Proximal abdominal aortic aneurysm neck changes after endovascular repair and their association with time, endograft size and type and ancillary measures

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Purpose

The endovascular aneurysm repair (EVAR) is a relatively new technique for the treatment of abdominal aortic aneurysms (AAA). Since its introduction in 1991, by Parodi and Volodos [1,2], it has rapidly expanded and has allowed clinicians to treat a higher-risk group of patients, who were unsuitable for an open repair. Research suggests that EVAR has lower early morbidity and mortality rates compared to the open repair, but higher long term complication rates (41% Vs 9%).[3,4] Some of the post-operative complications are associated with the changes at the proximal neck of the AAA.[5] The objectives of this project were to assess these changes.

In particular, this study focused on the association of proximal AAA neck changes with:

- time
- the endograft size used during the EVAR
- the endograft type used during the EVAR
- the use of ancillary graft during EVAR
- the use of Palmaz stent during EVAR
Methods and Materials

Fifty-two patients, who underwent EVAR for an AAA over a period of eight years, were identified from a prospective database.

The management of these patients was according to the hospital protocol for endovascular AAA repair, which includes CT Angiography (CTA):

- pre-operatively for planning
- within the early post-operative period
- at three to six months post-operatively
- at one year post-operatively
- yearly thereafter

These images were retrieved from the PACS system (Picture Archiving and Communication System), for each one of the 52 patients.

Vessel analysis protocol

An AW VolumeShare 2 software was used on a Workstation in order to analyse the images. The operator had to identify the main branches of the abdominal aorta on the screen and define the start and end of section. All views (axial, coronal and sagittal) were displayed at the same time in the screen, allowing the person using the computer to simultaneously navigate in them (Fig.1).

Once the anatomical structures were identified on the CT scan, the software would then track the central line of the aorta at this area and display its lumen (Fig.2 and Fig.3).

At the axial view the most caudal renal artery was identified and the cursor was moved just distal to it. This would also move the measuring line at the lumen view. The measurement of the aortic neck area in \( \text{mm}^2 \), at this level was taken. At the same time, at the cross section view (X-view) the minimum and maximum diameter were measured and a mean diameter calculation was provided. The process just described was repeated at four different levels (Fig.4 and Fig.5):

- Distally to the most caudal renal artery (labelled 'inferior RA')
- 10 mm above the most caudal renal artery (labelled 'above RA')
- 10 mm below the most caudal renal artery (labelled ‘10mm’)
- 20 mm below the most caudal renal artery (labelled ‘20mm’)


The yellow measuring line was set to automatically indicate two more levels, 10mm above and 10mm below it, which can be seen in Figure 3 and 4. The measurement was provided each time only for the central longest line.

**Theatre logbook data collection**

The relevant theatre logbooks were retrieved. The entries for all 52 patients were found and information was collected on the size and type of graft employed, on the different ancillary measures and the contrast media that were used.

**Computerised Radiology Information System (CRIS) data collection**

All 52 patients' records were examined at CRIS system. The notes kept by radiologists for each endovascular repair were reviewed and the different complications that arose, during and after the procedure, were documented in the proforma.

**Data analysis**

The analysis of the data was performed using Excel and the IBM SPSS Statistics 19 software.

This included performing T-tests to check the following null hypotheses:

- The rate of change of the aortic proximal neck area is not associated with the endograft size used
- The rate of change of the aortic proximal neck area is not associated with the endograft type used
- The rate of change of the aortic proximal neck area is not associated with the use of ancillary graft
- The rate of change of the aortic proximal neck area is not associated with the use of Palmaz stent

The rate of change in area was calculated, based on the difference between the baseline and last available measurement. It was calculated for each aortic level separately. The equation that describes it is:

\[
\text{rate of change} = \frac{(\text{final area} - \text{baseline area})}{\text{time interval}}
\]

The area was measured in mm\(^2\) and the time in months.
Fig. 1: Axial, coronal and sagittal views of an AAA from a pre-operative CTA scan. At the coronal view a right CIA aneurysm is also displayed.

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Fig. 2: 3D Volume rendering view, displaying the aortic central line and the four branches (coeliac trunk, superior mesenteric artery, right and left renal artery), which were identified at the beginning of the process.

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Fig. 3: Lumen view of the aorta and the area measuring line.

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Fig. 4: Lumen view of the aorta displaying all four levels, where measurements were taken. The area was measured automatically.

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**Fig. 5:** Cross section view at the level 10mm above the most caudal renal artery, with minimum, maximum and mean diameter automatically calculated. Measurements were taken at all four levels.

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Results

The demographic and baseline characteristics of the patient sample are summarized in Table 1.

Results from the definitive data analysis (DDA)

After confirming the normal distribution of the data, the definitive analysis followed. The descriptive statistics of the rates of area change at each level are displayed in Table 2.

The absolute values of the mean rate of change were progressively getting smaller from the level above the renal arteries towards the level 20mm below the most caudal renal artery. The level above the most caudal renal artery had the biggest rate of change.

1. Rate of change of aortic area and endograft size

The rates of change at the different levels of the aortic neck were plotted against the graft size, in order to check for association. Boxplots (Fig.6-9) and T-tests showed that there was not an association between the endograft size used and the rate of change in the aortic area.

2. Rate of change of aortic area and endograft type

Independent samples T-test was also performed to check the hypothesis that the rate of change of the aortic proximal neck area is not associated with the endograft type used. It appeared that the choice between Zenith and Aorfix endograft had no significant effect on the rate of change of the aortic area (Table 3).

3. Rate of change of aortic area and the use of ancillary graft

Independent samples T-test was performed for the use of ancillary graft (cuff) and Palmaz stent separately. The use of ancillary graft did not have a significant association with the rate of the area change (Table 4).

4. Rate of change of aortic area and the use of Palmaz stent

The use of the Palmaz stent is not strongly related with the aortic area change, apart from the level at 10mm above the most caudal renal artery. At this level the p-value was less than 0.005 (Table 5), which may suggest that using a stent could reduce the rate of change of the aortic area.
**Table 1: Baseline characteristics for 52 EVAR patients**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>75 (57-87)</td>
</tr>
<tr>
<td>Gender</td>
<td>M:F = 49:3</td>
</tr>
<tr>
<td>Endograft type</td>
<td>Zenith Cook: Aorfix Lombard = 45:7</td>
</tr>
<tr>
<td>Endograft size</td>
<td>30 (24-36)</td>
</tr>
<tr>
<td>Stent</td>
<td>11.5%, n = 6</td>
</tr>
<tr>
<td>Ancillary graft</td>
<td>7.7%, n = 4</td>
</tr>
<tr>
<td>CEPOD</td>
<td>urgent: early surgery: elective = 1:2:49</td>
</tr>
<tr>
<td>Follow-up (months)</td>
<td>19 (3-48)</td>
</tr>
<tr>
<td>Complications</td>
<td>25%, n = 13</td>
</tr>
</tbody>
</table>

Table 1: Baseline characteristics.

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**Table 2:** Rate of change in proximal aortic neck area per month (mm²/month)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate at the level 10mm above the most caudal renal artery</td>
<td>52</td>
<td>-88.70</td>
<td>15.73</td>
<td>-3.9779</td>
<td>14.00835</td>
</tr>
<tr>
<td>Rate at the level of the most caudal renal artery</td>
<td>52</td>
<td>-43.43</td>
<td>15.78</td>
<td>-3.2713</td>
<td>9.35367</td>
</tr>
<tr>
<td>Rate at the level 10mm below the most caudal renal artery</td>
<td>52</td>
<td>-32.53</td>
<td>21.32</td>
<td>-2.0878</td>
<td>9.69020</td>
</tr>
<tr>
<td>Rate at the level 20mm below the most caudal renal artery</td>
<td>52</td>
<td>-38.50</td>
<td>18.43</td>
<td>-1.7861</td>
<td>9.87019</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Fig. 6**: Boxplot displaying the association of rate of change of the aortic area at the level 10mm above the most caudal renal artery and graft size.

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Fig. 7: Boxplot displaying the association of rate of change of the aortic area at the level of the most caudal renal artery and graft size.

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Fig. 8: Boxplot displaying the association of rate of change of the aortic area at the level of 10mm below the most caudal renal artery and graft size.

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**Fig. 9:** Boxplot displaying the association of rate of change of the aortic area at the level of 20mm below the most caudal renal artery and graft size.

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Table 3: Independent samples T-test for endograft type

<table>
<thead>
<tr>
<th>Graft type</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate above RA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZENITH</td>
<td>45</td>
<td>-4.4805</td>
<td>14.43592</td>
<td>2.15138</td>
<td>0.696</td>
</tr>
<tr>
<td>AORFIX</td>
<td>7</td>
<td>-7.684</td>
<td>11.19551</td>
<td>4.23150</td>
<td></td>
</tr>
<tr>
<td>Rate at RA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZENITH</td>
<td>45</td>
<td>-2.4895</td>
<td>9.45437</td>
<td>1.40937</td>
<td>0.658</td>
</tr>
<tr>
<td>AORFIX</td>
<td>7</td>
<td>-8.2972</td>
<td>7.35740</td>
<td>2.78033</td>
<td></td>
</tr>
<tr>
<td>Rate 10mm below RA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZENITH</td>
<td>45</td>
<td>-1.1024</td>
<td>9.50170</td>
<td>1.41643</td>
<td>0.851</td>
</tr>
<tr>
<td>AORFIX</td>
<td>7</td>
<td>-8.4228</td>
<td>9.05413</td>
<td>3.42214</td>
<td></td>
</tr>
<tr>
<td>Rate at 20mm below RA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZENITH</td>
<td>45</td>
<td>-3.896</td>
<td>9.64268</td>
<td>1.43745</td>
<td>0.523</td>
</tr>
<tr>
<td>AORFIX</td>
<td>7</td>
<td>-7.4850</td>
<td>10.12605</td>
<td>3.82525</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Rate of change of aortic area and endograft type.

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Table 4: Rate of change of aortic area and the use of ancillary graft.

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Table 5: Rate of change of aortic area and the use of Palmaz stent.

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Conclusion

The data analysis revealed that:

- There is low possibility for the rate of change in area of the proximal aortic neck to be associated with the endograft type and size used, or with the use of ancillary graft.
- There is a possible association between the rate of change of the proximal aortic neck area and the use of Palmaz stent. An independent samples T-test revealed a low P-value (p<0.005) between the rate of area change at the level of 10mm above the most caudal renal artery and the use of Palmaz stent.

The association of neck dilation with time and of the aorta above the stent-graft landing zone with deployment of a Palmaz stent merit further investigation. This is particularly important given the widening indications for EVAR to include hostile proximal landing zones.
References


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