Surgical Treatment of Ascending Aortic Aneurysms

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Surgery on the Ascending Aorta

1. When to operate?
2. Fundamental anatomic patterns.
3. Options for replacing the aortic root.
4. Brain protection
   (Entertaining video)
Surgery on the Ascending Aorta

1. When to operate?
2. Fundamental anatomic patterns.
3. Options for replacing the aortic root.
4. Brain protection
   (Entertaining video)
Increased Risk of Complication
Yearly risk of dissecting prior to operative repair

Yearly Risk of Dissection Prior to Operative Repair

- Initial Aortic Size (cm)
  - 3.5 to 3.9: 2.2%
  - 4.0 to 4.9: 1.5%
  - 5.0 to 5.9: 2.5%
  - > 6.0: 3.7%
• This analysis strongly supports the advisability of elective, preemptive surgical intervention for the lethal condition of large thoracic aortic aneurysms
Table 5. Risk of Complications by Aortic Diameter and Body Surface Area With Aortic Size Index Given Within Chart

<table>
<thead>
<tr>
<th>Aortic Size (cm)</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
<th>6.0</th>
<th>6.5</th>
<th>7.0</th>
<th>7.5</th>
<th>8.0</th>
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<td></td>
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<tr>
<td>1.30</td>
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<td>3.08</td>
<td>3.46</td>
<td>3.85</td>
<td>4.23</td>
<td>4.62</td>
<td>5.00</td>
<td>5.38</td>
<td>5.77</td>
<td>6.15</td>
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<td>1.40</td>
<td>2.50</td>
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<td>3.21</td>
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<td>3.93</td>
<td>4.29</td>
<td>4.64</td>
<td>5.00</td>
<td>5.26</td>
<td>5.51</td>
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<tr>
<td>1.50</td>
<td>2.33</td>
<td>2.67</td>
<td>3.00</td>
<td>3.33</td>
<td>3.67</td>
<td>4.00</td>
<td>4.33</td>
<td>4.67</td>
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<td></td>
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<tr>
<td>1.60</td>
<td>2.19</td>
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<td>2.80</td>
<td>3.13</td>
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<td>3.75</td>
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<td>4.38</td>
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<td>1.70</td>
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<td>2.65</td>
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<tr>
<td>1.80</td>
<td>1.94</td>
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<td>2.50</td>
<td>2.78</td>
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<td>3.33</td>
<td>3.61</td>
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<tr>
<td>1.90</td>
<td>1.84</td>
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<td>2.89</td>
<td>3.10</td>
<td>3.33</td>
<td>3.57</td>
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<tr>
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<td>2.00</td>
<td>2.25</td>
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<td>3.57</td>
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<td>2.10</td>
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<td>2.86</td>
<td>3.10</td>
<td>3.33</td>
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<tr>
<td>2.20</td>
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<td>2.27</td>
<td>2.50</td>
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<td>1.52</td>
<td>1.74</td>
<td>1.96</td>
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<td>2.83</td>
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<tr>
<td>2.40</td>
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<td>1.67</td>
<td>1.88</td>
<td>2.08</td>
<td>2.29</td>
<td>2.50</td>
<td>2.71</td>
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<tr>
<td>2.50</td>
<td>1.40</td>
<td>1.60</td>
<td>1.80</td>
<td>2.00</td>
<td>2.20</td>
<td>2.40</td>
<td>2.60</td>
<td>2.80</td>
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</tbody>
</table>

- Low risk (~1% per yr)
- Moderate risk (~8% per yr)
- Severe risk (~20% per yr)

White area indicates low risk, light gray area indicates moderate risk, and dark gray area indicates severe risk.

BSA = body surface area.

But—What about numerator and denominator? \( x/y \)

Numerator ______ Acute Patients
Denominator ______ Entire Population

Figure 13: Dissections Do Occur at Small Sizes

Distribution of aortic size at the time of presentation with acute type A aortic dissection (cm). Purple bars indicate patients with diameters <5.5 cm. Adapted, with permission, from Pape et al. (15). Figure Illustration by Rob Flewell.
Figure 14: Huge General Population at Risk Explains the Occurrence of Some Dissections at Small Sizes

Depiction of a normal distribution curve of aortic size (marked in SDs). Note how small the "tails" of such a curve are. Large aneurysms would reside far out in the tails. While dissections do occur at small dimensions, note how rapidly the at-risk group increases in number as the putative criterion diameter goes from $d_1$ to $d_2$. We anticipate that millions of Americans harbor small thoracic aortic aneurysms, making for a very large denominator of vulnerable patients, and a correspondingly low likelihood of dissection at small sizes. See the "Dissections Can and Do Occasionally Occur at Small Aortic Sizes" section for details. Figure illustration by Rob Flewell.
121 patients in long-term f/u

108 patients to med rx

13 pts met surgical criteria- but not surgical candidates or refused

50 pts became sx-ic or reached size criteria → TO OR

58 pts remained under MED RX

47 elective

3 urgent (lost to f/u until event)

9 deaths

0 aortic deaths

9 deaths

High rate of deaths in pts. triaged to surgery

Surgery Criteria
- 5.5 cm (non-Marfan)
- 5.0 cm (Marfan)
- Onset of sx

NO AORTIC DEATH IN PTS USING THIS ALGORITHM

THE ALGORITHM WORKS
# How Do You Handle....

<table>
<thead>
<tr>
<th>Aorta</th>
<th>Valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD CRITERIA</td>
<td>STD CRITERIA</td>
</tr>
</tbody>
</table>

- **Operating For....**
  - Aorta
  - Valve
<table>
<thead>
<tr>
<th></th>
<th>Aorta</th>
<th>Valve</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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</tr>
<tr>
<td>Valve</td>
<td></td>
<td></td>
</tr>
</tbody>
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How Do You Handle....
<table>
<thead>
<tr>
<th></th>
<th>Aorta</th>
<th>Valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aorta</td>
<td></td>
<td>Replace if will not give &gt;10y normal service.</td>
</tr>
<tr>
<td>Valve</td>
<td>Replace @ 4.5 cm.</td>
<td></td>
</tr>
</tbody>
</table>
Surgery on the Ascending Aorta

1. When to operate?
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3. Options for replacing the aortic root.
4. Brain protection
   (Entertaining video)
Three morphologies of the aortic root and ascending aorta.
Note: normal-sized proximal aortic root does not dilate later, even in long-term follow-up.

No need to replace more.

Supra-aortic tube graft

No need to do valve-sparing in this setting. Rather, “root-sparing”
Cannot leave dilated root behind: will enlarge, dissect, or rupture.

Root replacement (or alternate)
Can go either way: tube or composite, depending on age, condition:

Old, frail: Tube
Young, strong: Composite
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   (Entertaining video)
Key Questions in Choice of Procedure

• With what do we replace the resected tissue?
Key Questions in Choice of Procedure

- How much to we resect?
- With what do we replace the resected tissue?
  - Ross Procedure
  - Homograft
  - Allograft (Medtronic FreeStyle)
  - Composite graft
    - Mechanical
    - Biological
  - Valve-sparing procedure
Ross Procedure

• “Loosing steam” due to
  – Complexity
  – Late problems
    • AI
    • PJ
    • Homograft calcification
  – Increasing reoperations
    • These are tough reoperations!

Reserve for special situations: Patient or environment

*Circulation.* 2010;122:1153-1158.
Homograft

- Preservation, sterility issues.
- Latest information from Prof. Yacoub indicates suboptimal performance in mid-term: persistent immunologic antigenicity.
- Best reserved for infection cases.


Poor long-term performance of homografts (Yacoub)

Log-rank $P < .001$

<table>
<thead>
<tr>
<th>Freedom from</th>
<th>5-year</th>
<th>8-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freestyle</td>
<td>95% ± 3%</td>
<td>85% ± 5%</td>
</tr>
<tr>
<td>Homograft</td>
<td>69% ± 6%</td>
<td>37% ± 7%</td>
</tr>
</tbody>
</table>

Log-rank $P = 0.024$

<table>
<thead>
<tr>
<th>Freedom from need reoperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% ± 0% 100% ± 0%</td>
</tr>
<tr>
<td>98% ± 2% 90% ± 5%</td>
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</tbody>
</table>

No. at risk

| Freestyle | 90 | 68 | 51 | 43 | 27 |
| Homograft  | 76 | 51 | 43 | 30 | 12 |
Allograft (Medtronic FreeStyle)

- Good performance
- None of preservation issues of homografts
- Non-antigenic
- Sewing ring delicate—perhaps would be better if bulkier
Biological valved conduits
(No prefabricated versions available in US.)
Biological Valved Conduit Actuarial Survival

Follow up in years

Actuarial Survival

No AS, AI, Reoperation
Mechanical valved conduit: Technical Tips

- Reinforce coronary buttons with Teflon “washers”
- L button is inaccessible after completion
Rescue Coronary Artery Bypass Grafting (CABG) after Aortic Composite Graft Replacement

Ali Shahriari, M.D., Michael Eng, M.D., Maryann Tranquilli, R.N., and John A. Elefteriades, M.D.

Section of Cardiac Surgery, Yale University School of Medicine, New Haven, Connecticut
Composite Graft: Superb Long-Term Performance

Freedom from Bleeding & Thromboembolism

Thromboembolism: 1%
Bleeding: 3.7%

Survival: 95% @ 7 yrs.
Event-free survival: 94% @ 7 yrs

Time (months)
Valve-Sparing Operation

- Gaining popularity
- Gaining positive f/u
- Technical expertise building
- Remodeling vs. Reimplantation?
Valve-Sparing Operation

Cautions
• Don’t need for supracoronary aneurysm
• Care in
  – AS (NO!)
  – Endocarditis (NO)
  – Valve perforations (NO)
  – Associated AI (only < mod)
  – Marfan disease (et al)
  – Bicuspid valve
  – Children
  – Acute Type A dissection
  – p-Failed Ross

COMPOSITE: Durable, but requires anticoagulation.

VALVE-SPARING: No anticoagulation, but does it leave AI and is it durable?

Composite graft vs. Valve-sparing
### Freedom from Reoperation

<table>
<thead>
<tr>
<th>Study</th>
<th>Follow-up (yrs)</th>
<th>Composite</th>
<th>Valve-sparing</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zehr (2004)</td>
<td>5</td>
<td>96%</td>
<td>63%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>n=203</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Karck (2004)</td>
<td>5</td>
<td>92%</td>
<td>84%</td>
<td>0.31</td>
</tr>
<tr>
<td>n=119</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patel (2008)</td>
<td>8</td>
<td>96%</td>
<td>86%</td>
<td>0.1</td>
</tr>
<tr>
<td>n=140</td>
<td></td>
<td></td>
<td></td>
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</table>

Note: Remember, AI is very well tolerated and reoperation is unappealing, so reoperation means the patient was seriously ill.
## Freedom from Aortic Insufficiency

<table>
<thead>
<tr>
<th>Study</th>
<th>Follow-up (yrs)</th>
<th>Survival</th>
<th>Mod to Sev Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yacoub (1998)</td>
<td>10</td>
<td>89%</td>
<td>36%</td>
</tr>
<tr>
<td>n = 158</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>David (2007)</td>
<td>10</td>
<td>54%</td>
<td>22%</td>
</tr>
<tr>
<td>n = 103</td>
<td></td>
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</tbody>
</table>
Fig. 2. Progression of aortic insufficiency and need for aortic valve replacement/repair. Solid lines denote patients requiring surgery. Dashed lines reflect patients with progression of aortic insufficiency currently being followed. VSRR, value-sparing root replacement; MVR, mitral valve replacement; AVR, aortic valve replacement; AV, aortic valve; Preop, preoperative.
Choice of conduit

• Many options for materials/technique
  – Homograft
  – Allograft (FreeStyle)
  – Biological conduit
  – Mechanical conduit
  – Valve-sparing procedure (David)

• Replace what needs to be replaced
  – Root-sparing (tube graft) for “supra-aortic” aneurysm
  – Root-replacement (some type) for annuloaortic ectasia
  – Choice for tubular aneurysm
Choice of procedure

Composite - Valve-sparing

Gold Standard

Gaining momentum
Surgery on the Ascending Aorta

1. When to operate?
2. Fundamental anatomic patterns.
3. Options for replacing the aortic root.
4. Brain protection
   (Entertaining video)
- **Straight DHCA suffices for brain protection.**