateral branches and are also suitable to allow a microcatheter to be placed through them to deposit GDCs in the gap between the stent and the inner wall of the aneurysm.10–12,15,16

All patients presenting with SAH were treated using the combined stent–coil placement procedure; in four of these patients the procedure was performed before Day 5 post-SAH. Although the total number of patients in this subgroup is relatively small, we found that the risk of intraoperative rupture was not increased in the setting of acute SAH.

One patient (Case 2) harbored a left VA fusiform aneurysm and a right VA dissecting aneurysm. The findings in this case may be added to recent evidence indicating that dissecting and fusiform aneurysms are interchangeable entities. Fusiform aneurysms may become dissecting aneurysms if hemodynamic stress is induced, and some fusiform aneurysms may be damaged dissecting aneurysms that have undergone a healing process.19

Flexibility, trackability and radiopacity, although improved in new stents, are still a main concern for surgery and limit navigation through tortuous vessels. These devices are still far from ideal and, furthermore, appropriate stent selection is currently restricted by the limited availability of sizes and lengths. In two instances (Cases 2 and 7), 18-mm-long stents were too short to reach the target. At present, longer stent–balloon systems tend to be less flexible and trackable.

In three instances (Cases 2, 5, and 7), two shorter and more flexible stents were placed, abutting each other, taking the place of a single long stent that could not have been used to negotiate the vessel curves.

We found that some technical considerations are of paramount importance to reach a distal target by using a stent. We increasingly tend to use a triaxial guiding catheter system composed of a No. 8 French catheter and a coaxial No. 6 French catheter. The former catheter is placed in the subclavian artery and the latter selectively in the V2 segment. This combination allows adequate proximal support for the procedure. Distal support is achieved by navigating the microguidewire across the target and as far as the P2 and P3 segments. Recent technical advances such as The Magnet allow microcatheter exchange while maintaining the position of the microguidewire.

Suboptimal stent placement was observed in cases treated during our early stenting experience; however, the learning curve for treating intracranial lesions with stents, while avoiding technical problems, has been steep. Inadequate stent size selection (length and/or diameter), under-expansion of the stent (fear of over-dilation), and the inability to deflate the balloon fully after stent release has contributed to suboptimal placement. In such cases, a second stent can be placed, abutting the first, and the desired target can thereby be covered.

The final goal of the treatment of hemorrhage-producing dissecting aneurysms is to prevent a subsequent rupture, while preserving the VA patency. Both can be achieved using this combined endovascular approach. In the near future, covered stents may provide a novel means for occlusion of dissecting aneurysms.

Conclusions

We report our experience with the use of intracranial stents alone or in combination with coils for the treatment of dissecting aneurysms of the VA. The method of using an intravascular stent to maintain the patency of the arterial lumen while allowing strategic coil placement in the aneurysmal sac and providing an artificial aneurysm neck provides another endovascular treatment option for aneurysms not amenable to clipping or conventional GDC placement, while maintaining the patency of the VA.

With continuing development of more flexible balloon and stent systems, focusing on tracking, flexibility, radiopacity, and thrombogenic properties, intracranial arterial stent placement will become one of the best management procedures for dealing with VA dissecting aneurysms.

References


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Address reprint requests to: Pedro Lylyk, M.D., Sanchez de Bustamante 2184, PB Dpto B (1425), Buenos Aires, Argentina. email: plylyk@lylyk.com.ar.