Effects of long thoracic stentgrafts on the pathophysiology of the heart

FRANS MOLL
Diederik van Bakel et al.
Distensible walls – Function

• Aortic compliance lowers impedance of ejection and decreases afterload

• Aortic stiffening plays important role in cardiovascular disease $^{6,7}$

• Endografts for TEVAR are much stiffer than the native aorta


Study on impact of TEVAR

- Assess impact of TEVAR-induced aortic stiffening on stroke work
- Used computational modeling to calculate left ventricular (LV) stroke work
- Measured cardiac remodeling before and 1 year after TEVAR from ECG-gated CTA and echocardiography
Methods: Patient Population

- 8 patients were retrospectively included (6 female), mean age 68±14 years
- All patients were prescribed antihypertensive drugs following TEVAR
Methods: Geometric Models

- 8 patients pre-TEVAR and post-TEVAR
Methods: Hemodynamic Data

- In- and outflow conditions were tuned to match patient-specific cardiac output and blood pressure measurements.

A mathematical heart model was applied to calculate LV stroke work.
Results

- FSI analysis calculated a **26% increase in LV stroke work** following TEVAR:

  pre-TEVAR 0.94±0.32 J vs post-TEVAR 1.18±0.38 J (P=.001)
Results

• Morphologic measurements confirmed an LV mass index increase post-TEVAR
  
  +26% with echocardiography (P=.034)
  +15% with ECG-gated CTA data (P=.016)
Results

• LV mass index had a significant positive correlation with both the stroke work (SW) and mean blood pressure (BP)
Conclusions – Impact of TEVAR on LV

- TEVAR was associated with a 26% increase in LV stroke work and a 15–26% increase in LV mass during follow-up
- Intensive anti-hypertensive management is needed to control blood pressure following TEVAR
- More compliant devices needed to reduce stiffness mismatch with aorta
- Restoring the original aortic anatomy and function renders best results
Aortic Rupture after zone 2 TEVAR

A 74 year-old female patient died 3 months after branched zone 2 TEVAR
Aortic Rupture after zone 2 TEVAR

- 74 year-old patient
- Presented with:
  - 49-mm mid-ascending aneurysm
  - 63-mm proximal descending aneurysm
- Medical History:
  - Hypertension
  - Hypercholesteremia
  - Smoking 25 pack years
Follow-up

- After 2 years CTA follow-up
Plan → TEVAR first

- Proximal descending aneurysm treated first with zone 2 TEVAR
  Plan repair of ascending aneurysm in second stage

TEVAR:
- Proximal landing zone 2 diameter: 34-mm
- Distal landing zone descending aorta: 42-mm
- Diameters and lengths of proximal and distal Gore endografts:
  1x TBE: 37x100-mm
  2x c-TAG: 45x150-mm
TEVAR procedure

- Deployment complicated by 5-mm dislocation and Type Ia endoleak
- Proximal extension devices were deployed 2x 45x46-mm
TEVAR procedure

- Balloon dilation of extension devices caused infolding
CTA post-TEVAR

- Infolding (blue) and bird-beaking (yellow) of proximal extension devices
30-day follow-up

- Stable position of endograft, no endoleak
- 1-mm increase ascending aorta
- Of note, low blood pressure
3-months

- Patient expired in her sleep
- Cause of death: hemopericardium due to aortic rupture
Functional-Structure Interaction

FSI simulations

- 3 models: Pre-TEVAR, Post-TEVAR and Virtual Uncomplicated endograft deployment (VUED)

Aortic Wall Tissue Properties

<table>
<thead>
<tr>
<th></th>
<th>E [MPa]</th>
<th>h [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ascending A</td>
<td>2.0</td>
<td>2.7</td>
</tr>
<tr>
<td>2 Aortic arch</td>
<td>1.6</td>
<td>2.6</td>
</tr>
<tr>
<td>3 Descending A</td>
<td>2.6</td>
<td>4.0</td>
</tr>
<tr>
<td>4 Descending</td>
<td>1.8</td>
<td>2.8</td>
</tr>
<tr>
<td>5 Endograft</td>
<td>55.2</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Pre-TEVAR FSI simulation

• Match preop data
Results – Aortic Pressure

- Ascending aortic pressures

![Graph showing ascending aortic pressure comparisons between Pre-TEVAR, Post-TEVAR, and VUED conditions. The graph plots pressure against time, with key pressure readings indicated.]
Results – Vascular Deformation Mapping

- Normalized index of displacement (NID) = \((J - 1) / \text{Pulse Pressure}\)

NID +173% in rupture region
Conclusion – Aortic Rupture

- Stiffness mismatch between endograft and native aorta increases pulse pressure in the unstented segments of the aorta, increasing wall stresses.

- This should be taken into account in preoperative planning.

- Strict blood pressure control and development of new endografts is needed to reduce risk of complications due to stiffness mismatch.
Effects of long thoracic stentgrafts on the pathophysiology of the heart

FRANS MOLL
Diederik van Bakel et al.