Distal aortic reintervention after surgery for acute DeBakey type I or II aortic dissection: open versus endovascular repair

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Disclosure of Interest

Rita Karianna Milewski, MD, PhD

I do not have any potential conflict of interest
Aortic Dissections
Risk of Late Distal Aortic Interventions

DeBakey I
Stanford A

DeBakey II
Stanford A

DeBakey III
Stanford B
DeBakey I and II Dissection

Over the last 20 years, diagnostic modalities, perioperative management and operative techniques for acute Type I or II aortic dissection have improved.

More are surviving the acute phase
– Aortic centers mortality rates 5-15%

However, for many patients the initial operation is not a cure
Risk of Late Distal Arch and Descending Aorta Reintervention

Most acute ascending aortic dissection patients, the dissection process extends beyond the left subclavian artery

Both residual DeBakey I dissection and those with DeBakey II are at increased risk of late aortic events

For patients successfully operated on for acute ascending aortic dissection, the late risk of death is significantly increased over that of the healthy population
Risk of Distal Aortic Reintervention

Late dissection aneurysmal aorta or de novo dissections develop requiring distal reintervention

Residual distal dissected aorta segments grow at rate 1-7mm/y

Risk of late interventions following proximal repair of ascending dissection is 6-15%
Paradigm Shift

• Open surgical repair is the gold standard for treating aortic events following Type I or II dissection repair

• Paradigm shift in favor of endovascular therapy for distal aortic dissections
Comparative Open and Endovascular Study Design for Distal Aortic Reintervention

Comparative analysis of outcomes of open versus endovascular procedures in patients with distal aortic pathologies following proximal repair for acute DeBakey I or DeBakey II dissection
Inclusion and Exclusion Criteria

Inclusion

– All aortic pathologies that occurred after type I or II dissection repair distal to the replaced ascending aorta

– Comparison of reinterventions for the aortic arch and the descending aorta.

Exclusion

– Connective tissue disease
Goals of Interventional Approach

The goals of open and endovascular distal aortic intervention differ:

– Open – remove all aortic pathology

– Endovascular approach aims to prevent aortic dilatation by promoting false lumen thrombosis and stabilization
Open aortic replacement or Endovascular remodeling

- maximum aortic diameter ≥5.5 cm,
- rapid aneurysmal degeneration with growth rate >1 cm/year,
- suture line aneurysm,
- malperfusion syndrome due to compression of the true aortic lumen
- penetrating atherosclerotic ulcers and
- large re-entries between false and true lumen in the descending aorta
# Reintervention Cohorts

<table>
<thead>
<tr>
<th></th>
<th>All (n = 141)</th>
<th>Open group (n = 87)</th>
<th>Endovascular group (n = 54)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>63 (55; 72)</td>
<td>63 (55; 72)</td>
<td>63 (56; 71)</td>
<td>0.89</td>
</tr>
<tr>
<td>Over 80 years old</td>
<td>8 (6)</td>
<td>5 (6)</td>
<td>3 (6)</td>
<td>1.00</td>
</tr>
<tr>
<td>Male gender</td>
<td>100 (71)</td>
<td>61 (71)</td>
<td>39 (72)</td>
<td>0.41</td>
</tr>
<tr>
<td><strong>History of aortic dissection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DeBakey type I</td>
<td>123 (87)</td>
<td>74 (85)</td>
<td>49 (91)</td>
<td>0.44</td>
</tr>
<tr>
<td>DeBakey type II</td>
<td>18 (13)</td>
<td>13 (15)</td>
<td>5 (9)</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Proximal repair</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic valve repair</td>
<td>110 (78)</td>
<td>66 (76)</td>
<td>44 (81)</td>
<td>0.53</td>
</tr>
<tr>
<td>Aortic root replacement</td>
<td>26 (18)</td>
<td>16 (18)</td>
<td>10 (19)</td>
<td>0.84</td>
</tr>
<tr>
<td>Aortic aneurysm</td>
<td>6 (4)</td>
<td>6 (7)</td>
<td>0</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Distal repair</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No arch replacement</td>
<td>55 (39)</td>
<td>43 (49)</td>
<td>12 (22)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hemiarch replacement</td>
<td>76 (54)</td>
<td>42 (48)</td>
<td>34 (63)</td>
<td>0.13</td>
</tr>
<tr>
<td>Total arch replacement</td>
<td>10 (7)</td>
<td>2 (2)</td>
<td>8 (15)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Antegrade TEVAR</td>
<td>14 (10)</td>
<td>2 (2)</td>
<td>12 (22)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Current clinical presentation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>124 (88)</td>
<td>77 (89)</td>
<td>47 (87)</td>
<td>1.00</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>6 (4)</td>
<td>3 (3)</td>
<td>3 (6)</td>
<td>0.86</td>
</tr>
<tr>
<td>Hyperlipidaemia</td>
<td>31 (22)</td>
<td>20 (23)</td>
<td>11 (20)</td>
<td>0.88</td>
</tr>
<tr>
<td>Renal failure</td>
<td>10 (7)</td>
<td>3 (3)</td>
<td>7 (13)</td>
<td>0.07</td>
</tr>
<tr>
<td>COPD</td>
<td>16 (11)</td>
<td>11 (13)</td>
<td>5 (9)</td>
<td>0.73</td>
</tr>
<tr>
<td>Current smoker</td>
<td>12 (9)</td>
<td>7 (8)</td>
<td>5 (9)</td>
<td>0.95</td>
</tr>
<tr>
<td>Coronal artery disease</td>
<td>14 (10)</td>
<td>10 (12)</td>
<td>4 (7)</td>
<td>0.62</td>
</tr>
<tr>
<td>BAV</td>
<td>5 (4)</td>
<td>1 (1)</td>
<td>4 (7)</td>
<td>0.14</td>
</tr>
<tr>
<td>History of stroke</td>
<td>4 (3)</td>
<td>2 (2)</td>
<td>2 (4)</td>
<td>0.97</td>
</tr>
<tr>
<td><strong>Current distal aortic pathology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic arch aneurysm</td>
<td>56 (40)</td>
<td>52 (58)</td>
<td>4 (7)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Thoracoabdominal aneurysm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crawford I</td>
<td>47 (33)</td>
<td>24 (28)</td>
<td>23 (43)</td>
<td>0.10</td>
</tr>
<tr>
<td>Crawford II</td>
<td>15 (11)</td>
<td>9 (10)</td>
<td>6 (11)</td>
<td>0.89</td>
</tr>
<tr>
<td>Crawford III</td>
<td>5 (4)</td>
<td>3 (3)</td>
<td>2 (4)</td>
<td>0.70</td>
</tr>
<tr>
<td>Crawford IV</td>
<td>1 (1)</td>
<td>1 (1)</td>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>Abdominal aortic aneurysm</td>
<td>4 (3)</td>
<td>0</td>
<td>4 (7)</td>
<td>0.02</td>
</tr>
<tr>
<td>True lumen compression</td>
<td>13 (9)</td>
<td>3 (3)</td>
<td>10 (19)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>’De novo’ type III dissection</td>
<td>2 (1)</td>
<td>0</td>
<td>2 (2)</td>
<td>0.15</td>
</tr>
<tr>
<td>PAU</td>
<td>2 (1)</td>
<td>0</td>
<td>2 (2)</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Distal Reintervention Cohort Analysis

• Analysis of 141 patients (two centers)
  – University of Pennsylvania, Philadelphia, PA, USA
  – Heart Center Freiburg University, Freiburg, Germany

• Distal Reintervention
  – Aortic Arch 56
  – Descending Aorta 87

• Dissection pathology
  – DeBakey I (87%)
  – DeBakey II (13%)

• Average Age 63y
• Male 70%
## Initial Acute Dissection

### Ascending Procedure Analysis

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemiarch</td>
<td>54%</td>
</tr>
<tr>
<td>Total Arch</td>
<td>7%</td>
</tr>
<tr>
<td>No arch procedure</td>
<td>39%</td>
</tr>
<tr>
<td>Antegrade TEVAR</td>
<td>10%</td>
</tr>
<tr>
<td>Procedure</td>
<td>Count</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Open</td>
<td>52</td>
</tr>
<tr>
<td>Hemiarch</td>
<td>20</td>
</tr>
<tr>
<td>Total arch</td>
<td>32</td>
</tr>
<tr>
<td>Hybrid</td>
<td>4</td>
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</tbody>
</table>
Total Arch Procedure
Hybrid Arch Procedure
Zone 2 Arch Repair
Antegrade Stent Arch Repair
Distal Descending Aorta Reintervention Procedures

<table>
<thead>
<tr>
<th>Procedure Type</th>
<th>Hemiarch Proportion</th>
<th>Antegrade Stent Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open (35)</strong></td>
<td>Hemiarch</td>
<td>48%</td>
</tr>
<tr>
<td></td>
<td>Antegrade stent</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Endovascular (50)</strong></td>
<td>Hemiarch</td>
<td>63%</td>
</tr>
<tr>
<td></td>
<td>Antegrade stent</td>
<td>22%</td>
</tr>
</tbody>
</table>
Descending Aortic Pathology

- **Open**
  - Crawford extent I 24
  - Crawford extent II 9
  - Crawford extent III 3
  - Crawford extent IV 3

- **Endovascular**
  - Crawford extent I 23
  - Crawford extent II 6
  - Crawford extent III 2
  - Crawford extent IV 4

- **Malperfusion** 13
- **De novo Debakey III** 3
- **Re-entries** 3
- **PAU** 2
## Distal Aortic Arch Outcomes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Open</th>
<th>Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Re-Reinterventions</strong></td>
<td></td>
<td>3/52 (5.8%)</td>
<td>1/4 (25%)</td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Descending Aortic Reintervention Outcomes

<table>
<thead>
<tr>
<th></th>
<th>All (n = 85)</th>
<th>Open group (n = 35)</th>
<th>Endovascular group (n = 50)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time between primary surgery and distal reintervention (years)</td>
<td>1.3 (0.3; 4.1)</td>
<td>2.7 (0.8; 6.7)</td>
<td>0.6 (0.1; 3.5)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Urgency of reintervention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>7 (8)</td>
<td>3 (9)</td>
<td>4 (8)</td>
<td>1.00</td>
</tr>
<tr>
<td>Urgent (&lt;24 h)</td>
<td>19 (22)</td>
<td>7 (20)</td>
<td>12 (24)</td>
<td>0.86</td>
</tr>
<tr>
<td>Elective</td>
<td>59 (69)</td>
<td>25 (71)</td>
<td>34 (68)</td>
<td>0.92</td>
</tr>
<tr>
<td>Reintervention time (min)</td>
<td>110 (100; 140)</td>
<td>250 (140; 260)</td>
<td>110 (90; 120)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>8 (9)</td>
<td>8 (23)</td>
<td>0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Stroke</td>
<td>1 (1)</td>
<td>0</td>
<td>1 (2)</td>
<td>1.00</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>1 (1)</td>
<td>1 (3)</td>
<td>0</td>
<td>0.35</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1 (1)</td>
<td>1 (3)</td>
<td>0</td>
<td>0.35</td>
</tr>
<tr>
<td>Renal failure</td>
<td>2 (2)</td>
<td>1 (3)</td>
<td>1 (2)</td>
<td>1.00</td>
</tr>
<tr>
<td>Chest re-exploration for bleeding</td>
<td>2 (2)</td>
<td>2 (6)</td>
<td>0</td>
<td>0.12</td>
</tr>
<tr>
<td>ICU time</td>
<td>2 (1; 3)</td>
<td>3 (2; 4)</td>
<td>2 (1; 2)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>In-hospital time</td>
<td>6 (5; 8)</td>
<td>6 (4; 8)</td>
<td>5 (5; 8)</td>
<td>0.89</td>
</tr>
<tr>
<td>Secondary reintervention</td>
<td>6 (7)</td>
<td>2 (6)</td>
<td>4 (8)</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Analysis of Outcomes of Descending Aortic Reintervention

Open Procedure in hospital mortality 8 (23%)
  – 7/8 (88%) thoracoabdominal replacements
  – 2/7 (30%) non-elective reinterventions
Survival for Descending Aortic Reinterventions

<table>
<thead>
<tr>
<th>Method</th>
<th>1 year</th>
<th>5 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>74 +/- 8%</td>
<td>65 +/- 9%</td>
</tr>
<tr>
<td>Endovascular</td>
<td>96 +/- 3%</td>
<td>92 +/- 5%</td>
</tr>
</tbody>
</table>
Survival After Descending Aortic Reintervention

Log rank, $P < 0.01$
Freedom From Descending Aorta Distal Reintervention

Open
1 year 100+/-0%
5 year 93+/-7%

Endovascular
1 year 96+/-3%
5 year 90+/-5%
Freedom From Distal Re-Reintervention

Log rank, $P = 0.50$

Patients at risk:
- Open surgery:
  - 50
  - 19
  - 12

- Endovascular repair:
  - 35
  - 17
  - 12

Time (years)
Distal Descending Aorta Stabilization

Endovascular Stabilization – 86%
  – Growth – 14%
    5 patients had aorta > 5.5cm during follow-up
    2 continued growth at 0.5cm over 6mo
    – Endovascular re-intervention
      4 endovascular (no in hospital mortality)
  – Medical management
    3

Open Stabilization – 98%
  2 endovascular (one 70d in hospital mortality)
Analysis of Open and Endovascular Outcomes

Current guidelines for managing aortic pathologies for open and endovascular have same thresholds.

The average time between surgery for acute dissection and reintervention was shorter in patients undergoing endovascular descending aortic repair when compared with open surgery.

Endovascular approach does not eliminate aortic disease; however it does slow its progression and may be a treatment option especially in older patients or those with comorbidities.

Despite a technically successful endovascular reintervention, over 10% of patients attained threshold aortic diameter values for re-reintervention during this mid-term follow-up study.

Overall survival was significantly better in patients undergoing descending aortic endovascular reintervention.
In centers with low mortality and morbidity open surgical repair remains the gold standard, especially in younger patients.

Endovascular intervention on the descending aorta in experienced hands offers a benefit when treating late aortic complications after type I or II aortic dissection repair.

It does not eliminate the aortic disease; however, as it does slow its progression, it is a sensible treatment option, especially in older patients.

Endovascular repair is associated with lower in-hospital mortality and better survival.
Future Directions in Distal Arch and Descending Reintervention

Branched and fenestrated endografts are currently may being utilized as a treatment therapy for arch pathology.

The use of a hybrid approach facilitates the treatment of extensive aortic pathology by combining the benefits of open proximal reconstruction with the minimally invasive nature of a second staged TEVAR treatment.

Various procedures such as varying zoned arch procedures at the time of acute ascending dissection repair to build a platform for distal arch and descending procedures.

With the rapid technologic advancements in endovascular designs and innovative therapeutic strategies technology can be utilized as a catalyst to develop procedures for patients for whom no other surgical options existed in the past.
Thank you
Paradigm Shift

- Paradigm shift for distal aortic dissections in favor of endovascular therapy
Cohort Demographic Analysis

- Average Age 63y
- Male 70%
Descending Aortic Pathology

- Malperfusion: 13
- De novo: 3
- Re-entries: 3
- PAU: 2
The rate of endovascular distal aortic reinterventions per year throughout the study period
Analysis Summary

- The average time between surgery for acute dissection and reintervention was shorter in patients undergoing endovascular descending aortic repair when compared with open surgery.
Analysis Summary

• In-hospital mortality after descending aortic reintervention was lower in patients classified for endovascular treatment.

• Despite a technically successful endovascular reintervention, over 10% of patients attained threshold aortic diameter values for re-reintervention during this mid-term follow-up study.

• Overall survival was significantly better in patients undergoing descending aortic endovascular reintervention.
Limitations

This study is limited by several factors. First, since most of the patients were operated on for acute dissection at regional hospitals, we were unable to provide all the details on their primary surgery and on their aortic dissection anatomy. Furthermore, this is a mid-term follow-up study; therefore, a definitive conclusion on the need for late re-reintervention after open or endovascular aortic repair cannot be drawn. Finally, we did not provide individual causes of death for the entire cohort, since none of our study patients were autopsied and, during interviews, family members or general practitioners could cite a plausible cause of death in only a few patients.
Hybrid Approaches

- The impetus for hybrid approaches in the treatment of complex aortic arch pathologies is exactly this synergistic effect of endovascular technique with open surgery.

- For the staged approach a significant number of patients who undergo the first stage do not progress to the second open stage.

- The use of a hybrid approach facilitates the treatment of extensive aortic pathology by combining the benefits of open proximal reconstruction with the minimally invasive nature of a second staged TEVAR treatment.
Outcomes

• In hospital mortality
  Open  20%
  Endovascular  0%

• Spinal Ischemia
  Open  1 patient
Distal Descending Aorta Reintervention Procedures

- Open (35)
- Endovascular (50)
> 1 Distal Reintervention

- Open
  - 2 endovascular (one in hospital mortality)
- Endovascular
  - 4 endovascular (no in hospital mortality)
Technology as a Catalyst

• With the rapid technologic advancements in TEVAR designs and innovative therapeutic strategies technology can be utilized as a catalyst to develop procedures for patients for whom no other surgical options existed in the past
Analysis of Open and Endovascular Intervention

• Current guidelines for managing aortic pathologies for open and endovascular have same thresholds

• Endovascular approach is generally earlier and in patients with multiple comorbidities or advanced age

• Endovascular therapy in patients with no aortic aneurysm, but with large re-entries between false and true lumen to initiate false lumen thrombosis and reduce the risk of later false lumen dilatation and true lumen collapse.

• Shorter interval between acute dissection repair and reintervention for endovascular versus open surgery.
  – less invasive endovascular approach
  – aortic remodelling
Analysis of Open and Endovascular Intervention

• Current guidelines for managing aortic pathologies for open and endovascular have same thresholds.

• Endovascular approach is generally earlier and in patients with multiple comorbidities or advanced age.

• Endovascular therapy in patients with no aortic aneurysm, but with large re-entries between false and true lumen to initiate false lumen thrombosis and reduce the risk of later false lumen dilatation and true lumen collapse.

• Shorter interval between acute dissection repair and reintervention for endovascular versus open surgery.
  – less invasive endovascular approach
  – aortic remodelling
Summary

• The average time between surgery for acute dissection and reintervention was shorter in patients undergoing endovascular descending aortic repair when compared with open surgery

• In-hospital mortality after descending aortic reintervention was lower in patients undergoing endovascular compared to open procedure

• Despite a technically successful endovascular reintervention, over 10% of patients attained threshold aortic diameter values for re-reintervention during this mid-term follow-up study

• Overall survival was significantly better in patients undergoing descending aortic endovascular reintervention.
Endovascular Stents

- Widely utilized for aortic aneurysms
- Controversial in aortic dissections
Hybrid Arch Procedures