Panacea or problem: flow diverters in the treatment of symptomatic large or giant fusiform vertebrobasilar aneurysms

Clinical article


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Object. The use of flow-diverting stents has gained momentum as a curative approach in the treatment of complex proximal anterior circulation intracranial aneurysms. There have been some reported attempts of treating formidable lesions in the posterior circulation. Posterior circulation giant fusiform aneurysms have a particularly aggressive natural history. To date, no one approach has been shown to be comprehensively effective or low risk. The authors report the initial results, including the significant morbidity and mortality encountered, with flow diversion in the treatment of large or giant vertebrobasilar aneurysms at Millard Fillmore Gates Circle Hospital.

Methods. The authors retrospectively reviewed their prospectively collected endovascular database to identify patients with intracranial aneurysms who underwent treatment with flow-diverting devices and determined that 7 patients had presented with symptomatic large or giant fusiform vertebrobasilar aneurysms. The outcomes of these patients, based on the modified Rankin Scale (mRS), were tabulated, as were the complications experienced.

Results. Among the 7 patients, Pipeline devices were placed in 6 patients and Silk devices in 1 patient. At the last follow-up evaluation, 4 patients had died (mRS score of 6), all of whom were treated with the Pipeline device. The other 3 patients had mRS scores of 5 (severe disability), 1, and 0. The deaths included posttreatment aneurysm ruptures in 2 patients and lack of improvement in neurological status related to presenting brainstem infarcts and subsequent withdrawal of care in the other 2 patients.

Conclusions. Whether flow diversion will be an effective strategy for treatment of large or giant fusiform vertebrobasilar aneurysms remains to be seen. The authors’ initial experience suggests substantial morbidity and mortality associated with the treatment and with the natural history. As outcomes data slowly become available for patients receiving these devices for fusiform posterior circulation aneurysms, practitioners should use these devices judiciously.

Key Words: flow diversion, flow reversal, fusiform vertebrobasilar aneurysm, Pipeline device, interventional neurosurgery

Since the initial reports by Fiorella et al. and the voluminous experience from Lylyk et al. in Argentina, the use of flow-diverting stents has gained momentum in the treatment of both saccular and fusiform aneurysms, mainly of the internal carotid artery, but also of the vertebrobasilar system. Flow diverters are stents with much higher metal coverage and lower porosity than traditional intracranial stents, whose aim is to redirect flow through an artificially created lumen inside the parent vessel and away from the aneurysm, whether saccular or fusiform. Additionally, flow diverters provide a scaffold for neointimal growth and healing of the vessel wall. The porosity of the stent is thought to allow for blood flow to continue through perforating arteries, given the demand of these vessels. Although flow is still possible into the aneurysm lumen, the stagnation of blood is responsible for aneurysm thrombosis, which usually oc-

Abbreviations used in this paper: BA = basilar artery; mRS = modified Rankin Scale; PITA = Pipeline embolization device for the Intracranial Treatment of Aneurysms; SAH = subarachnoid hemorrhage; VA = vertebral artery.
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curs in a delayed fashion. The results have been promising: Lylyk et al.\textsuperscript{14} reported angiographically documented occlusion rates of 56\%, 93\%, and 95\% at 3, 6, and 12 months, respectively, whereas the investigators of the recently conducted PITA trial\textsuperscript{15} reported a 93\% occlusion rate at 6 months.

In April 2011, the Pipeline embolization device (ev3/ Covidien Vascular Therapies) gained FDA approval for large or giant wide-necked intracranial aneurysms in the internal carotid artery from the petrous to the superior hypophyseal segments. The Silk stent (Balt Extrusion) was approved for use outside the US in 2007. As of March 2010 and August 2010, 1178 and 1500 patients had been treated with the Pipeline and the Silk devices, respectively;\textsuperscript{21} the majority of these flow diverters have been used for carotid artery pathology. Despite the overwhelmingly positive reports of the results obtained with these devices,\textsuperscript{18,14,15,19,21} minimal evidence exists outside the confines of a clinical study documenting the potential limitations of these devices. Two previous publications have documented serious complications: late-onset BA thrombosis (after 2 years)\textsuperscript{8} and perforator infarction.\textsuperscript{20} As the authors of one of these publications have indicated, the true incidence of perforator infarction is not yet known.\textsuperscript{20} Although the use of flow diverters in the anterior circulation may be useful for internal carotid artery aneurysms below the anterior choroidal artery, aneurysms of the posterior fossa are quite different. The perforator-rich regions of the vertebrobasilar system make the use of flow diverters in this region an entirely different entity.

Vertebrobasilar fusiform aneurysms remain one of the most formidable lesions treated by neurosurgeons to date, with no firmly accepted management paradigm. According to some, the natural history renders mortality to date, with no firmly accepted management paradigm. The pore size is 0.02–0.05 mm\textsuperscript{21} and the device is meant to create thrombosis of the aneurysm while allowing for patency of the arterial perforators. A series of Pipeline devices can be placed and overlapped to aid in aneurysm thrombosis or to extend the overall construct length for aneurysm morphologies that are particularly long. Adjunctive coil placement may enhance aneurysm thrombosis.

The Silk stent or flow diverter represents a similar technology and has been available outside the US for use in the treatment of intracranial aneurysms.\textsuperscript{2,10–13,21} This device is a braided mesh cylinder constructed of 25\% platinum and 75\% nickel-cobalt chromium alloy; the metallic coverage afforded is approximately 30\%–35\% of the surface area.\textsuperscript{21} The pore size is 0.02–0.05 mm\textsuperscript{21}. The device is meant to create thrombosis within the aneurysm while allowing for patency of the arterial perforators. A series of Pipeline devices can be placed and overlapped to aid in aneurysm thrombosis or to extend the overall construct length for aneurysm morphologies that are particularly long. Adjunctive coil placement may enhance aneurysm thrombosis.

The Pipeline embolization device is a braided mesh cylinder constructed of 25\% platinum and 75\% nickel-cobalt chromium alloy; the metallic coverage afforded is approximately 30\%–35\% of the surface area.\textsuperscript{21} The pore size is 0.02–0.05 mm\textsuperscript{21}. The device is meant to create thrombosis within the aneurysm while allowing for patency of the arterial perforators. A series of Pipeline devices can be placed and overlapped to aid in aneurysm thrombosis or to extend the overall construct length for aneurysm morphologies that are particularly long. Adjunctive coil placement may enhance aneurysm thrombosis.

Here, we report the results of flow diversion in the treatment of symptomatic large or giant fusiform vertebrobasilar aneurysms at our institution, including Pipeline device–related complications that resulted in significant morbidity and mortality. Despite the initial enthusiasm accompanying the introduction of flow diverters, our recent experience has caused us to reassess strategies that include the use of flow diverters in these very complex aneurysms.

Methods

We retrospectively reviewed the prospective endovascular database at Millard Fillmore Gates Circle Hospital and determined that 25 patients had been treated to date with the Pipeline embolization device, either as part of the Pipeline for Uncoilable or Failed Aneurysms Study\textsuperscript{22} or subsequent to FDA approval of this device. An additional patient underwent treatment with the Silk flow-diverting stent through a humanitarian device exemption.\textsuperscript{1} Patients who present with aneurysms not amenable to routine endovascular or open surgical treatment are presented for discussion at a weekly case conference attended by neurosurgeons proficient in both therapeutic approaches. Among the 26 patients treated with flow diverters (25 with the Pipeline device, 1 with Silk device), 7 patients with fusiform vertebrobasilar aneurysms underwent treatment with either the Silk (n = 1) or the Pipeline (n = 6) device between October 2009 and August 2011 (Table 1). (In addition, during the same time frame, 3 other patients presented with symptomatic large or giant fusiform vertebrobasilar aneurysms, and while awaiting scheduled flow-diversion procedures, 1 suffered a fatal brainstem infarct and 2 suffered fatal SAHs.)

Prior to flow-diverter placement, patients are routinely placed on aspirin and clopidogrel, and response testing to both medications is performed to confirm therapeutic responses to aspirin and clopidogrel. Adjunctive coiling is performed to assist in thrombosis of the aneurysm when deemed necessary during the procedure.

Clinical outcomes were assessed during follow-up evaluations using the mRS. All follow-up evaluations were conducted at the clinic or by correspondence with the primary neurosurgical team close to the patient’s home.

The institutional review board at the University at Buffalo, State University of New York, approved this study.

Study Devices

The Pipeline embolization device is a braided mesh cylinder constructed of 25\% platinum and 75\% nickel-cobalt chromium alloy; the metallic coverage afforded is approximately 30\%–35\% of the surface area.\textsuperscript{21} The pore size is 0.02–0.05 mm\textsuperscript{21}. The device is meant to create thrombosis within the aneurysm while allowing for patency of the arterial perforators. A series of Pipeline devices can be placed and overlapped to aid in aneurysm thrombosis or to extend the overall construct length for aneurysm morphologies that are particularly long. Adjunctive coil placement may enhance aneurysm thrombosis.

The Silk stent or flow diverter represents a similar technology and has been available outside the US for use in the treatment of intracranial aneurysms.\textsuperscript{2,10–13,21} This device is a braided mesh cylinder made from 48 nickel-titanium and platinum microfilaments to provide 35\%–55\% metallic coverage.\textsuperscript{21} The pore size is 110–250 \(\mu\text{m}\).\textsuperscript{21} The Silk stent is braided tighter than the Pipeline stent and may be re-sheathed when deployed less than 90\%; however, placing this device may require use of another nitinol device, the Leo stent (Balt Extrusion) (high radial force, ease of delivery, and re-sheathable up to 90\% deployed\textsuperscript{23}), to provide a scaffold of support.\textsuperscript{1}

Results

The results of this series are presented in Table 1. The last 4 patients were all treated within the last 3 months of this report. Case 1 has been previously reported.\textsuperscript{1} Briefly, this 75-year-old man presented with progressive gait instability and imbalance. He was found to have a giant par-
TABLE 1: Data obtained in 7 patients undergoing Silk or Pipeline device placement for large or giant symptomatic vertebrobasilar artery fusiform aneurysms

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Preop Stroke</th>
<th>Presentation</th>
<th>Preop mRS Score</th>
<th>Aneurysm Shape</th>
<th>Aneurysm Max Diameter (mm)</th>
<th>Aneurysm Estimated Length (mm)</th>
<th>No. of Flow Diversions†</th>
<th>Device Sizes in mm (no. if &gt;1)</th>
<th>Coils</th>
<th>Postop Stroke at Last FU</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>75</td>
<td>no</td>
<td>difficulty ambulating, dizziness</td>
<td>1</td>
<td>fusiform, midbasilar</td>
<td>14.3</td>
<td>31</td>
<td>2 Silk &amp; 1 Leo stent</td>
<td>4.5 × 50, 4.5 × 30</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>2</td>
<td>66</td>
<td>yes</td>
<td>slurred speech, recurrent aspirations, gait instability, cognitive impairment, hydrocephalus, quadriparesis</td>
<td>4</td>
<td>fusiform, holobasilar</td>
<td>23.3</td>
<td>85</td>
<td>9</td>
<td>3.75 × 20 (3), 4 × 20 (3), 4.25 × 20 (3)</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>3</td>
<td>57</td>
<td>no</td>
<td>headache, incidental</td>
<td>1</td>
<td>fusiform, holobasilar</td>
<td>17.5</td>
<td>76</td>
<td>5</td>
<td>5 × 30, 5 × 20 (4)</td>
<td>yes ischemic, brainstem</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>no</td>
<td>hemiparesis, facial weakness</td>
<td>2</td>
<td>fusiform, distal basilar trunk</td>
<td>35.6</td>
<td>29.1</td>
<td>4 × 20, 4 × 12, 3.75 × 12 (3)</td>
<td>no ischemic, brainstem; SAH</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>42</td>
<td>no</td>
<td>facial numbness, vertigo &amp; ataxia</td>
<td>2</td>
<td>mixed fusiform &amp; saccular, midbasilar</td>
<td>37.1</td>
<td>10.9</td>
<td>3</td>
<td>4 × 18, 4 × 12, 3.75 × 16 (3)</td>
<td>yes ischemic, brainstem</td>
<td>6</td>
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<tr>
<td>6</td>
<td>51</td>
<td>yes</td>
<td>thalamus &amp; pons stroke; only dysarthria after tPA 2 wks prior to treatment</td>
<td>3</td>
<td>fusiform, holobasilar</td>
<td>9.5</td>
<td>61.5</td>
<td>5</td>
<td>5 × 20 (2), 5 × 16 (2), 5 × 12, 4.75 × 14 (2), 4.75 × 16 (2)</td>
<td>no ischemic, brainstem</td>
<td>5</td>
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<tr>
<td>7</td>
<td>55</td>
<td>yes</td>
<td>pontine stroke, dysphagia, left hemiplegia</td>
<td>4 on admission, 5 before angiogram</td>
<td>fusiform, holobasilar</td>
<td>8.5</td>
<td>56</td>
<td>3</td>
<td>5 × 35 (2), 5 × 30</td>
<td>yes yes, progression of stroke</td>
<td>6</td>
</tr>
</tbody>
</table>

* FU = follow-up; max = maximum; tPA = tissue plasminogen activator.
† Cases 2–7 underwent Pipeline device placement.
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Illustrative Cases

Complications

Case 2. This 66-year-old man was referred from out of state for treatment of a near-giant vertebrobasilar artery fusiform aneurysm. On presentation, he had severe medullopontine brainstem compression, ischemia, and quadriparesis, with difficulty protecting his airway and dysphagia. See Fig. 2A–D for further details of this case.

Case 4. This 42-year-old man presented with upper midbrain compression and ischemic injury, with left hemiparesis from a giant distal BA fusiform aneurysm. He underwent placement of a Pipeline device from the proximal posterior cerebral artery to the proximal BA, in which 3 minimally overlapping devices were used. Significant flow was still evident in the aneurysm, but because of concern for perforator infarction, we halted further addition of Pipeline devices. Also, we placed the patient on a heparin infusion immediately after the procedure. Later, on the same day as the procedure, the patient developed dysarthria and right hemiparesis. A CT scan showed no hemorrhage or large-vessel occlusion (including patency of the implanted Pipeline devices). Heparin was discontinued, and eptifibatide was started. Symptoms resolved later that evening. The next morning, the patient, taken to undergo angiography, become obtunded on the angiography table; his pupils were pinpoint but reactive.

Fig. 1. Case 3. A: Anteroposterior view of left VA angiogram demonstrating a vertebrobasilar fusiform aneurysm. B: Anteroposterior and lateral views of a left VA angiogram revealing a vertebrobasilar fusiform aneurysm after placement of the first Pipeline device. C: Anteroposterior and lateral views after the second Pipeline deployment. D: Anteroposterior and lateral views of the right VA occluded by a balloon during the balloon test occlusion procedure. E: Anteroposterior and lateral views of coil embolization of the distal right VA. F: Anteroposterior and lateral views of the final angiogram after treatment.
Emergency CT revealed aneurysm rupture from the posterior aspect of the aneurysm into the brainstem. Care was withdrawn, and the patient died shortly thereafter.

**Case 5.** This 42-year-old woman presented with intermittent episodes of left facial numbness, vertigo, and ataxia. She was otherwise healthy and denied a family history of aneurysms. Neurological examination revealed only a mild decrease in sensation of cranial nerve V on the left side. Magnetic resonance imaging demonstrated a 3.7-cm giant mid-BA aneurysm. An angiogram obtained 1 week later confirmed the presence of a giant mid-BA aneurysm projecting posteriorly with a small left posterior communicating artery and no evidence of the right posterior communicating artery.

One month after presentation, the patient underwent successful placement of 3 Pipeline devices with adjunctive detachable coil embolization, after starting aspirin and clopidogrel. During the procedure, she developed left-sided weakness but responded to the administration of eptifibatide. On follow-up examination 3 weeks after the procedure, she exhibited only very mild ataxia on the left. Repeat MRI demonstrated a large left prepontine cistern BA giant aneurysm with evidence of aneurysm thrombosis around the coil mass. Follow-up angiography 1 month postprocedure demonstrated significant additional thrombosis and some residual filling of the aneurysm neck. The patient’s clinical condition started to worsen—worsening ataxia and weakness on the left—and repeat MRI done 6 weeks postprocedure still showed the 3.7-cm prepontine BA aneurysm, status postcoiling. She was seen at our clinic again 8 weeks after the procedure and was still slightly ataxic and now had some facial numbness on the left, worse than her preoperative status. Steroid therapy was initiated. Four days later, the patient presented with a diffuse SAH and was soon pronounced brain dead.

**Case 6.** This 51-year-old man presented to an out-of-town institution with dizziness, right facial droop, slurred
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speech, right gaze difficulty, diplopia, difficulty ambulating, and sweating. He was found to have right pontine and thalamic strokes. He received intravenous thrombolytic agents and recovered, except for residual dysarthria. A large aneurysm of the entire BA was found on angiography during that admission (Fig. 3A). The patient was referred to our institution for treatment of the aneurysm within 2 weeks of his stroke. His history included coronary artery bypass grafting and myocardial infarction. His admission mRS score was 3 (for dysarthria and gaze nystagmus). He underwent placement of 9 Pipeline devices of varying sizes (Fig. 3B).

After the procedure, the patient developed amnestic fugax, which was thought to be related to intravenous administration of contrast material but may have been related to evolving occipital strokes. He was placed on an epilbitidate infusion overnight. The next day, MRI showed bilateral cerebellar infarcts and ischemia in the medial left and right occipital lobes, more so on the right side (Fig. 3C–F). These strokes can be attributed either to emboli from the aneurysm or device construct or simply from emboli that were caused by catheter or wire manipulation within a diseased vessel. During his hospitalization, the patient developed right-sided hemiplegia and dysconjugate gaze and was nonverbal and dependent on ventilation for 2 weeks. Extubation was performed successfully, but the patient required percutaneous gastrostomy for feeding. At last follow-up, which was 4 weeks after the procedure while still hospitalized, his vision was intact and he was following commands with his left side and nodding to questions but remained nonverbal. His discharge angiogram showed a patent device construct, and a quantitative MR angiogram showed patent posterior cerebral arteries with artifact at the construct site (Fig. 3G–I).

Case 7. This 55-year-old woman presented with dysarthria, dysphagia, and severe left hemiparesis. Prior to treatment and within 2 days of presentation, she suffered neurological deterioration and lost the ability to speak, and she became quadriplexic with minimal use of her right upper extremity. She still followed commands but appeared nearly locked-in. An MRI study showed increased infarct volume in the pons compared with the right upper extremity. She still followed commands but remained nonverbal. His neurological status failed to improve after Pipeline placement. Conservative treatment in these cases may have had the same result given the ischemic disease burden. In these 2 patients who experienced both pre- and postoperative ischemic events, the deployment of multiple overlapping stents is 1 potential cause for thromboembolic events, especially in perforator territories; this should be avoided if possible. When treating these aneurysms, it may be judicious to minimize the number of devices and await aneurysm thrombosis over time rather than seek an immediate cure with additional devices; however, this approach must be weighed against the risk of continued filling of the aneurysm and rupture (which was also seen in this series).

The other 2 deaths were caused by postprocedural aneurysm rupture with fatal SAH and brainstem hemorrhage. In 1 of the 2 cases, the aneurysm ruptured in the acute phase within 24 hours of treatment. This may be explained by a ball-valve–type mechanism with increased stresses on the dome of the aneurysm and eventual rupture of the aneurysm. The hemorrhage occurred too early for a substantive inflammatory response that may have resulted in breakdown of the aneurysm wall and subsequent rupture. In fact, a recent publication documented this effect in a computational fluid dynamics study in which the authors recommended that continued inflow could potentially result in a tense and dangerous aneurysm. The second rupture occurred in a delayed fashion 8 weeks after intervention. The patient had angiographic evidence of continued inflow at 4 weeks and worsening compressive symptoms just prior to rupture. Here, the underlying rupture may have been a complex interplay between hemodynamics and thrombosis-induced inflammatory cascades along aneurysmal walls. This has been recently reported utilizing MRI and autopsy studies.

It has been suggested and sometimes demonstrated that the compressive effects of intact aneurysms have improved by inducing aneurysm thrombosis, even without creating significantly noticeable differences in size. Whether stagnant thrombus within a fusiform aneurysm truly does ameliorate vascular compression syndromes of the brainstem is unknown. Whether coiling the aneurysm in addition to flow diversion provides added protection from hemorrhage (with the added cost being that of mass effect from coiling a giant aneurysm) is debatable at best.

Only 2 patients made a good recovery (Table 1). What we can determine definitively from our initial experience...
is that we must learn more about flow diversion in these lesions. Our understanding of how perforators, thrombus, and flow are influenced by flow diversion is minimal at best. Rigorous study is critical if this technology is going to prove beneficial for these lesions. The grim natural history of large aneurysms of the entire BA potentially justifies intervention attempts. The patients are often young and have much to gain from a cure, considering their life expectancy. Previously, good outcomes were reported in 67% of patients in the surgical experience of Drake and

Fig. 3. Case 6. A: Anteroposterior view of a left VA angiogram demonstrating a large vertebrobasilar fusiform aneurysm. B: Posttreatment anteroposterior angiogram. C–F: Magnetic resonance images demonstrating numerous areas of positive diffusion-weighted imaging changes in the bilateral occipital lobes (C), bilateral cerebellum (D), large thrombosed aneurysm compressing the brainstem (E), and medial left occipital mild diffusion positivity (F). G: Quantitative MR angiography demonstrating nearly symmetrical cerebral blood flow in both posterior cerebral arteries despite the absence of flow detection in the BA, presumably due to artifact. H: Final anteroposterior angiographic view (early filling) of left VA injection. I: Final anteroposterior view (early filling) of left VA injection. LACA = left anterior cerebral artery; LMCA = left middle cerebral artery; LPCA = left posterior cerebral artery; LVA = left VA; RACA = right anterior cerebral artery; RMCA = right middle cerebral artery; RPCA = right posterior cerebral artery; RVA = right VA.
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<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Cases of Vertebral Basilar Fusiform Aneurysms</th>
<th>Treatment Device</th>
<th>No. of Device-Related Complications</th>
<th>No. of Deaths</th>
<th>No. of Cases of Postop Angiographic Obliteration</th>
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<tr>
<td>Fiorella et al., 2008, 2010</td>
<td>1</td>
<td>Pipeline</td>
<td>1</td>
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<td>0</td>
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<td>Fiorella et al., 2009</td>
<td>1</td>
<td>Pipeline</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Byrne et al., 2010</td>
<td>10</td>
<td>Silk</td>
<td>2</td>
<td>2</td>
<td>NA</td>
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<tr>
<td>Kulcsár et al., 2010</td>
<td>1</td>
<td>Silk</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lubicz et al., 2010</td>
<td>3</td>
<td>Silk</td>
<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
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<td>4</td>
<td>Silk</td>
<td>1</td>
<td>1</td>
<td>0</td>
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<tr>
<td>present study</td>
<td>7</td>
<td>Silk (1), Pipeline (6)</td>
<td>6</td>
<td>4</td>
<td>2</td>
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</table>

* NA = not available.

Peerless and 73% in the most recent published completely endovascular experience from Belgium. However, the authors from Belgium used flow diverters in only 4 of 31 cases. In a series of 12 flow-diverter cases for BA aneurysms, 66% had good functional outcomes, but there were 5 strokes (41%).

Currently, we are still at a loss for finding an optimal safe and effective treatment for large or giant vertebrobasilar fusiform aneurysms. Strategies applied thus far have mixed results at best, including most recently flow diversion. For those patients presenting with aneurysms on the smaller end of the spectrum here, or those already exhibiting ischemic stroke, it may be more appropriate to continue the best medical therapy, and this is something we would consider more strongly now for similar aneurysms. The issues we have identified by evaluating complications encountered in treating these lesions are that patients who present with symptoms can have rapid deterioration following presentation (Case 7), most commonly from progressive ischemic symptoms and brainstem infarcts as well as ruptures. Although the window of opportunity for treatment appears to be limited and medical therapy may or may not halt the progressive course, a careful determination of the risks and benefits of intervention is appropriate.

Conclusions

The ideal treatment of fusiform vertebrobasilar aneurysms and large aneurysms of the entire BA remains debatable and must be investigated on a case-by-case basis in terms of the availability of collateral flow, the response to balloon test occlusion, the patient’s microsurgical risk, and the anatomy in terms of aneurysm size, type, and location. Treatment by endovascular means with flow diversion is one option but is not necessarily the safest or most definitive treatment modality. The ability for perforators to draw blood through the flow-diversion devices remains unproven, with complications having occurred both at the authors’ institution and in other reports. Most importantly, in a frank and deliberate discussion with the patient and family, one needs to describe the state of information including the dismal natural history and complications associated with all methods of treatment. We have opted to cease treating most large aneurysms of the entire BA with flow-diversion techniques until we can gain further understanding of the hemodynamic effects on brainstem perforators.

Disclosure

Drs. Abla, Britz, Dumont, Kan, and Jahshan report no conflict of interest. Dr. Hopkins receives grant/research support from Toshiba; serves as a consultant to Abbott Vascular, Boston Scientific; Cordis, Micrus, and W. L. Gore; holds a financial interest in Access Closure, Augmenix, Boston Scientific; Claré Medical Inc., Micrus, and Valor Medical; has a board/trustee/officer position with Access Closure, Claré Medical Inc., and Micrus (until September 2010); belongs to the Abbott Vascular speakers’ bureau; and receives honoraria from Bard, Boston Scientific, Cordis, Memorial Healthcare System, Complete Conference Management, SCAI, and Cleveland Clinic. Dr. Levy receives research grant support (principal investigator: Stent-Assisted Recanalization in acute Ischemic Stroke [SARIS]), other research support (devices), and honoraria from Boston Scientific and research support from Codman & Shurtleff, Inc., and ev3/Covidien Vascular Therapies; has ownership interests in Intratech Medical Ltd. and Myx accessed Closure; serves as a consultant on the board of Scientific Advisors to Codman & Shurtleff, Inc.; serves as a consultant per project and/or per hour for Codman & Shurtleff, Inc., ev3/Covidien Vascular Therapies, and TheraSyn Sensors, Inc.; and receives fees for carotid stent training from Abbott Vascular and ev3/Covidien Vascular Therapies. Dr. Levy receives no consulting salary arrangements. All consulting is per project and/or per hour. Dr. Siddiqui has received research grants from the National Institutes of Health (co-investigator: NINDS 1R01NS064592-01A1, Hemodynamic induction of pathologic remodeling leading to intracranial aneurysms) and the University at Buffalo (Research Development Award); holds financial interests in Hotspur, Intratech Medical, StimSox, and Valor Medical; serves as a consultant to Codman & Shurtleff, Inc., Concentric Medical, ev3/Covidien Vascular Therapies, GuidePoint Global Consulting, and Penumbra; belongs to the speakers’ bureaus of Codman & Shurtleff, Inc., and Genentech; serves on an advisory board for Codman & Shurtleff; and has received honoraria from American Association of Neurological Surgeons’ courses, an Emergency Medicine Conference, Genentech, Neocure Group LLC, and from Abbott Vascular and Codman & Shurtleff, Inc., for training other neurointerventionists in carotid stenting and for training physicians in endovascular stenting for aneurysms. Dr. Siddiqui receives no consulting salary arrangements. All consulting is per project and/or per hour. *Boston Scientific’s neurovascular business has been acquired by Stryker.
Author contributions to the study and manuscript preparation include the following. Conception and design: Abla, Siddiqui, Levy. Acquisition of data: Abla, Kan, Dumont, Britz. Analysis and interpretation of data: Abla, Kan, Dumont, Jaehnan. Drafting the article: Abla, Dumont, Siddiqui, Levy. Critically revising the article: all authors. Final approval of the manuscript: all authors.

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References


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