Advantages and Limitations of MLFM Stents for Aortic Aneurysm Treatment: When do they work and when don`t they?

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Disclosure

I have the following potential conflicts of interest to report:

☐ Consulting
☐ Employment in industry
☐ Shareholder in a healthcare company
☐ Owner of a healthcare company
☐ Other(s)
☒ I do not have any potential conflict of interest
☐
Paradigm-Shifting Technology Platform

- The behavior of the multilayer has been examined in silico, in vitro, in vivo, and in clinical settings.
- It remodels the parent artery which reduces wall shear stress and allows endothelial cells to regenerate.
- Non-covered 3D multilayer design laminates blood flow, diverts it away from aneurysm vortex and allows an organized laminar thrombus to form. Actions that reduces shear stress and protects the artery’s endothelial lining and the arterial wall elastin layer. Overall it reduces the probability of the aneurysm tendency to rupture.
- Lines of Zahn, characteristic of thrombi appearing in the aorta, can be visible with microscopic alternating layers (laminations) of platelets mixed with fibrin in MLFM induced thrombi. They confirm that the thrombus formation occurs overtime and appear as lighter and darker layers of red blood cells.
- By virtue of its porous geometrical construction it also preserves flow to vital organs through covered branches.
What do we know?

Flow Modulation works in small vessels and saccular Aneurysms

Aneurysm exclusion is achieved with simple low porosity single-layer stents. Pipeline from Covidien, Surpass from Stryker and Fred from Terumo.
Issues according to the Literature
Flow Modulation in:

- Large Aneurysms > 7 cm no tolerance for further increase in diameter
- Mycotic Aneurysms
- Ruptured Aneurysms
- Symptomatic Aneurysms
- Infected Stent Grafts
- Previous Stent Grafts
When the MFM May Not Be Effective: Due to Technical Errors

- Lack of sufficient proximal and distal healthy zone to avoid peri-MFM leak
  (it needs at least 2 cm for enough sealed wall apposition)

- Lack of sufficient overlapping; It needs at least 3 cm. (the overlapping in front the branches does not effect the lamination of the flow)

- The large size must be inserted in the small one to avoid endoleak type III

- The Stenosed branches must be treated prior to MFM deployment
Contraindications

3D Reconstruction

Intra-mural Calcifications
Aortic integrity compromised

Possible location of previous contained rupture
Flow Modulating Chimney grafts
Enhanced Gutter Thrombosis?
mortality and complications are mostly related to the complexity of the procedure.

- 7% in juxta- and pararenal AAA.
- 10% in suprarenal and TAAA IV
- 22% in TAAA I, II, III

Marzelle, Presles & Becquemin - On behalf of WINDOWS trial participants.
Hypothesis: Disease Modifying Solution in TAAA

- Procedure time takes an average 45 minutes less contrast volume, radiation exposure.
- Diverts blood along the direction of the systolic wave and convert vortices to lamination within the aneurysm.
- Laminates blood flow and allows an organized thrombus to form as onion layers (Line of Zahn).
- Preserves flow into covered branch arteries.
- Endothelization of MFM mesh over time.

Line of Zahn in Popliteal Aneurysm Courtesy Dr Aun (Brazil)

Dr. Barchiche Courtesy (Molière Hospital Belgium)
Hypothesis: Disease Modifying Solution in TAAA

- Procedure time takes, on average 45 minutes less contrast volume, radiation exposure.
- Diverts blood along the direction of the systolic wave and away from the aneurysm vortices.
- Laminates blood flow and allows an organized thrombus to form.
- Preserves flow into covered branch arteries.
- **Endothelization** of MFM mesh over time.
False Lumen AA after Type B Dissection

Vascular Centre Catholic Hospital Group Duesseldorf
Augusta Hospital
Post Dissection Aneurysm

Contraindication:

Branches arising from False Lumen:

55% Pressure drop in visceral arteries when supplied by false lumen
TAAA II

Vascular Centre Catholic Hospital Group Duesseldorf
Augusta Hospital
Indication: Penetrating Ulcer 38.8 mm
38.1 mm 1 month postop.
40.4 mm after 6 months

No further change in Diameter after 2 years and Thrombosis
<table>
<thead>
<tr>
<th></th>
<th>TAAA</th>
<th>N = 7</th>
<th>MARS Stent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of Procedure</td>
<td>min</td>
<td></td>
<td>43 (35 - 71)</td>
</tr>
<tr>
<td>Duration of Fluoroscopy</td>
<td>min</td>
<td></td>
<td>14 (7 - 22)</td>
</tr>
<tr>
<td>Contrast Volume</td>
<td>ml</td>
<td></td>
<td>(35 (20 - 60)</td>
</tr>
<tr>
<td>(mean, range)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Branch Patency

Total Number of Branches: 68

Occluded 1, 1.40%
No Significant Reduction in Diameter in 34 months (> 5 mm) in large aneurysms > 8 cm

(n = 7)
Flow Modulation PAU + Saccular AA (> 5 mm)

N = 15
PAU and Small Saccular Aneurysms
Results: TAAA > 8 cm MARS Stent

- Iliac artery occlusion: 1
- Graft separation requiring placement of an additional graft: 3
- Type I leak: 2
- Mortality: 2
Pitfalls: Diameter 9 cm  TAAA II
78 years
MARS Stent  3 months later

- Component Separation
- Rupture prior to Intervention

Pitfalls:

- Rigidity and Non Compliance of older Version of graft
2nd Generation Aortic Multilayer Flow Modulator

- Up to 20cm in length, 4.5cm in diameter delivery system 18F.
- CE Mark approved in February 2014
- On fast track for an HDE FDA approval anticipated before the end of 2015.
- Intended for true, degenerative, TAAA aneurysms with diameter range 5.5- to 7 cm.
Endothelialization of the MFM®
Patient CFD_032_006

Dr Barchiche – Belgium
The role of Flow modulation in Aortic Dissection

Follow-Up at 3 Days
Type A Dissection    The role of Bare Metal Stents
Type A Dissection    The role of Flow Modulating Stents
38 patients compassionate use

81% Failure to land in normal aorta

12 cases inadequate overlap

11 cases small stent into larger one

71% aneurysm related mortality
What Matters: Longer Term Follow Up: STRATO 3 years French Trial
STRATO

- Age >= 80
- ASA >= 3
- Hx of Aortic Surgery
- CAD
- Cardiac Renal or Respiratory Insufficiency
- Hostile Abdomen / Thorax
All cause Mortalities

<table>
<thead>
<tr>
<th>Mortality Cumulative Mortality</th>
<th>30 days</th>
<th>6 months</th>
<th>12 months</th>
<th>24 months</th>
<th>36 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause</td>
<td>0</td>
<td>0</td>
<td>1/23</td>
<td>2/23</td>
<td>4/23</td>
</tr>
<tr>
<td>Patients Reference</td>
<td>Cause of Deaths</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC0308_FRA_25_10;</td>
<td>At M34, Hepa7c Abscess aJer surgical interven7on.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC0308_FRA_25_14;</td>
<td>F---Up at M20, refused a re---interven7on for Endoleak Type I.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC0308_FRA_54_01;</td>
<td>At M12. Inadequate overlapping.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC0308_FRA_69_03;</td>
<td>Died at home w/o informa7on.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC0308_FRA_69_06;</td>
<td>At M32. No informa7on.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC0308_FRA_75_09</td>
<td>At M15 due to a bowel ischemia.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IC0308_FRA_91_01</td>
<td>At M31 due to Thyroid cancer.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### No Aneurysm Rupture, No Migration, No Stent Fracture

<table>
<thead>
<tr>
<th>Rupture 36 months</th>
<th>1 month</th>
<th>12 months</th>
<th>24 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0% (0/22)</td>
<td>0% (0/21)</td>
<td>0% (0/17)</td>
</tr>
</tbody>
</table>
## Clinical Success

<table>
<thead>
<tr>
<th>Clinical Success</th>
<th>6 months</th>
<th>12 months</th>
<th>24 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aneurysm</td>
<td>65% (13/20)</td>
<td>75% (15/20)</td>
<td>92% (12/13)</td>
</tr>
<tr>
<td>Aorta and MFM</td>
<td>100% (20/20)</td>
<td>100% (20/20)</td>
<td>100% (13/13)</td>
</tr>
</tbody>
</table>
80 year old male smoker with COPD, hyperuricemia, renal insufficiency and has previously underwent an aortic valve replacement operation.

The lesion’s length was 59mm, extending from L2 to the lower edge of L3 and exhibiting a maximal axe diameter of 50 mm pre-implantation.

24 month follow up shows all vital arterial branches are patent, stable and organized thrombus, reduction in maximal axe diameter to 48mm despite residual circulation which is essential to perfuse the renals.
Indications that must be discussed

- TAAA < 7 cm
- Penetrating Aortic Ulcers
- Tru Lumen Dissection
- Intramural Hematoma

Worth looking into this Technology
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