Treatment of vertebrobasilar fusiform aneurysms
Chicago Approach
VertebroBasilar Fusiform Aneurysms

Rare... but...

one of the most formidable vascular lesions encountered
VB Fusiform Aneurysms

- < 2% of all intracranial aneurysms
- Strong association with hypertension
- Presentation:
  - Ischemic stroke
  - Hemorrhagic stroke
  - Compression (Mass effect)
    - Brainstem, CN palsies, Hydrocephalus

- Poor natural history
  - Increased risk of stroke
  - Median survival 7.8 years
1990’s – Magic wall self expanding stent
From bench research to clinical application of flow diversion
Incredible case and wonderful clinical outcome

Pre- stent 3 months follow-up post stent
1990’s other cases not so successful

Problems:

1. Access
2. Lack of neuro devices
3. Timing of surgery
4. Best antiplatelet and anticoagulation
5. No intravascular imaging
How about Flow Diverters?

“Home made”

The real “thing”
### FD in posterior circulation

Bad outcomes reported!

<table>
<thead>
<tr>
<th>Case</th>
<th>Pre op mRS score</th>
<th>Post op stroke</th>
<th>Post op mRS score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>no</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>no</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>yes</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>yes</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>yes</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>yes</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>yes</td>
<td>6</td>
</tr>
</tbody>
</table>

**Siddiqui et al. JNS 116: 1258-1266, 2012**
Illustration showing a **fusiform thrombosed holobasilar aneurysm** with multiple patent branches on the walls of the aneurysm with preserved flow in them through the thrombus.

These aneurysms are not good candidates for flow diversion and carry a high risk of brainstem stroke.
Can you use flow diverters for both?

Carotid

Basilar
Learning Curve of FD

Data from intrePED registry

Adverse event rates drop with experience (learning curve)
# IntrePED (International Retrospective Study of the Pipeline Embolization Device: A Multi-center Aneurysm Treatment Study)

<table>
<thead>
<tr>
<th>Design</th>
<th>Multi-center, retrospective, post-market registry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Determine the incidence of important safety outcomes in patients who have undergone Pipeline™ embolization for intracranial aneurysms in a true clinical setting</td>
</tr>
<tr>
<td>Primary Endpoint</td>
<td>Rate of neurologic adverse events after treatment with Pipeline™</td>
</tr>
<tr>
<td>Population &amp; Sample Size</td>
<td>906 Aneurysms in 793 patients treated with the Pipeline™ since approval</td>
</tr>
<tr>
<td>Sites</td>
<td>17 centers worldwide</td>
</tr>
</tbody>
</table>

![Graph showing neurological mortality and M&M rates](image_url)

- **Neurological Mortality Rate**
  - 3.8% (30/793)
  - 8.4% (67/793)

- **Neurological M&M**
  - 3.8% (30/793)
  - 8.4% (67/793)
<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Posterior Circulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Aneurysms</td>
<td>95</td>
</tr>
<tr>
<td>Number of Patients</td>
<td>91</td>
</tr>
<tr>
<td>Follow-up duration (median)</td>
<td>22.4 +/- 10.5</td>
</tr>
<tr>
<td>Procedure time (min)</td>
<td>88.0 (34 – 294)</td>
</tr>
<tr>
<td>Mean +/- SD (N)</td>
<td>98.3 +/- 51.4 (85)</td>
</tr>
<tr>
<td>Location</td>
<td>Saccular</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>PCA</td>
<td>2 (13.3)</td>
</tr>
<tr>
<td>BA</td>
<td>22 (50.0)</td>
</tr>
<tr>
<td>VA</td>
<td>7 (21.2)</td>
</tr>
<tr>
<td>PICA</td>
<td>3 (100.0)</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
</tr>
</tbody>
</table>
### IntrePED posterior circulation

<table>
<thead>
<tr>
<th>Major Complications</th>
<th>Fusiform</th>
<th>Dissecting</th>
<th>Saccular</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurological morbidity</td>
<td>5/26 (19.2%)</td>
<td>1/26 (3.9%)</td>
<td>2/35 (5.7%)</td>
<td>0/4 (0%)</td>
</tr>
<tr>
<td>Neurological mortality</td>
<td>3/26 (11.5%)</td>
<td>1/26 (3.9%)</td>
<td>3/35 (8.6%)</td>
<td>0/4 (0%)</td>
</tr>
<tr>
<td>Neurological morbidity &amp; mortality</td>
<td>7/26 (26.9%)</td>
<td>1/26 (3.9%)</td>
<td>4/35 (11.4%)</td>
<td>0/4 (0%)</td>
</tr>
</tbody>
</table>
Summary and Conclusion

- Major complications after PEDs treatment in posterior circulation aneurysms were ischemic stroke in 6, hemorrhage in 2, spontaneous aneurysm rupture in 1, and death in 7 patients among 91 patients with 95 posterior circulation aneurysms treated.
- Use of PEDs ≥ 3 was a strong predictor for morbidity and mortality after placement of Pipeline Flow Diverter in patients with posterior circulation aneurysms.
- Fusiform aneurysms were also a predictor for morbidity and mortality after placement of PEDs in posterior circulation.
# Reports of flow diversion for posterior circulation aneurysms

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Patients</th>
<th>No. of Fusiform Aneurysms</th>
<th>No. of Ischemic Complications (%)</th>
<th>No. of Hemorrhagic Complications (%)</th>
<th>No. of Disabilities Related to PEDs (%)</th>
<th>No. of Deaths Related to PEDs (%)</th>
<th>Mean FU (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phillips et al., 2012 (3 centers)</td>
<td>32</td>
<td>20</td>
<td>3 (9.4)</td>
<td>2 (6.3)</td>
<td>3 (9.4)</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Siddiqui et al., 2012</td>
<td>7</td>
<td>3</td>
<td>5 (71.4)</td>
<td>2 (28.6)</td>
<td>1 (14.3)</td>
<td>2 (28.6)</td>
<td>4.5</td>
</tr>
<tr>
<td>Chalouhi et al., 2013</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Toth et al., 2015</td>
<td>6 (7 aneurysms)</td>
<td>2</td>
<td>3 (50)</td>
<td>0</td>
<td>2 (33)</td>
<td>1 (16.6)</td>
<td>14.5</td>
</tr>
<tr>
<td>Munich et al., 2014</td>
<td>12</td>
<td>12</td>
<td>4 (33)</td>
<td>0</td>
<td>3 (25)</td>
<td>1 (8.3)</td>
<td>11</td>
</tr>
<tr>
<td>Buffalo series, 2014</td>
<td>12</td>
<td>12</td>
<td>1 (8.3)</td>
<td>0</td>
<td>1 (8.3)</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>
Chicago experience on endovascular treatment of vertebrobasilar aneurysms

Nov 2014
Approach: Hybrid stent/FD overlapping construct staged contralateral VA sacrifice and or coiling of aneurysm

Goals:

1) Variable Arterial Coverage
2) Gradual aneurysm thrombosis

Increased Safety?
Technical Considerations

1) Protection of perforating arteries:
   - rostral basilar artery may contain a higher density of perforating arteries
   - these arteries may be more sensitive to changes in flow dynamics and acute aneurysm thrombosis
   - territories served by these arteries may have more severe clinical manifestations when perforators are occluded

2) Staged contralateral vertebral artery occlusion

3) Anti-platelet therapy:
   - confirmation of platelet inhibition
   - strict adherence to dual agent anti-platelet therapy
63 year old female presented with right facial droop, dysarthria, and right tinnitus

Medical history: Hypertension & Obesity
1\textsuperscript{st} Stage

- Build a hybrid construct with Enterprise and Pipeline across both aneurysms

2\textsuperscript{nd} Stage

- Coiling of sidewall aneurysm and possible sacrifice of right vertebral artery
1st Stage

4/19/2013 Placement of PED and enterprise (Hybrid construct)
2nd Stage

6/7/2013

Light coiling of AICA aneurysm

Decided not to occlude contralateral vertebral artery
12 months follow up
9/20/13 Keep close imaging follow-up!!!!
• HPI: Patient 53yo male with history of right side headache in 2013.
• CT showed fusiform basilar aneurysm, no SAH.
• Physical exam: neuro intact
• Several interventional procedures since than.
50 y/o man presenting with headaches and diplopia

2/13/13  1st Step placement of PED proximal to AICAs
2/13/2013 – Placing enterprise stent distal to PED
Hybrid Construct – Enterprise and PED

2/13/2013
2 months after the initial procedure, the patient presented with recurrence of symptoms

Headaches and worsening in diplopia
Staged occlusion of contralateral vertebral
4/4/2013
Right VA occlusion Stage 2
10/17/2013
Stent-assisted coil embolization of “new” aneurysm
10/17/2013
Stent-assisted coil embolization of recurrent aneurysm
Final device count: Two enterprise stents + 1 PED + Coils
10/17/2013
Staged FD + Stent-assisted coil embolization

Final device count: Two enterprise stents + 1 PED + Coils
10/17/2013
Staged FD + Stent-assisted coil embolization
Final device count: Two enterprise stents + 1 PED + Coils
12 months follow up
• HPI: Patient 54yo female with history of headaches for 2 years.
• CT/MRI showed tortuous fusiform aneurysm of the basilar artery.
• Parafalcine and right parietal meningioma.
• Physical exam: decrease sensation of left side of face, left arm and chest.
• Had right parietal craniotomy for tumor resection in 06/03/2013.
Day of Treatment

Pre Stent Deployment 3D DSA fused with post-stent deployment DynaCT Micro

Notice vessel deformation from device placement
Basilar artery aneurysm s/p Pipeline-Enterprise hybrid construct
6 month angiogram revealed residual filling of aneurysm
Discontinued dual anti-platelets
Follow-up DSA demonstrating positive remodeling of aneurysm sac and preservation of branches
mRS=0
Follow Up

5s 3D DSA Dual-Volume

DynaCT Micro
2nd Follow Up

Excellent Neck Coverage and Good Wall Apposition
A few important points for the future...
<table>
<thead>
<tr>
<th>Stent</th>
<th>Approximate Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuroform, Enterprise</td>
<td>6%</td>
</tr>
<tr>
<td>Liberty, Lvis</td>
<td>15%</td>
</tr>
<tr>
<td>PED, Silk, Fred, Surpass, P64</td>
<td>30%</td>
</tr>
</tbody>
</table>
PRU range $>50 < 210$

Dormant Platelets

Activated Platelets
Developing intravascular imaging with OCT for brain vessels
<< 29.9 mm, 5.0 mm/sec
MCA – Lenticulostriate perforators
Flow - Diverter

Self-expanding Stent
Thromboembolic Risk

- PRU>208 + procedure > 116 min – high risk
- PRU<208 + procedure > 116 min – moderate risk
- PRU>208 + procedure < 116 min – moderate risk
- PRU<208 + procedure < 116 min – low risk


Thromboembolic complications with Pipeline Embolization Device placement: impact of procedure time, number of stents and pre-procedure P2Y12 reaction unit (PRU) value.
What about patients with ventriculostomy?

• Technique for shunt
  – Expose ventriculostomy burr hole
  – Cut ventriculostomy catheter and discard proximal section
  – Attach shunt valve directly to original ventriculostomy catheter

• No movement of ventriculostomy catheter
Intraoperative Monitoring

Have all the “amenities” that we have for clipping

Motor VER SSEP EEG
8 Overlapping Pipeline stents
Angioplasty within Pipeline
Device/Vessel Mismatch Behavior

Memory effect

“gap”

Aneurysm

Nominal diameter

Maximum diameter

5.0 mm

3.0 mm

5.0

5.25

TZ

3.0

3.0 mm

5 x 20 mm PED

Nominal diameter
Addressing mismatch

3.0 mm PED

5.0 mm PED

3.0 mm ID

5.0 mm ID

TZ
Symptomatic occluded aneurysm
Conclusions:

- Vertebrobasilar fusiform and recurrent large and giant aneurysms remain formidable lesions associated with high morbidity and mortality when left untreated.

- Safer treatments may allow early intervention prior to quality of life permanently affected.

- Treatment with a variable coverage may be an alternative to invasive and extensive open vascular reconstruction and unpredictable impact of FD coverage.

- Progressive thrombosis of the aneurysm is a fine balance of controlling blood coagulation and flow remodeling.

- OCT imaging could be helpful mapping perforators for tailored coverage.
Hope to see you there!!!

www.wlnc.net