What happens to the neck after EVAR and EVAS?

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Disclosure

Speaker name:
MMPJ Reijnen

I have the following potential conflicts of interest to report:

- Consulting
- Employment in industry
- Stockholder of a healthcare company
- Owner of a healthcare company
- Other(s)

- I do not have any potential conflict of interest
The infrarenal neck

• Anatomy of the infrarenal neck is key in planning endovascular repair of abdominal aortic aneurysms
• Fixation and seal of EVAR depends on oversizing and hooks/barbs
• Oversizing enhances seal and fixation, but also places continuous radial force on the anatomic neck
• Endovascular sealing (EVAS) relies on different concept with polymer filled endobags providing stability and seal from the aneurysmal lumen
The infrarenal neck

Configuration may affect:

- Morphology
- Movement during cardiac cycle
- Flow and wall shear stress
- Neck enlargement
1. Morphology

retrospective CT analysis

• 50 consecutive patients
• Operated between March 2014 and July 2014
• Elective cases only, both inside and outside the IFU
• CTA at three time points:
  • Pre-operative,
  • Early postoperative (<6 weeks)
  • One-year CTA imaging
• Exclusion: Incomplete data or missing imaging, UAI and/or accessory devices (chimney’s, cuffs, extensions)
## 1. Morphology

*retrospective CT analysis*

<table>
<thead>
<tr>
<th>Demographics</th>
<th>(n = 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male gender</td>
<td>43 (86%)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>73.5 ± 6.2</td>
</tr>
<tr>
<td>Hypertension</td>
<td>37 (74%)</td>
</tr>
<tr>
<td>Cardiac history</td>
<td>26 (52%)</td>
</tr>
<tr>
<td>TIA/CVA</td>
<td>11 (22%)</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>5 (10%)</td>
</tr>
<tr>
<td>Max AAA diameter (mm)</td>
<td>58.4 (±7.8)</td>
</tr>
<tr>
<td>Neck length (mm)</td>
<td>23.8 (±13.6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedural data</th>
<th>(n = 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural time (min)</td>
<td>85 ±20</td>
</tr>
<tr>
<td>Polymer volume (mL)</td>
<td>76 ±40</td>
</tr>
<tr>
<td>Endobag pressure (mmHg)</td>
<td>201 ± 20</td>
</tr>
<tr>
<td>Hospital admittance (days)</td>
<td>4 ± 2</td>
</tr>
</tbody>
</table>
1. Morphology

retrospective CT analysis

• Measurement of using semi-automatic CLL in pre- and post-operative imaging; angles, tortuosity, lengths and volumes

• AAA, endobag and stent volume segmented separately and analyzed
1. Morphology
retrospective CT analysis

<table>
<thead>
<tr>
<th>Neck anatomy</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck tortuosity</td>
<td>1.2 ± 0.2</td>
<td>1.2 ± 0.2</td>
<td>1.3 ± 0.3</td>
</tr>
<tr>
<td>Max. diameter (mm)</td>
<td>27.7 ± 3.2</td>
<td>26.9 ± 3.5</td>
<td>27.7 ± 3.8</td>
</tr>
<tr>
<td>Suprarenal aortic diameter (mm)</td>
<td>25.9 ± 3.2</td>
<td>26.5 ± 3.9</td>
<td>26.9 ± 3.7</td>
</tr>
<tr>
<td>cul-de-sac volume (mL)</td>
<td></td>
<td>2.14</td>
<td>2.44</td>
</tr>
<tr>
<td>α angle (suprarenal angle)</td>
<td>11.5 ± 8.1</td>
<td>10.8 ± 7.7</td>
<td>10.2 ± 7.0</td>
</tr>
<tr>
<td>β angle (distal angle)</td>
<td>17.8 ± 16.5</td>
<td>9.5 ± 8.3</td>
<td>10.9 ± 7.8</td>
</tr>
</tbody>
</table>

- **Unchanged neck diameters** during first year
- Sustained **straightening** of the infrarenal neck
- **Stability** in stent position
- Organization of thrombus volume and trend towards **decrease in volume** during the first year suggesting depressurization
2. Movement
ECG-gated CT study

- There is an up to 3-mm movement of the renal arteries both near and distant from the aorta\(^1\)
- EVAR inhibits proximal, but not distal renal motion up to 30%\(^1\)
- Interim analysis of 8 patients with ECG-gated CT scan before and after EVAS

2. Movement

ECG-gated CT study

<table>
<thead>
<tr>
<th></th>
<th>preoperative</th>
<th>postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>systole</td>
<td>diastole</td>
</tr>
<tr>
<td>Maximal suprarenal diameter (mm)</td>
<td>28.5 ± 5.0</td>
<td>29.4 ± 4.4</td>
</tr>
<tr>
<td>Maximal diameter proximal neck (mm)</td>
<td>26.4 ± 5.8</td>
<td>25.1 ± 3.6</td>
</tr>
<tr>
<td>Maximal diameter distal neck (mm)</td>
<td>24.0 ± 7.3</td>
<td>24.4 ± 5.9</td>
</tr>
<tr>
<td>Total neck volume (mL)</td>
<td>9.5 ± 12.0</td>
<td>9.7 ± 9.2</td>
</tr>
<tr>
<td>Right renal artery angulation</td>
<td>43.5 ± 16.8</td>
<td>50.0 ± 20.3</td>
</tr>
<tr>
<td>Left renal artery angulation</td>
<td>52.5 ± 37.8</td>
<td>56.0 ± 20.3</td>
</tr>
<tr>
<td>β angulation left stent</td>
<td>10.0 ± 6.3</td>
<td>9.0 ± 13.5</td>
</tr>
<tr>
<td>β angulation right stent</td>
<td>11.0 ± 12.3</td>
<td>9.0 ± 22.8</td>
</tr>
<tr>
<td>‘Cul de sac’ volume</td>
<td>1.0 ± 2.0</td>
<td>0.5 ± 1.8</td>
</tr>
</tbody>
</table>

- No significant changes in neck morphology during cardiac cycle pos-EVAS
- Stable angles of the Nellix stents during cardiac cycle
- Larger distal neck diameter post-EVAS

Interim analysis; Data may be subjected to changes
3. Flow and wall shear stress

- Physiological flow model:
  - Based on second order windkessel model
  - Peak flow 60 mL/sec
  - Flow equal to all out flow vessels
  - 120/80 mmHg, 60 BPM
  - Blood mimicking fluid: 4.3 cP

- Flow fields obtained with laser particle image velocimetry (PIV)

- End points: Wall shear stress and Oscillatory shear index
3. Flow and wall shear stress

**Suprarenal aorta:**

- Fluid is accelerated near renal orifice during peak systolic phase
- Flow reversal suprarenal aortic wall during end-systolic phase
- WSS and OSI are comparable in all models
3. Flow and wall shear stress

Renal artery:
• Laminar flow profile in all models
• Area of lower minimal WSS in caudal wall of renal artery in all models (lowest for EVAR model)
• Higher maximum WSS in same area for EVAS model
• No differences in WSS and OSI in other locations
3. Flow and wall shear stress

• The studied endografts are related to an undisturbed flow in the suprarenal aorta
• Changes in flow occur in the renal artery within physiologic limits
  • Local decrease in minimum WSS in all stented models
  • Increase in maximum WSS post-EVAS

EVAR and EVAS are **NOT** related to an increased risk on atherosclerosis of acute thrombosis based on flow alterations
4. Neck enlargement

• Neck enlargement is common after EVAR and related to reinterventions

• Potential differences between EVAR and EVAS

Proximal Fixation by Nitinol stent (Endurat®, Excluder®)
Stainless steel stent (Zenith®)
More radial force

NELLIX®
Total Anatomic Fixation by Polymer-filled Endobags
No residual radial force
4. Neck enlargement

- Retrospective, radiologic (CT) study
- 49 patients treated with EVAS and 56 with EVAR
- Treated between 2008 – 2010
  - EVAS: Riga, Latvia and Auckland, NZ
  - EVAR: Nieuwegein, NL
- All patients treated on-IFU
- Mean EVAR oversizing was 12.8% ± 2.7% (range, 7%-31%)
- Up to 4.8 years follow-up for EVAS (median 3 yrs) and 4.6 years for EVAR (median 2 yrs)
- Core-lab adjudicated

4. Neck enlargement

**Level 1:** Infrarenal aortic neck diameter just below lower most renal artery

**Level 2:** Proximal end of the endograft

**Level 3:** 5mm below proximal end of endograft

4. Neck enlargement

4. Neck enlargement

- Immediate neck enlargement:
  - EVAS $1.1 \pm 0.5$ mm
  - EVAR $2.6 \pm 0.5$ mm

- Neck enlargement at three years:
  - EVAS $0.5 \pm 0.9$ mm
  - EVAR $3.8 \pm 1.0$ mm

- Annual post implant rate of increase in neck diameter 5-fold higher after EVAR

Conclusions

• No significant change in neck morphology at one-year follow-up after EVAS
• Increased distal infrarenal neck diameter after EVAS, but no changes in neck morphology during the cardiac cycle
• EVAS and EVAR are related to unchanged flow patterns and WSS in the suprarenal aorta and physiological changes in the proximal renal artery
• Neck enlargement is lower after EVAS compared to EVAR
What happens to the neck after EVAR and EVAS?

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