Aortic stents, types, selection, tricks in deployment.

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Endovascular Treatment of Thoracic Aortic Aneurysms

The first description of replacement of a remote stent graft was by Voldos, 1986 published in Russia.
Several stent grafts are commercially available. Most of them are based on the same principle, with polyester dacron or PTFE graft combined with Gianturco or Gianturco like stent of stainless steel or nitinol. These stents are either sutured or melted to the wall.

The ring stents used for abdominal aorta (Anaconda and Aorfix) are not used for thoracic AO except in one trial.

Stent graft used for thoracic AO are simpler, constructed as straight tubes. Zenith uses hooks to facilitate anchoring. Other stents rely on radial force. There are more than 8 CE marked thoracic stent grafts for thoracic AO available in Europe. Gore TAG, Gore CTAG, Cook Zenith TX2, Medtronic Valiant Captivia, Bolton Relay, Jotec E vital.
Table 11-1: Etiology of Thoracic Aortic Disease Treated at the Arizona Heart Institute between 2000 and 2005 (n = 280)

<table>
<thead>
<tr>
<th>Etiology</th>
<th>n (%)</th>
</tr>
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<tbody>
<tr>
<td>Aneurysm</td>
<td>159 (47%)</td>
</tr>
<tr>
<td>Type II dissection</td>
<td></td>
</tr>
<tr>
<td>Acute</td>
<td>46 (19%)</td>
</tr>
<tr>
<td>Chronic</td>
<td>63 (15%)</td>
</tr>
<tr>
<td>Penetrating ulcer</td>
<td>39 (11%)</td>
</tr>
<tr>
<td>Contained rupture</td>
<td>58 (13%)</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>35 (5%)</td>
</tr>
<tr>
<td>Intramural transection</td>
<td>10 (3%)</td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>7 (2.4%)</td>
</tr>
<tr>
<td>Atheroatherosclerotic aneurysm</td>
<td>2 (0.7%)</td>
</tr>
<tr>
<td>Extramural inclusion</td>
<td>1 (0.3%)</td>
</tr>
</tbody>
</table>

Figure 11-1: Embolization repair of a distal aneurysm. Thoracic aortic arch before stent graft deployment (left) and after endovascular exclusion (right).

Figure 11-2: Type II dissection presenting with subarachnoid. Intravenous contrast (CT) demonstrates contrast material in both the true and false lumens with arrows depicting the intimal flap. Axial CT scan (right) shows almost complete interruption of the aorta from the aortic arch layers with contrast material within the smaller true lumen.

Figure 11-3: Principles of endovascular repair for type II dissection. Illustration depicting endovascular exclusion of the primary intimal tear (left) with a covered stent graft (right). (Courtesy of the Arizona Heart Institute.)
FIGURE 1  Drawing showing acute type B aortic dissection with true and false lumen and extension of the dissection flap into the left renal artery. SMA = superior mesenteric artery. (Reprinted with permission from Op Tech Thor Cardiovasc Surg 14:2-11, 2009.)

FIGURE 2  A, Endograft covering the entry tear of the dissection, reciprocal expansion of the aortic true lumen and collapse of the aortic false lumen, and relief of dynamic obstruction of the celiac and superior mesenteric arteries. B, Narrowing of the left renal artery true lumen persists. If a significant pressure gradient persists between the aorta and the renal artery beyond the terminal point of the false lumen, a stent is used to treat the narrowing. F, False lumen; SMA, Superior mesenteric artery; T, thrombus. (Reprinted with permission from Fisted HJ, Williams DM. Endovascular therapy for multifocal dissection in acute type B aortic dissection. Op Tech Thor Cardiovasc Surg 14:2-11, 2009.)

FIGURE 3  Stages in performing the fenestration procedure. Monitoring is by intravascular ultrasound (not depicted), which can be positioned in the true or false lumen. A, The flap is punctured from the smaller into the larger lumen, usually the true and false lumens, respectively. B, A guidewire is passed into the opposite lumen through the needle. C, The puncture hole is extended by dilating an angioplasty balloon, which is held stationary and centered on the flap, typically 14 mm in diameter. D, This results in a transverse intimal tear. SMA, Superior mesenteric artery.
Challenges of Endovascular Repair of the Aortic Arch

- **Seal zone**: Adequate seal zone
- **Device Durability**: Long term durability remains a major concern, high pulsatility of the aortic arch > significant fatigue loading conditions that could lead to graft wear, stent fracture and stent kink.
- **Device alignment**
- **Aortic valve**: Avoid trauma of the AV with guide wire and the stiff tip of devices

- **Stroke**: remains a major concern after endovascular repair of the thoracic aorta (6-10%).
  
  **Mortality**: up to 23% in hybrid repairs because the majority of patients have severe comorbidities

Finally careful surgical planning and attention to anatomic and comorbid conditions should be considered in order to reduce device and procedure mortality.
Figure 13-4. Type B dissection depicted by graphic angiogram (top), with major vessel leak through the left subclavian (artery view), and axial CT scan demonstrating true (smaller) and false (larger) aneurysms in the distal thoracic aorta (artery view).

Figure 13-5. Reconstructed CT scan after end graft deployment showing persistent composite of the distal false lumen (top view). Stainless steel Stenture Z stent (artery view) with both manually crimped (artery view).KeyCode Endoprosthesis G1 style after endovascular treatment to illustrate the aortic stent graft (artery view), with a corresponding improvement in true lumen patency (artery view).

Figure 13-15. Principles of thoracic endografting. Endovascular exclusion of aortic disease requires a segment of nonaneurysmal proximal and distal aorta of at least 20 mm.
Figure 13-16. LEFT, Contrast-enhanced CT scan demonstrating contrast material within the excluded aneurysm sac from a patent left subclavian artery (type II endoleak). RIGHT, Graphic illustrating a type II endoleak from a patent left subclavian artery. (Right image courtesy of the Arizona Heart Institute.)

History
- A 72-year-old man with a previous endovascular repair of a giant thoracic aneurysm.
- The left subclavian artery had been excluded by the covered stent, resulting in a type II leak of moderate size.

Figure 13-21. 3D reconstructions of contrast-enhanced CT scan. Type II leak is seen as blue fuzzy material under the arch to the left side. The leak was successfully addressed by coil embolization of the left subclavian artery. The coil can be seen in the very proximal left subclavian artery in the CT reconstructions. (Courtesy of Mark Peterson, MD, Toronto, Canada.)
Technical Considerations

- Landing zones considerations
- Left subclavian artery considerations
- Celiac axis considerations
- Access considerations
- Imaging considerations
LANDING ZONE CONSIDERATIONS

- The presence of a significant and/or circumferential aortic mural thrombus at either the proximal or distal attachment sites would compromise fixation and seal of the implanted stent graft.

LANDING ZONE CONSIDERATIONS

- Planned placement of the COVERED (top edge of fabric) portion of the stent graft

- Requires implant to occur in Zones 0 or 1
WHEN TO REVASCULARIZE THE LSA?

- Left internal mammary to coronary bypass
- Dominant left vertebral artery
- Right subclavian artery stenosis or occlusion
- Aberrant right subclavian artery
- Extensive thoracic aorta coverage or previous infrarenal aneurysm repair
- Left arm AV fistula
- Left arm ischemia

VALIANT CAPTIVIA

- Wide range of diameters (22_46) mm
- Lengths: 100-150-200 mm
- Free flow, closed
- Straight, Tapered
**IMPLANTING ADDITIONAL SECTIONS**

- If 2 stents with different diameters are to be used, the smaller one should be placed first whether proximal or distal then the larger one deployed next.

- Minimum overlap is 5cm (overlap the single 8 and zero markers) If the 2 components have different diameters and preferred to be 7-10cm if the 2 components have the same diameter.

- FreeFlo and Bare Spring Straight ends should never be placed inside the fabric covered section of another stent graft – this may result in abrasion of the fabric by the bare spring and result in graft material holes or broken sutures.

**ANGIOGRAM**

- Perform angiography upon completion of an implant procedure to verify stent graft apposition, and any endoleaks at the proximal and distal ends of the stent graft.

- Assess the stent graft for mid-graft and graft junction endoleaks.

- The most reliable course of endoleak management is by remodelling the stent graft with a balloon and, if needed, placing an additional stent graft.
Complications associated with Endovascular Repair for Thoracic Aortic Disease

- Endoleak (type 1-1v)
- Graft collapse
- Graft Migration
- Retrograde Aortic Dissection
- Aortic Rupture (stent struts)
- Access complications
- Reintervention

EVAR
BIFURCATED STENT GRAFT DESIGN

M-shaped proximal stents provide wall apposition and minimize in-folding

Suprarenal stent with anchor pins provide secure fixation

High density multi-filament polyester graft material

OVERVIEW OF STENT GRAFT COMPONENTS AND DESIGN

Marker Configuration
1. Radiopaque Marker
2. "e" Marker
3. Radiopaque Gate Marker
4. Aortic Extension and Abdominal Tube
5. Bifurcated Component
6. Iliac Extension
7. Contralateral Limb

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
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<tbody>
<tr>
<td>Stents</td>
<td>Nickel-Titanium (Nitinol) Alloy</td>
</tr>
<tr>
<td>Button Radiopaque Markers</td>
<td>Platinum-Iridium Alloy</td>
</tr>
<tr>
<td>&quot;e&quot; Radiopaque Marker</td>
<td>Platinum</td>
</tr>
<tr>
<td>Contralateral Gate Marker</td>
<td>Platinum Iridium</td>
</tr>
<tr>
<td>Graft Material</td>
<td>Polyester</td>
</tr>
<tr>
<td>Suture</td>
<td>Polyester and Polyethylene</td>
</tr>
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</table>
Combined Branched / Fenestrated SG

- Branches
- Fenestration
- Indwelling Catheters
Figure 13-25. Branched endograft for thoracoabdominal aneurysm repair (LEFT) and reconstructed CT scan after repair (RIGHT).

### Table 1: Classification of Endoleaks and Endotension

<table>
<thead>
<tr>
<th>Endoleak Type</th>
<th>Source of Perigraft Flow</th>
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<tbody>
<tr>
<td>I</td>
<td>Attachment site</td>
</tr>
<tr>
<td>Ia</td>
<td>Proximal, aortic end</td>
</tr>
<tr>
<td>Ib</td>
<td>Distal, iliac end</td>
</tr>
<tr>
<td>Ic</td>
<td>Iliac occluder</td>
</tr>
<tr>
<td>II</td>
<td>Branch leaks</td>
</tr>
<tr>
<td>IIa</td>
<td>Simple: one patent branch</td>
</tr>
<tr>
<td>IIb</td>
<td>Complex: two or more patent branches</td>
</tr>
<tr>
<td>III</td>
<td>Stent graft defect</td>
</tr>
<tr>
<td>IIIa</td>
<td>Junctional leak or modular disconnect</td>
</tr>
<tr>
<td>IIIb</td>
<td>Fabric holes</td>
</tr>
<tr>
<td>IV</td>
<td>Stent graft porosity &lt;30 days after implantation</td>
</tr>
<tr>
<td>Primary endoleak</td>
<td>Present from the time of EVAR</td>
</tr>
<tr>
<td>Secondary endoleak</td>
<td>Diagnosed after a prior negative CTA</td>
</tr>
<tr>
<td>Endotension</td>
<td>AAA enlargement with increased intrasac pressure after EVAR with no endoleak on CTA</td>
</tr>
</tbody>
</table>
ASCENDING AORTIC ENDOGRAFTS

Initial Examples (n=24)

- Type A IMH/Dissection: 6 (2 <14days)
- Trauma: 2
- Fistula to PA (iatrogenic): 1
- Mycotic Aneurysm: 7
  fungal: 4 (transplant: single lung -- 1, heart/lung -- 2, and double lung -- 1)
- Anastomotic Pseudoaneurysm: 8 (heart transplant: 1 )
CHALLENGES POSED BY THE ASCENDING AORTA

Anatomy

• Stent parking place (shorter)
• Curved geometry
• Non-cylindrical shapes
• Large diameter
• Neck mismatch frequent (taper, reverse taper)
• Branches (coronaries, innominate, bypass grafts)

CHALLENGES POSED BY THE ASCENDING AORTA

Physiology

• Increased flow
• Enhanced compliance--dynamic aortic deformation
• Proximal aortic movement
• Cardiac dynamics
• Respiratory motion
Acute Type-A Dissection

CTA post stent-graft

Follow-up at 6 weeks
Conclusion

- Deployment of a covered stent through the femoral artery avoids thoracotomy incision, aortic cross clamping and physiologic perturbations associated with open surgery.
- High-quality imaging is critical to ensure successful endovascular repair.
- Hybrid endovascular-open procedures are used to treat patients whose proximal or distal landing zone are close (<20 mm) to critical branch vessels.

THANK YOU........