TEVAR and the Aortic Arch:
Challenges, Planning and Techniques for Good Outcomes

Tilo Kölbl, MD, PhD
University Heart Center Hamburg
University Hospital Eppendorf
Gold Standard for Descending Aorta
Descending Aorta
TEVAR vs. Open

Metaanalysis of comparative studies
TAA and Type B Dissection (n = 5888)

TEVAR better:
- 30d mortality
- Paraplegia rate
- Transfusion
- Cardiac compl.
- Renal function
- Pneumonia
- Reoperation
- ICU and Hospital LOS

Gold Standard for the Arch

Surgery for the aortic arch:
* Open repair
* Elephant trunk

Mortality rates 5-15%

Stroke: 4-12%

Minakawa et al. 2010; Ann Thorac Surg 90:72-7
Endovascular Challengers

Frozen Elephant Trunk
Tsagakis et al. 2013 Ann Cardiothorac Surg 2:612-20

Hybrid Repair
Chiesa et al. 2010 J Endovasc Ther 17:1-11

Branched/Fenestrated Repair
Aortic Arch Zones

Ishimaru-classification
Aortic Arch Zones

Ishimaru-classification

75 – 80% of TEVAR Involve the Arch!
Challenges of the Aortic Arch

- Branch vessels
  Patency / endoleak

- Pulsatility
  Oversizing / migration

- Curvature
  Conformity / infolding

- Access
  Distance / profile / kinking
Outline

* Planning
* Challenges
* Techniques
Most technical Errors follow insufficient planning!
Planning

- Perpendicular measurement
- Multiplanar-reconstruction (MPR)
- Pulsatility
- Graft-properties
- Proximal Landing
Workstation
Perpendicular Diameter in MPR
Perpendicular Diameter

28.2 mm

31.2 mm

31.2 mm
Pulsatility

Toward Endografting of the Ascending Aorta: Insight into Dynamics Using Dynamic Cine-CTA

Joffrey van Prehn, MD; Koen L. Vincken, PhD; Bart E. Muhs, MD, PhD; Gijsbrecht K. W. Barwegen, BS; Lambertus W. Bartels, PhD; Mathias Prokop, MD, PhD; Frans L. Moll, MD, PhD; and Hence J. M. Verhagen, MD, PhD

J ENDOVASC THER 2007;14:551–560

15% Max Diameter Change
Pulsatility

Dynamic Cine-CT Angiography for the Evaluation of the Thoracic Aorta; Insight in Dynamic Changes with Implications for Thoracic Endograft Treatment


10% Max Diameter Change
Hypovolemia and Aortic Diameter

More Oversizing for TEVAR in Transection with Hypotension!

Jonker et al 2010; EJVES; 40:564-71
Preferred landing site:

- Length
- Diameter
- Shape
- Thrombus
- Non-dissected healthy aortic wall
Proximal Landing
Proximal Landing

Endovascular Treatment of Acute Complicated Type B Dissection: Morphological Changes at Midterm Follow-up

- 52 patients, FU 31m
- 47 stentgrafts distal to LSA
- 9 patients proximal erosion and aneurysm
- 3 patients with rupture, 2 fatal

Manning et al, JEVT, 2009
Techniques

- Access-techniques

- Endovascular Techniques
  - Arch-conformance
  - Fenestrated / branched Devices
  - In-situ Fenestration
Access Techniques

- Iliac-conduit
- Paving and Cracking
- Through & Through-Wire
- Transcardiac Access
Access Techniques
Access Techniques
Iliac Conduit
Paving and Cracking
Through&Through-Wire

Stiff Guidewire

Soft transbrachial Throughwire
Transseptal Through-Wire
Transseptal Through-Wire
Transapical Through-Wire
Windsocket Effect – Retroflexion

Kasirajan et al; J Vasc Surg 2010

Cook TX2
Case: Retroflection
Case: Retroflection
Case: Retroflection
IVC Balloon Occlusion

\[ \frac{1}{2} \times \text{MAP within 1 minute} \]
Insufficient SG-conformity to the anatomy of the arch

→ Aortic wall erosion
→ Type 1 endoleak
→ Stent-graft collapse
Potential Factors

- Angulation of arch
- Small aortic diameter
- Stent-graft oversizing
- Transsection
- Stent-graft rigidity
Potential Factors

- Angulation of arch
- Small aortic diameter
- Stent-graft oversizing
- Transsection
- Stent-graft rigidity

Malorientation of the sealing stent!
Zenith® TX2 ProForm®

Controlled Deployment by ProForm
Controlled Deployment by ProForm
Aortic Arch Techniques for Zone 0
Zone 0 – Debranching
Zone 0 – Debranching
Zone 0 – Chimney Graft
Zone 0 – Chimney Graft
Zone 0 – Chimney Graft
Zone 0 – In-Situ Fenestration
Zone 0 – In-Situ Fenestration
Zone 0 – In-Situ Fenestration
In situ laser fenestration during emergent thoracic endovascular aortic repair is an effective method for left subclavian artery revascularization.

Richard E. Redlinger Jr, MD, Sadaf S. Ahanchi, MD, and Jean M. Panneton, MD, Norfolk, Va

In-Situ Laser Fenestration
Zone 0 – Fenestrated Stent-Graft
Branched Arch Repair

Aortic Arch Reconstruction by Transluminally Placed Endovascular Branched Stent Graft

Kanji Inoue, MD; Hiroaki Hosokawa, MD; Tomoyuki Iwase, MD; Mitsuru Sato, ME; Yuki Yoshida, MT; Katsuya Ueno, RT; Akiyoshi Tsubokawa, MD; Terumitsu Tanaka, MD; Shunichi Tamaki, MD; Takahiko Suzuki, MD

- 1995-1998
- N=15
  - 14 single branch,
  - 1 triple branch
- Outer branches
- Traction wire

Inoue et al. 1999; Circulation 100:316-21
Branched Arch Repair

Endovascular Repair of the Aortic Arch

Timothy A. M. Chuter, DM, and Darren B. Schneider, MD

- 2003 – 2010 (?)
- N=10-20 (?)
- Outer branch
- Transcervical access

Chuter et al. 2007; Perspect Vasc Surg Endovasc Ther 19(2):188-92
Zone 0 – Branched Stent-Graft

A-Branch:
- Arch aneurysms
- Internal side-branches
- Nitinol & stainless steel Z-stents
- Low-profile high density dacron fabric
- Self orienting delivery system
- Controlled deployment
Zone 0 – Branched Stent-Graft
Branched Arch Endograft

- Multicenter Study
- \( n = 38 \)
- Technical success 32/38
- Mortality 5/38 (13%)
- Stroke/TIA 6/38

### TABLE 6. Comparative analyses between first 10 patients (early experience group) and next 28 patients (late experience group)

<table>
<thead>
<tr>
<th></th>
<th>Early experience (n = 10)</th>
<th>Late experience (n = 28)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early mortality</td>
<td>3 (30.0; 0.0-60.0)</td>
<td>2 (7.1; 0-16.9)</td>
<td>.066</td>
</tr>
<tr>
<td>Overall mortality</td>
<td>3 (30.0; 0.0-60.0)</td>
<td>6 (21.4; 5.9-36.9)</td>
<td>.67</td>
</tr>
<tr>
<td>Technical failure</td>
<td>3 (30.0; 0.0-60.0)</td>
<td>3 (10.7; 0.0-22.5)</td>
<td>.15</td>
</tr>
<tr>
<td>Type 1 endoleak</td>
<td>3 (30.0; 0.0-60.0)</td>
<td>2 (7.1; 0-16.9)</td>
<td>.066</td>
</tr>
<tr>
<td>Intraoperative complications</td>
<td>4 (40; 8.0-72.0)</td>
<td>3 (10.7; 0.0-22.5)</td>
<td>.04</td>
</tr>
<tr>
<td>All secondary procedures</td>
<td>4 (40; 8.0-72.0)</td>
<td>3 (10.7; 0.0-22.5)</td>
<td>.04</td>
</tr>
<tr>
<td>Early secondary procedures for endoleak</td>
<td>2 (20; 0.0-46.1)</td>
<td>0 (0)</td>
<td>.015</td>
</tr>
<tr>
<td>All secondary procedures for endoleak</td>
<td>3 (30.0; 0.0-60.0)</td>
<td>0 (0)</td>
<td>.014</td>
</tr>
<tr>
<td>Transient ischemic attack and strokes</td>
<td>3 (30.0; 0.0-60.0)</td>
<td>3 (10.7; 0.0-22.5)</td>
<td>.15</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>3 (30.0; 0.0-60.0)</td>
<td>1 (3.6; 0.0-10.6)</td>
<td>.019</td>
</tr>
<tr>
<td>Stroke</td>
<td>0 (0)</td>
<td>2 (7.1; 0-16.9)</td>
<td>.38</td>
</tr>
<tr>
<td>Operative time, min</td>
<td>320 (271.5-360)</td>
<td>248.3 (199.0-270.0)</td>
<td>.03</td>
</tr>
<tr>
<td>Radiograph duration, min</td>
<td>120 (52.8-264.5)</td>
<td>39 (30.0-59.4)</td>
<td>.007</td>
</tr>
<tr>
<td>Volume of contrast media injected, cc</td>
<td>150 (136.0-220.0)</td>
<td>150 (86.0-206.25)</td>
<td>.34</td>
</tr>
<tr>
<td>Ascending aorta diameter &gt;38 mm</td>
<td>4 (40; 8.0-72.0)</td>
<td>7 (25; 8.7-41.3)</td>
<td>.37</td>
</tr>
</tbody>
</table>

Values for operative time, radiograph duration, and volume of contrast media injected are given as median (quartile 1-quartile 3). Other values are given as n (%; 95% confidence interval). Boldface indicates P values < .05.
Comparing...

Fenestrated vs. Branched
## Indications

<table>
<thead>
<tr>
<th></th>
<th>Fenestrated Device (n=6)</th>
<th>Branched Device (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAU</td>
<td>1 (inner curvature)</td>
<td>2 (outer curvature)</td>
</tr>
<tr>
<td>Post-traumatic aneurysm at the subclavian artery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type B Dissection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arch involvement</td>
<td>2 (dissection proximal of the subclavian)</td>
<td>2 (aneurysm of the arch)</td>
</tr>
<tr>
<td>Arch Aneurysm</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Residual Dissection</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Type A Dissection</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Fenestrated Device (n=6)</td>
<td>Branched Device (n=9)</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Target Vessels</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Median of Target Vessels</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Vessel Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bovine Innominate Artery</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Innominate Artery</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>LCA</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>LSA</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
Comparing...

Branched Arch Graft

Fenestrated Arch Graft
Potential CONs for Fenestrated Arch Grafts

- Alignment of fenestrations difficult
- No strutfree fenestrations larger than 12mm restricts use for innominate artery
- Preloaded wire may entangle in struts of scallop
Potential CONs for Branched Arch Grafts

- Higher risk for trapped air and embolism
- Maximum ascending diameter 38mm and minimum length of 70mm limits use.
- Required left-ventricle wire position limits use in mechanical aortic valves
Conclusion

Well, we're both fruit.

There is a Difference
Conclusions

- Arch-vessels, curvature and access are main challenges.
- Perpendicular measurement, multiplanar reconstruction, centerline reconstruction required.
- Rapid development depending on local infrastructure.
- Feasible and lifesaving option in patients unfit for surgery.
- Role of stent-grafts in the aortic arch not yet defined.