Endovascular WEB Flow Disruption in Middle Cerebral Artery Aneurysms: Preliminary Feasibility, Clinical, and Anatomical Results in a Multicenter Study

BACKGROUND: The endovascular treatment of middle cerebral artery (MCA) aneurysms with unfavorable anatomy (wide neck, unfavorable morphology) is frequently challenging. Flow disruption with the WEB is a potentially interesting endovascular treatment for this type of aneurysm.

OBJECTIVE: To report in a multicenter series the preliminary treatment experience of MCA aneurysms with flow disruption by the WEB.

METHODS: Thirty-three patients with 34 MCA aneurysms were treated with the WEB in 5 European centers. The ability to successfully deploy the WEB, procedure- and device-related adverse events, morbidity and mortality of the treatment, and short-term angiographic follow-up results were analyzed.

RESULTS: Most treated aneurysms were unruptured (85.3%) and were between 5 and 10 mm (85.3%) with a neck size $\leq 4$ mm (88.2%). The treatment failed in 1 of the 34 aneurysms (2.9%) owing to a lack of appropriate device size. Treatment was performed exclusively with the WEB in 29 of 33 aneurysms (87.9%). Additional treatment (coiling and/or stenting) was used in 4 of 33 aneurysms (12.1%). Mortality of the treatment was 0.0% and morbidity was 3.1% (intraoperative rupture with modified Rankin Scale score of 3 at the 1-month follow-up). In short-term follow-up (range, 2-12 months), adequate occlusion (total occlusion or neck remnant) was observed in 83.3% of aneurysms.

CONCLUSION: WEB flow disruption seems to be a promising technique for the treatment of complex MCA aneurysms, particularly those with a wide neck or unfavorable dome-to-neck ratio.

KEY WORDS: Aneurysms, Endovascular treatment, Flow Disruption, Middle cerebral artery, WEB

Severa series, including the International Subarachnoid Trial (ISAT), Barrow Ruptured Aneurysm Trial, Clinical and Anatomical Results in the Treatment of Ruptured Intracranial Aneurysms (CLARITY), and Analysis of Treatment by Endovascular Approach of Nonruptured Aneurysms (ATENA), have demonstrated the broad utility of aneurysm coiling in the management of both ruptured and unruptured aneurysms.1-4 In most of these series, no subgroup analysis was available to determine whether clinical outcome was different according to aneurysm location.2,4 In ISAT, the number of middle cerebral artery (MCA) aneurysms was relatively small (303 aneurysms), but the subgroup analyses showed that death or dependency at 1 year was not affected by aneurysm location.5

However, the location of endovascular treatment, especially in MCA aneurysms, is still a matter of debate; long-term follow-up data of the ISAT showed that the proportion of survivors at 5 years who were independent did not differ...
between the 2 groups: 83% for endovascular treatment and 82% for neurosurgical treatment (but the risk of death was significantly lower in the clipping group compared with the clipping group).

Endovascular treatment is also associated with a relatively high rate of aneurysm recanalization (20.8%), leading to aneurysm retreatment in 10.3% of patients.

In some aneurysms, coiling is simply impossible because of the aneurysm shape, particularly when the neck is wide. For these specific situations, new endovascular techniques like remodeling technique or flow diversion have been developed, reducing the number of situations in which endovascular treatment is impossible.

The debate is heightened for MCA aneurysms because they are considered favorable for clipping because of their accessibility and may be difficult to coil because of the frequently complex anatomy of MCA trifurcation and frequent broad base of the aneurysm. A limited number of recent series analyzed the surgical results for MCA aneurysms. Several series have shown that endovascular treatment of MCA aneurysms is feasible and effective in selected cases. Because they are often wide necked, endovascular treatment of MCA aneurysms by coiling alone is not always feasible, and an unmet need exists for an endovascular approach.

WEB flow disruption is a new technique using an intraneurysmal device to disrupt the intra-aneurysmal flow and subsequently create intra-aneurysmal (and intradevice) thrombosis. Clinical results were previously reported with the WEB device in 19 patients and 5 centers (14, 8, 5, 3, and 3 patients in each center). One patient harboring 34 MCA aneurysms were treated with the WEB device and showed high feasibility of treatment, good safety, and acceptable short-term anatomic results. The goal of the present study is to analyze the feasibility, safety, and efficacy of WEB flow disruption in the treatment of MCA aneurysms.

**PATIENTS AND METHODS**

**Objective**

The goal of this retrospective, multicenter clinical series is to assess the feasibility, safety, and short-term and midterm efficacy of the endovascular treatment of MCA aneurysms by WEB flow disruption.

**Patient Selection**

The study received Institutional Review Board approval in the 5 participating centers. In each center, indication for treatment and its modality (surgery or endovascular treatment) were decided on a case-by-case basis by a local multidisciplinary team including neurosurgeons, neuroanesthesiologists, neurologists, and neuroradiologists. The selection of aneurysms treated with the WEB device was made autonomously in each center by the interventional neuroradiologists according to aneurysm characteristics (aneurysm status, aneurysm location and size, neck size). Informed consent was obtained from all patients. The WEB device is illustrated in Figure 1.

The device is composed of an inner and outer nitinol braid held together by proximal, middle, and distal radiopaque markers and creating 2 compartments: 1 distal and 1 proximal. The WEB implant is deployed similarly to endovascular coil systems through microcatheters with an internal diameter ≥ 0.027 in. The detachment system is electrothermal and instantaneous. The WEB received a CE Mark for unruptured and ruptured aneurysms.

**Procedure**

The treatment of aneurysms with the WEB was done using techniques similar to those used in the treatment of aneurysms with coils (eg, general anesthesia, intraoperative treatment with intravenous heparin, single or double femoral approach). Preoperative, intraoperative, and postoperative antplatelet therapy was managed in each center as indicated for typical endovascular treatment with coils (or stent and coils if this approach was a potential alternative treatment).

After accurate evaluation of aneurysm anatomy (aneurysm morphol- ogy, aneurysm transverse diameter and height, and neck size) by the treating physician using magnetic resonance imaging and 2-dimensional and 3-dimensional digital subtraction angiography (DSA), it was determined whether treatment with WEB was indicated, along with appropriate device sizing.

After positioning of a guiding catheter into the internal carotid artery or vertebral artery, the aneurysm was catheterized with a Rebar 27 (Covidien/ev3, Irvine, California), Marksman 27 (Covidien/ev3), Headway 27 (Microvention, Tustin, California), DAC 038 (Concentric Medical, Mountain View, California), or Penumbra 41 (Penumbra, Alameda, California). The WEB device chosen according to aneurysm measurements was then positioned in the aneurysmal sac. A control angiogram was performed to check the position of the device in the aneurysm and to evaluate flow stagnation inside the aneurysm. If the position was not satisfactory, the device was repositioned. If the size was not appropriate, the device was repositioned and another device was deployed into the aneurysm. When the right-sized device was correctly positioned, a final DSA run was performed. Treatment with ancillary devices (balloon, coils and stent) was performed if deemed necessary by the treating physician.

Follow-up of the patients was conducted according to the usual clinical practice of each center.

**Data Collection**

For each patient and aneurysm, the following data were collected: age, sex, aneurysm status (ruptured/unruptured), aneurysm location and size (transverse diameter and height), neck size, modalities of treatment (perioperative medications, associated treatment), intraoperative complications (aneurysm rupture, thromboembolic events, device problems), and postoperative complications (thromboembolic complications, delayed rupture).

The quality of the aneurysm occlusion was assessed by the treating physician by DSA at the end of the procedure and in the short-term follow-up.

**Data Analysis**

Population, feasibility of the treatment, rate of intraprocedural and postprocedural complications, morbidity (defined as modified Rankin Scale [mRS] score >1) and mortality at 1 month, and immediate and follow-up angiographic outcome were evaluated.

At the short-term follow-up (months), the quality of the aneurysm occlusion was evaluated using the 3-grade Montreal scale (total occlusion, neck remnant, aneurysm remnant).

**RESULTS**

Data on the patient and aneurysm population are given in Table 1. From October 2010 to July 2012, 33 patients (28 women and 5 men) 35 to 77 years of age (mean, 55.8 ± 10.0 years) harboring 34 MCA aneurysms were treated with the WEB device in 5 centers (14, 8, 5, 3, and 3 patients in each center).
had 2 MCA aneurysms. Two aneurysms were ruptured and treated 1 day after the rupture. Three aneurysms were recanalized aneurysms after previous treatment with coiling. Twenty-nine aneurysms were unruptured aneurysms.

Aneurysm dome width was < 5 mm in 3 of the 34 aneurysms (8.8%), 5 to 10 mm in 29 aneurysms (85.3%), and > 10 mm in 2 cases (5.9%).

Neck size was < 4 mm in 4 of 34 aneurysms (11.8%) and ≥ 4 mm in 30 aneurysms (88.2%). Dome-to-neck ratio (transverse diameter/neck) was ≤ 1.5 in 26 of the 34 aneurysms (76.5%) and > 1.5 in 8 aneurysms (23.5%).

### Treatment Failure and Modalities

The WEB device was successfully deployed in 33 of the 34 aneurysms (97.1%). In 1 patient, the transverse diameter of the aneurysm was 5.5 mm, and neither the 6-mm-diameter device nor the 5-mm-diameter device was appropriate for aneurysm occlusion. The aneurysm was treated with stenting and coiling. This patient was excluded from further analyses.

All but 1 aneurysm were treated with 1 device. In 1 aneurysm, 2 devices were deployed inside the aneurysm.

No antiplatelet treatment was given during the treatment of 17 of 33 aneurysms (51.5%). Antiplatelet therapy was used in 16 of 33 aneurysms (48.5%): 1 agent in 10 cases and 2 agents in 6 cases.

The treatment was performed exclusively with the WEB device in 29 of 33 aneurysms (87.9%). Additional treatment was used in 4 aneurysms (12.1%), including coiling in 2 aneurysms and stenting in 2 aneurysms. In 1 previously coiled MCA, the size of the aneurysm remnant was very difficult to evaluate, and the device used was too small; 2 additional coils were deposited after deployment of the WEB. In another patient, the aneurysm ruptured during treatment, and the rupture was treated with coils and glue (see below). In 2 patients, stenting was used because there was

---

**FIGURE 1.** A. The WEB device. B. The WEB device inserted into an aneurysm.
a small protrusion of the device in the parent vessel. The adverse events and clinical status of the patients are given in Table 2.

In 1 of 32 patients (3.1%), intraoperative rupture was observed after the WEB was deployed in a daughter sac. The rupture was treated rapidly with coils and glue with successful occlusion of the rupture site but with occlusion of 1 branch of the MCA bifurcation. The patient developed an ischemic lesion with hemiparesis. After 3 months, the patient still has a deficit and was evaluated as having an mRS score of 3.

In 5 of 32 patients (15.6%), thromboembolic events were observed. In 3 patients, events occurred under antiplatelet treatment (1 medication), whereas in 2 patients, no antiplatelet treatment was given. In 3 cases, events were noticed intraoperatively by DSA and treated with intra-arterial administration of thrombolytics, and no clinical worsening occurred (mRS score, 0 in the 3 patients). Thromboembolic events with clinical worsening were observed in 2 of 32 patients (6.3%). In 1 patient, the procedure was uneventful, but a transient hemiparesis was observed in the postoperative period. In another case, thrombus in an MCA branch was observed during the procedure and treated by intra-arterial administration of thrombolytics. Postoperatively, the patient had hemiparesis and vertigo, and magnetic resonance imaging showed an ischemic lesion in the pons, probably related to the diagnostic angiography performed before the endovascular treatment. At 1 month, the patient had an mRS score of 1. Finally, these 2 patients, although initially symptomatic, had mRS scores of 0 and 1 at 1 month.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex, Age, y</th>
<th>Aneurysm Status</th>
<th>Dome Width, mm</th>
<th>Neck Size, mm</th>
<th>APT</th>
<th>Additional Treatment</th>
<th>TE</th>
<th>IOR</th>
<th>mRS Score at 1 mo</th>
<th>Aneurysm Occlusion</th>
<th>DSA Delay, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F, 62</td>
<td>UnR</td>
<td>4.0</td>
<td>4.2</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>M, 55</td>
<td>UnR</td>
<td>4.1</td>
<td>2.0</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>TO</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>F, 66</td>
<td>Recan</td>
<td>5.3</td>
<td>2.6</td>
<td>1</td>
<td>Coils</td>
<td>Yes</td>
<td>No</td>
<td>0</td>
<td>TO</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>F, 45</td>
<td>UnR</td>
<td>7.2</td>
<td>4.8</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>1</td>
<td>TO</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>F, 57</td>
<td>UnR</td>
<td>5.5</td>
<td>4.7</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>TO</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>F, 44</td>
<td>UnR</td>
<td>6.0</td>
<td>6.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>F, 35</td>
<td>UnR</td>
<td>6.5</td>
<td>5.5</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>F, 57</td>
<td>UnR</td>
<td>11.0</td>
<td>7.0</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>AR</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>F, 42</td>
<td>UnR</td>
<td>5.5</td>
<td>5.0</td>
<td>0</td>
<td>Stent</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>F, 52</td>
<td>UnR</td>
<td>7.5</td>
<td>6.5</td>
<td>0</td>
<td>Glue + coils</td>
<td>No</td>
<td>Yes</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>F, 42</td>
<td>Recan</td>
<td>6.0</td>
<td>5.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>F, 58</td>
<td>UnR</td>
<td>6.0</td>
<td>6.0</td>
<td>0</td>
<td>Stent</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>F, 54</td>
<td>Recan</td>
<td>11.0</td>
<td>10.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>AR</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>F, 51</td>
<td>UnR</td>
<td>5.5</td>
<td>4.5</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>15</td>
<td>M, 58</td>
<td>UnR</td>
<td>7.0</td>
<td>6.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>16</td>
<td>F, 71</td>
<td>UnR</td>
<td>5.0</td>
<td>4.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>17</td>
<td>F, 51</td>
<td>UnR</td>
<td>9.0</td>
<td>12.0</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>12</td>
</tr>
<tr>
<td>18</td>
<td>F, 54</td>
<td>UnR</td>
<td>5.5</td>
<td>5.0</td>
<td>0</td>
<td>Failed</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>6</td>
</tr>
<tr>
<td>19</td>
<td>M, 64</td>
<td>UnR</td>
<td>7.0</td>
<td>5.5</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>F, 45</td>
<td>UnR</td>
<td>4.6</td>
<td>4.1</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>TO</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>F, 75</td>
<td>UnR</td>
<td>6.8</td>
<td>4.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>AR</td>
<td>5</td>
</tr>
<tr>
<td>22</td>
<td>F, 45</td>
<td>UnR</td>
<td>5.5</td>
<td>5.5</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>0</td>
<td>TO</td>
<td>5</td>
</tr>
<tr>
<td>23</td>
<td>F, 55</td>
<td>UnR</td>
<td>6.0</td>
<td>5.3</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>AR</td>
<td>7</td>
</tr>
<tr>
<td>24</td>
<td>F, 52</td>
<td>R</td>
<td>7.7</td>
<td>5.0</td>
<td>0</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>6</td>
</tr>
<tr>
<td>25</td>
<td>F, 48</td>
<td>UnR</td>
<td>9.0</td>
<td>6.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>AR</td>
<td>7</td>
</tr>
<tr>
<td>26</td>
<td>F, 77</td>
<td>R</td>
<td>7.0</td>
<td>5.4</td>
<td>0</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>F, 68</td>
<td>UnR</td>
<td>8.0</td>
<td>5.0</td>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>F, 58</td>
<td>UnR</td>
<td>8.9</td>
<td>8.0</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>6</td>
</tr>
<tr>
<td>29</td>
<td>M, 61</td>
<td>UnR</td>
<td>9.5</td>
<td>9.6</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>4.5</td>
</tr>
<tr>
<td>30</td>
<td>F, 50</td>
<td>UnR</td>
<td>8.4</td>
<td>7.4</td>
<td>1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>4</td>
</tr>
<tr>
<td>31</td>
<td>M, 62</td>
<td>UnR</td>
<td>8.7</td>
<td>4.7</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>6</td>
</tr>
<tr>
<td>32</td>
<td>F, 66</td>
<td>UnR</td>
<td>6.5</td>
<td>5.9</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>TO</td>
<td>3</td>
</tr>
<tr>
<td>33</td>
<td>F, 58</td>
<td>UnR</td>
<td>6.7</td>
<td>3.9</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>0</td>
<td>NR</td>
<td>6</td>
</tr>
</tbody>
</table>

APT, antiplatelet treatment; AR, aneurysm remnant; DSA, digital subtraction angiography; IOR, intraoperative rupture; mRS, modified Rankin Scale; NR, neck remnant; R, ruptured; Recan, recanalization; TO, total occlusion; Unr, unruptured.

In 1 of 32 patients (3.1%), intraoperative rupture was observed after the WEB was deployed in a daughter sac. The rupture was treated rapidly with coils and glue with successful occlusion of the rupture site but with occlusion of 1 branch of the MCA bifurcation. The patient developed an ischemic lesion with hemiparesis. After 3 months, the patient still has a deficit and was evaluated as having an mRS score of 3.

In 5 of 32 patients (15.6%), thromboembolic events were observed. In 3 patients, events occurred under antiplatelet treatment (1 medication), whereas in 2 patients, no antiplatelet treatment was given. In 3 cases, events were noticed intraoperatively by DSA and treated with intra-arterial administration of thrombolytics, and no clinical worsening occurred (mRS score, 0 in the 3 patients). Thromboembolic events with clinical worsening were observed in 2 of 32 patients (6.3%). In 1 patient, the procedure was uneventful, but a transient hemiparesis was observed in the postoperative period. In another case, thrombus in an MCA branch was observed during the procedure and treated by intra-arterial administration of thrombolytics. Postoperatively, the patient had hemiparesis and vertigo, and magnetic resonance imaging showed an ischemic lesion in the pons, probably related to the diagnostic angiography performed before the endovascular treatment. At 1 month, the patient had an mRS score of 1. Finally, these 2 patients, although initially symptomatic, had mRS scores of 0 and 1 at 1 month.
Midterm Aneurysm Occlusion and Retreatment

Midterm aneurysm occlusion was evaluated by DSA in 30 of 33 aneurysms (90.9%) 2 to 12 months after treatment (mean, 7.2 ± 3.7 months; median, 6.0 months). Total occlusion was observed in 8 of 30 aneurysms (26.7%; Figures 2 and 3), neck remnant in 17 of 30 aneurysms (56.7%; Figure 4), and aneurysm remnant in 5 of 30 aneurysms (16.7%). Adequate occlusion (total occlusion and neck remnant) was obtained in 25 of 30 aneurysms (83.3%).

DISCUSSION

This preliminary series shows that WEB intrasaccular flow disruption is highly feasible in MCA aneurysms despite the use of a much larger microcatheter than usually used for coil embolization, with low morbidity and mortality and good anatomic results in midterm follow-up.

Preliminary animal studies concluded that treatment with the WEB device was associated with promising rates of immediate- and long-term aneurysm occlusion in the rabbit elastase aneurysm model.21 Angiographic aneurysm occlusion was evaluated at 1, 3, 6, and 12 months, and the study also included histopathological analysis.

In our selected series, the treatment was highly feasible (97.1%) with 1 failure in 1 aneurysm. The failure was due to the fact that the appropriate device size (5.5 mm in diameter) was not available. According to the size of the currently available devices (5-11 mm in diameter in 1-mm increments), the treated aneurysms (maximum diameter) were mostly between 5 and 10 mm (85.3%). In the great majority of cases (88.2%), the aneurysm neck was ≥ 4 mm, indicating that this device is uniquely appropriate for the treatment of wide-necked MCA aneurysms in the above range.

The porosity and conformability of the WEB treat aneurysms similar to an initial 3-dimensional or framing coil. Framing coils are often “up-sized” or “right-sized” on the basis of aneurysm width or diameter to achieve apposition against the aneurysm wall and to provide a beginning scaffold across the aneurysm neck. If the framing coil is too large or too small, it is withdrawn and another size is chosen. WEB aneurysm treatment is nearly identical to this treatment. The sizing recommendation is to average the available aneurysm widths and heights and to select a WEB that is 1 mm larger than the average width and 1 mm smaller than the average height. If the selected size is too large or too small, the WEB is withdrawn and a new size is selected and deployed. However, markedly different from a single framing coil but as a result of gentle compression of the 1-mm up-sized width, the WEB can be placed at the neck of the aneurysm, and if it does not fill the entire aneurysm volume (ie, blebs or additional height), the implant still provides effective contrast stasis and eventual thrombosis in those distal areas and the aneurysm overall.

Despite the very specific population (wide-necked MCA aneurysms) and the fact that this series includes the first cases treated with this new technique (ie, learning curve), the rate of adverse events was low. Intraoperative rupture was observed in 1 case (3.1%) at the beginning of the experience of 1 center (The device was inadvertently deployed in a daughter sac). In the Brinjikji et al17 review of coiling of MCA aneurysms, the rate of intraoperative rupture was similar (3.1%). In the ATENA series dealing with unruptured aneurysms, intraoperative ruptures were observed in 2.6% of the procedures with a rate of 4.1% for MCA aneurysms.3 WEB thromboembolic events were globally observed in 15.6% of cases with clinical events in only 2 patients (6.3%), with 1 event unrelated to the treatment but related to the preoperative DSA. The rate of thromboembolic events was slightly higher compared with what was reported in the ATENA series (7.1% for the global population and 9.6% for MCA aneurysms) but is quite similar to what was reported in the CLARITY series dealing with ruptured aneurysms (global rate of thromboembolic events: 13.3%, leading to permanent deficit in 3.2% and death in 1.0%).2,3 In the Brinjikji et al17 review, morbidity and mortality resulting from thromboembolic complications were 3.2% and 0.6, respectively.

Despite this slightly higher rate of thromboembolic complications, clinical outcome at 1 month was satisfactory, with a mortality of 0.0% and a morbidity of 3.1%. These compare favorably...
with the mortality and morbidity of endovascular treatment of MCA aneurysms as reported in the Brinjikji et al\textsuperscript{17} review (1.2\% and 3.9\%, respectively). In recent large neurosurgical series, the results of the endovascular treatment with the WEB are also acceptable. In a recent large series with 263 patients with 339 unruptured aneurysms, the mortality and morbidity of surgical clipping were 0.4\% and 4.9\%, respectively.\textsuperscript{10} In another very recent series dealing with a high number of patients (543), surgical mortality and morbidity rates were 5.3\% and 4.6\%, respectively.\textsuperscript{12} The occurrence of thromboembolic events was not linked to the antiplatelet treatment given to the patient because events occurred in 3 patients treated with 1 antiplatelet medication and in 2 patients receiving no antiplatelet treatment. The modalities of the antiplatelet treatment were quite heterogeneous in this series.
Some patients were treated with 2 medications because a potential therapeutic option was stenting. In the other patients, antiplatelet treatment was used according to the current modalities of each center. Some centers are currently using perioperative and postoperative antiplatelet treatment when treating unruptured aneurysms, whereas other centers are not using any systematic antiplatelet treatment even for unruptured aneurysms.

Only short-term follow-up is available, and not in all patients (90.9%). Complete occlusion was observed in a relatively low percentage of aneurysms (26.7%), which is not really a surprise because most aneurysms have a complex shape. On the contrary, neck remnants were frequently observed (56.7%). This is due to the shape of the WEB and the type of aneurysms treated in this series. The proximal surface of the WEB is not flat but has a recess, which is concave from the direction of the parent artery. It was designed to minimize protrusion of the proximal marker in the parent vessel, but it contributes to the appearance of a neck remnant. A WEB neck remnant is likely fundamentally different from a coil remnant in that the exposed surface at the level of the neck is smooth compared with the irregular surface created by the coils. Of course, longer follow-up is needed to confirm that WEB neck remnants are stable and provide a durable aneurysm repair. Aneurysms treated in this series were mostly wide-necked aneurysms with MCA branches arising close to or at the neck. In some of these cases, the physician chose not to cover an MCA branch with the device to avoid thromboembolic events, thus creating a small neck remnant. Indeed, the evolution of these neck remnants in the midterm and long-term follow-up will be very important to analyze. However, it should be noted that adequate occlusion (complete occlusion or neck remnant) was obtained in a high percentage of cases (83.3%) and is the clinically relevant metric.

Standard endovascular treatment of MCA aneurysms with coils is particularly difficult when the neck is wide or when a branch arises close to or at the neck. In these situations, the remodeling technique can be an option using a hypercompliant balloon, a double-lumen balloon, or a double-balloon technique, but coil stabilization is not always feasible, particularly when the dome-to-neck ratio is unfavorable. Single or double stenting may be proposed for these aneurysms, but its use is usually limited to unruptured aneurysms because of double antiplatelet therapy considerations. Moreover, intraluminal stenting increases the risk of parent artery stenosis and thrombosis.

In addition, because of the putative need for double antiplatelet therapy, the use of flow diverters is limited to unruptured aneurysms. Because of the complex anatomy of the MCA bifurcation, the durable cure of the aneurysm is uncertain with the implantation of a single flow diverter. Moreover, preservation of the bifurcation branches and lenticulostriate arteries (if they are covered by the flow diverter) is relatively unpredictable. Indeed, surgical clipping is always an option for such complex MCA aneurysms but is more difficult to perform when the neck is wide, a branch is arising from the neck, or the wall is calcified around the neck. Then, the number of options for these complex MCA aneurysms is relatively limited, and having a new endovascular technique for their treatment will certainly be helpful for the management of this group of patients.

Our study has limitations. First, the number of patients is relatively small, but it was important to report this preliminary evaluation of this very new endovascular approach for MCA aneurysm treatment because it may be an interesting option for complex lesions. Second, midterm and long-term follow-up is needed to evaluate the efficacy of this treatment in terms of aneurysm recanalization.

**CONCLUSION**

In our selected series of complex MCA aneurysms, intrasaccular flow disruption with the WEB device was feasible in a high percentage of aneurysms with acceptable morbidity and mortality and encouraging short-term anatomic results. This technique
seems promising for the treatment of complex MCA aneurysms, particularly those with a wide neck or unfavorable dome-to-neck ratio. Larger series with midterm and long-term anatomic results are needed to confirm the value of this technique.

Disclosures

Drs Cognard, Klisch, Lubicz, and Pierot are consultants for Seqvent. Dr Pierot is principal investigator for the WEBCAST study (evaluation of the WEB device). Drs Cognard, Kliisch, Lubicz, and Szikora are investigators for the WEBCAST study. The other authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES


COMMENTS

The WEB device allows the deployment of a 3-dimensional nitinol construct for intra-aneurysmal flow disruption. The authors are to be commended for successfully deploying this device in 97.1% of their patients. Such devices have the benefit of being able to be used for wide-necked aneurysms in the subarachnoid hemorrhage patient population. The present study evaluated WEB embolization of 32 middle cerebral artery aneurysms.

Five of the 32 patients (15.6%) had thromboembolic complications, with subgroup analysis revealing that there was no protection with the use of a single antiplatelet agent. The WEB device should be considered an intra-aneurysmal stent because there is significant metal (WEB) coverage over the neck of the aneurysm. Consideration should be taken to place these patients on dual antiplatelets, as is routinely done for stent-assisted coiling patients. We have reported that the use of dual antiplatelets during elective coiling of aneurysms leads to a significant reduction in thromboembolic complications (International Stroke Conference, 2013). In the present study, 25 of the 30 patients with follow-up angiograms had complete occlusion of the aneurysm dome with minimal neck remnant.

One of the 32 patients treated had an intraoperative rupture leading to permanent disability. This was thought to have occurred when the device was deployed within a daughter sac of the aneurysm. Further analysis is needed to understand whether the WEB device should not be used for anatomically complex aneurysms or aneurysms with daughter sacs. We congratulate the authors on completing this important study and look forward to future studies focusing on appropriate aneurysm selection and mechanisms of reducing thromboembolic complications when the WEB device is used.

Aditya S. Pandey
Neeraj Chaudhary
Ann Arbor, Michigan

This article reviews the early experience of a novel endovascular tool used in the treatment of patients with middle cerebral artery aneurysms. The rate of thromboembolic events is significant, and there is no doubt that the use of this technology is controversial at this point. It is important to keep in mind that complete obliteration of the aneurysm remains the long-term goal. This technology achieved this aim in fewer than a third of the aneurysms treated, and midterm and long-term results will definitely be important in defining the exact place of this technology within the current armamentarium. Surgical clipping remains a safe and...
WEB flow disruption is an example of a promising new endovascular technology that can be applied to aneurysms like middle cerebral artery (MCA) aneurysms long considered unfavorable for coiling on the basis of their trifurcated anatomy, broad necks, dysmorphic shapes, and angiographically undecipherable branches. The authors used WEB flow disruption to treat 34 wide-necked MCA aneurysms that would not have been treated well by simple coiling, thereby broadening the range of aneurysms accessible to the neurointerventionalist. Patients were favorably selected, with only 12% presenting with ruptured aneurysms and only 6% of the aneurysms > 10 mm. Complications included intraoperative rupture in 3% and thromboembolic events in 16%, but complete obliteration was achieved in only 27%. The mean 7-month follow-up period is within the time window when endovascular advantages in safety are evident but problems associated with efficacy, durability, rehemorrhage, recurrence, and retreatment have not surfaced yet. Therefore, we cannot conclude that WEB flow disruption has favorably affected the natural history of MCA aneurysms. MCA aneurysms have long been considered favorable for clipping because they are accessible, can be easily manipulated after splitting the Sylvian fissure, and avail themselves to other treatment techniques like thrombectomy, clip reconstruction, and bypass when conventional clipping techniques fail. The MCA aneurysm is the best example of an aneurysm with microsurgical results that are widely regarded as superior to endovascular results. Our experience with 631 MCA aneurysms in 543 patients demonstrated that microsurgery continues to yield excellent results with a wide spectrum of lesions and patients that included giant (5%), thrombotic (8%), and dolichoectatic (5%) aneurysms; ruptured aneurysms in poor-grade patients (11%); and aneurysms in older patients (> 65 years of age; 24%)1 In our experience, 95% were clipped directly and 4% required bypass and trapping. Complete aneurysm obliteration was achieved in 98.3%, and 284 other aneurysms were clipped simultaneously. Outcomes were influenced more by ruptured presentation, Hunt-Hess grade, hemispecanectomy, and giant size than by surgical complications. To compare with WEB flow disruption results, morbidity and mortality for unruptured aneurysms are more appropriate and were 5.4% and 1.5%, respectively. There were no rehemorrhages or retreatments, and late angiographic follow-up (mean duration, 3.9 years) in 106 patients found no aneurysm recurrences.

From an evidence-based perspective, the preponderance of data still support microsurgical management of MCA aneurysms because of the capacity to treat all patients and all aneurysms with a variety of techniques, acceptably low morbidity/mortality, proven long-term durability, effective protection from aneurysm rupture, and approaches that are increasing minimally invasive. For now, the MCA aneurysm stands out as an example of how therapeutic management decisions can be based on aneurysm location alone. Patients are managed best when they are in specialized centers, receive care from dedicated experts, and have all treatment options available to them, including the latest new device. Still, they need straightforward recommendations from their neurosurgeons and other clinicians. Consensus supporting surgical clipping of MCA aneurysms is particularly strong, and clinicians should feel comfortable speaking with a clear and consistent voice that favors clipping for MCA aneurysms. In the meantime, new technology like WEB flow disruption should be rigorously studied to establish that endovascular results match surgical benchmarks before they are considered acceptable or even promising alternatives to surgery.

Felipe C. Albuquerque Phoenix, Arizona

WEB flow disruption and MCA aneurysms

Eric Sauvageau Columbus, Ohio

Michael T. Lawton San Francisco, California

Ana Rodríguez-Hernández