When NOT to in Cardiac Surgery: The David Reimplantation Procedure

The When NOT to in Cardiac Surgery series: Judgment Calls (AATS):

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CardioVascular Surgery &
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University of Pennsylvania, USA
Disclosures:

I have no disclosures related to this topic
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Marfan Root (41 yr. old Man) with 9 1\textsuperscript{st} Order Relatives with either Dissection, Death from Rupture, or Replaced Roots!
David V Re-implantation with Vascutek ValSalva Graft: 1:1 Annular to Sinotubular Jct. ratio

Note: Sinus Segment Diameter is 8 mm greater than Annular diameter
Candidates for David V Valve Sparing Reimplanation Operation? ……

Selection Concepts

- Any patient with an aortic root aneurysm and normal aortic cusps.
- Acute Type A Aortic dissection—difficult but durable.
- Patients with root aneurysm and abnormal cusps that are repairable (Prolapse not Fenestration).
- Bicuspid aortic valve—controversial.
- Severe aortic insufficiency heightens the difficulty (esp. cusp pathology with cusp repair).
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When NOT to do the David Reimplantation Procedure: Caution after a deeper look!

- Marfans (deeper look at failure modes)
- Fenestrations in the Leaflets
- Long Free margin length
- Pre-op AI and need for Cusp Repair
- Redo Ross
- Technical Issues vis-à-vis commissure height
- A very detailed look at Bicuspid valve
Marfan’s Sinus of Valsalva Aneurysm (7.0 cm.) with Severe (+4) AI

Valve Sparing ?? Too much AI, too much aneurysmal dilation, too much leaflet surface area,
Marfan’s Sinus of ValSalva Aneurysm (7.0 cm.) with Severe (+4) AI

Valve Sparing ?? Too much AI, too much aneurysmal dilation, too much leaflet surface area,

Key is Early Referral before significant AI
Marfans: Overall freedom from reoperation and AI >2+

Overall: 83.5 ± 8.6%
At 24 months

Is This really that good?

Freedom from SVD:
88.9 ± 8.1%
*excludes 1 pt for endocarditis
Freedom from AI >2+ in MFS patients at 10 yrs

80% in aneurysm group at 5 years

Progression of AR in Marfans: For both Yacoub and David

Huge Difference between Marfans and Non-Marfans
Why You May want a Sinus Segment

Aortic leaflet 17 months after a standard graft reimplantation (David I) operation

Zehr: J Thorac Cardiovasc Surg June 2001
So What is the big difference between these series and say .... the Hopkins Series?
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Role of Pre-op AI, especially in 3-cusp Valves

70% of Patients had PRE_OP +3/+4 AI therefore significant amounts of primary leaflet repair
Progression of AR after cusp intervention

Significantly higher in BOTH groups

(\( p = <0.001 \))
Other Special Issues (and myths) that might warrant a PAUSE in thinking about Re-implantation
Failed Ross in 30 Year Old Male (Redo Buttons):
Concept of COMBINATION Root aneurysm and
DECREASED Leaflet (Cusp) Surface Area
KEY POINT: top of the commissures at the level of the new STJ

- The height of the commissures are equal to the skirt
- The height of the commissures are shorter than the skirt
- The height of the commissures are longer than the skirt

David V Re-implantation (Tailored/Straight Graft)

Prior to Coronary Buttons or ST Jct Reconstruction

Notice the Arch Graft Type A Dissection and short Commissures
Young 32 yr. Woman with Bicuspid Aortic Valve with Mild-Moderate AI, Mild AS (leaflet restriction) and 8.0 cm Ascending Aneurysm
mean follow-up was 25 months (range, 1–51 months) and was 100% complete.
### Predictors of AR in Valve Sparing Root Surgery

#### Table 3. Multivariate Analysis for Significant Residual Aortic Regurgitation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial 50 cases</td>
<td>4.398</td>
<td>0.639–56.353</td>
<td>0.153</td>
</tr>
<tr>
<td>Age ≥50 years</td>
<td>1.636</td>
<td>0.111–3.554</td>
<td>0.618</td>
</tr>
<tr>
<td>Male</td>
<td>0.574</td>
<td>0.225–9.214</td>
<td>0.516</td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>4.993</td>
<td>0.171–9.616</td>
<td>0.267</td>
</tr>
<tr>
<td>Cusp repair</td>
<td>3.102</td>
<td>0.257–10.963</td>
<td>0.365</td>
</tr>
<tr>
<td>Bicuspid valve</td>
<td>3.804</td>
<td>0.475–75.428</td>
<td>0.211</td>
</tr>
<tr>
<td>Cusp prolapse</td>
<td>2.921</td>
<td>0.144–8.480</td>
<td>0.326</td>
</tr>
<tr>
<td>Repaired thin cusp</td>
<td>6.636</td>
<td>2.780–105.593</td>
<td>0.002</td>
</tr>
<tr>
<td>Cusp calcification</td>
<td>4.969</td>
<td>1.331–9.893</td>
<td>0.026</td>
</tr>
<tr>
<td>Use of Valsalva graft</td>
<td>0.641</td>
<td>0.119–3.021</td>
<td>0.756</td>
</tr>
<tr>
<td>AR ≥ moderate</td>
<td>0.674</td>
<td>0.130–4.806</td>
<td>0.725</td>
</tr>
<tr>
<td>Marfan</td>
<td>1.972</td>
<td>0.436–17.112</td>
<td>0.434</td>
</tr>
<tr>
<td>Aortitis</td>
<td>4.939</td>
<td>0.106–160.965</td>
<td>0.237</td>
</tr>
<tr>
<td>LVDd ≥ 55 mm</td>
<td>2.328</td>
<td>0.273–4.450</td>
<td>0.456</td>
</tr>
<tr>
<td>Ao diameter ≥ 50 mm</td>
<td>0.850</td>
<td>0.094–2.668</td>
<td>0.848</td>
</tr>
</tbody>
</table>
Candidates for David V Valve Sparing Reimplantation Operation? ...... Selection Concepts

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- Bicuspid aortic valve—controversial.
- Severe aortic insufficiency heightens the difficulty (esp. cusp pathology with cusp repair).
The Pure AI BAV Patient with Dilated/Aneurysmal Proximal aorta

NOTE: Pure AI, No Calcified Leaflets

Fairly large opening, no AS

Still frames to depict anatomy
### Surgical Repair BAV AI Classification:

Fundamentally we are discussing Ib with II

Most Common combination

<table>
<thead>
<tr>
<th>AI Class</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal cusp motion with FAA dilatation or cusp perforation</td>
<td>Cusp Prolapse</td>
<td>Cusp Restriction</td>
</tr>
<tr>
<td></td>
<td>Ib</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Id</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanism</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Repair Techniques (Primary)</td>
<td>STJ remodeling</td>
<td>Aortic Valve sparing: Reimplantation or Remodeling with SCA</td>
<td>Patch Repair</td>
</tr>
<tr>
<td>Ascending aortic graft</td>
<td><img src="image4.png" alt="Diagram" /></td>
<td><img src="image5.png" alt="Diagram" /></td>
<td>Autologous or bovine pericardium</td>
</tr>
<tr>
<td>Repair Techniques (Secondary)</td>
<td>STJ Annuloplasty</td>
<td>SCA</td>
<td>Prolapse Repair</td>
</tr>
<tr>
<td>SCA</td>
<td>SCA</td>
<td>SCA</td>
<td></td>
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BAV Ib + II usually associated with 15-25% larger annulus than standard for BSA
What kind of Operation are we Talking about?
Measuring the Amount of excess leaflet to resect (or plicate) for **Leaflet Free Margin Equality**

Treating the Prolapse
Raphe Release, Equalization of Free Margin, and Plication/Resection of Redundant leaflet

Coronary Buttons are cut.
210°/150° perimeter and Leaflet surface area ratios.
Placement of Sub-Annular “Fixation” Sutures for Annular Reduction and Stabilization

8-9 Geometrically placed Subannular Stabilization sutures (annular reduction 15-20%)
Construction of Stable (smaller) Annulus and Reimplantation of the “New Root” in 3 dimensions

Size to BSA

210/150 Neo ValSalva Root (Raphed BAV)
SubCommisural (Sub-annular) Annuloplasty (SCA)

Repair of the Valve WITHOUT a Root Procedure
Surgical Repair BAV AI Classification:
Fundamentally SCA is for pure Type II
Second Most Common combination

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<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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</table>

- Normal cusp motion with FAA dilation or cusp perforation
- STJ remodeling
- Aortic valve sparing: Reimplantation or Remodeling with SCA
- Patch Repair
- Autologous or bovine pericardium
- Prolapse Repair
- Triangular resection
- Free margin
- Resuspension
- Leaflet Repair
- Shaving
- De-leafletization
- Patch

BAV II usually associated with 15-25% larger annulus than standard for BSA
SO ....Bicuspid Aortic valve Reair Concepts (Direct Cusp or Leaflet)

- Even the free margin lengths: Plicate (or cut) the prolapsed cusp
- Annular Reduction (10-15%) and Stabilization with either Re-implantation (or Sub-Annular technique)
- Increase height (decrease length) of Free margin (gore-tex) ....if leaflet belly below annular plane.

- Bottom line: “Any purely insufficient valve with enough leaflet surface area can be repaired”

- How Dogmatic Should WE be with THIS APPROACH ??!
2002 to 2012: 734 patients with Bicuspid Aortic Valve Disease (the surgical practice BAV universe)

*AS ± Al or Al for isolated AVR (N=507) EXCLUDED

Valve Pathology (N= 734)

Al ± aortic root aneurysm (N=227)

Total BAV Repair = 76

Primary Leaflet Repair ± Ascending Aorta Replacement (N=43) Since 2005

Primary Leaflet Repair + Root Reimplantation (N=33) Since 2006

Bentall or Proximal Aortic Reconstruction (N=151) 2006-2011
Some Data to Ponder ......

SCA vs Reimplantation
Durability of Valve Sparing Root Reimplantation in BAV patients\textsuperscript{3}: El Khoury’s own data

N=151; 89 SCA vs 72 reimplantation

- 24 patients (49\%) in SCA group had peak gradient >20 mmHg, compared to 10 patients (19\%) in Reimplantation group

- At follow-up, freedom from reoperation was better in Reimplantation group (100\% vs 90\%), and \textbf{freedom from AI> 2+ was also better in Reimplantation group (100\% vs 77\%)}

- Conclusions: Compared to BAV repair only (SCA), valve repair + root reimplantation stabilizes the ventriculoaortic junction (ie Annulus), provides improved valve gradients, and is associated with much improved outcomes

K-M analysis: Simple Sub-Commisural Annuloplasmy (SCA) vs Reimplantation on AI

- Reimplantation: 5 years, 92 ± 6%
- Repair: 5 years, 62 ± 10%

p = 0.03

Bavaria et al; Presented at STS 2013; Ann Thor Surg (In Press)
Durability of Valve Sparing Root Reimplantation in BAV patients

Group 2 = Reimplantation

- 24 patients (49%) in group 1 had peak gradient >20 mmHg, compared to 10 patients (19%) in group 2

- At follow-up, freedom from reoperation was better in group 2 (100% vs 90%), and freedom from AI> 2+ was also better in group 2 (100% vs 77%)

- Conclusions: Compared to BAV repair only, valve repair + root reimplantation stabilizes the ventriculoaortic junction (ie Annulus), provides improved valve gradients, and is associated with improved outcomes.

So …. we still have a Major Dilemma: What do we do with THIS!!!! .... To “Root” or “Not to Root”??
Some more Data to Ponder …..

SCA in Dilated Aortic Annulus .... Which many, if not most, BAV patients have!
BAV repair (SCA) with dilated annulus (> 27mm): fails in short term

\[ p = 0.0003 \]

- Repair >27 mm: 34 ± 12%
- Repair ≤27 mm: 94 ± 5%
- Reimplantation >27 mm: 86 ± 10%

Actuarial freedom from reoperation after aortic valve repair in patients with a BAV depending on preoperative AVD.

SAME Conclusion: More Failure in Large Annulus

Aicher D et al. Circulation 2011;123:178-185 (Germany)
Actuarial freedom from reoperation after aortic valve repair in patients with a BAV and a preoperative AVD of >28 mm depending on the use of root replacement.

This data shows that there is a **SUBSTANTIAL** failure at 6 years requiring **REOPERATION** in patients with a > 28 mm Annulus (This is a lot of BAV patients!!) whether they have a SCA or “Remodeling” (Yacoub) style Root. Simple BAV repair here is a **DISASTER**!

Aicher D et al. Circulation 2011;123:178-185 (Germany)
Actuarial freedom from reoperation after aortic valve repair in patients with a BAV depending on operative technique.

This shows the MORE Robust ROOT STABILIZATION you have, the better the results!! BUT ……

Substantial Thickening and Calcification BUT an AI presentation: Not Really repairable WITHOUT resection and Pericardial patch augmentation .....
Actuarial freedom from reoperation after aortic valve repair in patients with a BAV depending on the use of a pericardial patch.

This is Awful!!

Long-Term Survival After the Bentall Procedure in Bicuspid Aortic Valve

Survival nearly same as age and sex matched group at 12 years!

The Alternative is not a FAILURE!!! Excellent Aortic Root outcomes in patients < 60.
Freedom from aortic reoperation for SVD

All Patients < 60 years

Fig 3. Freedom from reoperation of aortic root for structural valve deterioration (SVD) for the porcine bioroot (black line) and the mechanical root (gray line).
Late Valve Attrition: Valve-in-Valve adds MORE years to the Index operation at very little cost!
Conclusions for Bicuspid Valves

• BAV Repair for AI, with or without Root Aneurysm, is a GOOD operation in SELECTED patients. I do a lot of it and endorse it.

• However, There are significant relative contraindications to repair where the RESULTS are simply NOT satisfactory.

• They Include:
  • Calcification
  • Fenestration
  • Need for Patch augmentation
  • The Dilemma of the Large Annulus in Normal Root Diameter ..... A more complicated Root operation for essentially single valve leaflet disease?!

• Amid the BACKDROP of EXCELLENT BioRoot outcomes and V-in-V TAVI rescue.
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    - Since 2005

  - Primary Leaflet Repair + Root Reimplantation (N=33)
    - Since 2006

  - Bentall or Proximal Aortic Reconstruction (N=151)
    - 2006-2011
When NOT to do the David Reimplantation Procedure:
Conclusions for 3 Cusp Valves

- Marfans has worse outcomes than Non-Marfans especially:
  - If there is Eccentric “Important” AI
  - Multiple Fenestrations
  - Long Free Margin lengths need a “ValSalva” graft (David V)
- Fenestrations in the Leaflets (even worse if on the free margin and not the commissure) in Non-Marfans
- 3 cusp valves that require cusp repair, especially if very thin
- Type A Dissection is a judgment issue, not technical
Thomas Eakins: Gross Clinic (1878@JEFF) and Agnew Clinic (1888@PENN)

Great Progress in 10 years!

Thank You
Survival after discharge (10 year follow up)

KAPLAN-MEIER: Long-time Survival after Discharge (N = 120)

Long-time Survival:
Year 5: N = 101
Year 10: N = 44

70%
Freedom from aortic valve replacement: 87%
BAV repair (SCA) with dilated annulus (> 27mm): fails in short term

Freedom from aortic insufficiency >1+

- Group: >27 mm annulus
  - 34 ± 12%
  - 94 ± 5%

- Group: ≤27 mm annulus
  - Number at risk:
    - >27 mm annulus: 18
    - ≤27 mm annulus: 20

p = 0.0015

Severe Eccentric AI with Proximal Aortic Aneurysm and ST Jct Dilation

Different operation strategies for different diameter combinations
Bicuspid Aortic valve Repair Concepts (Direct Cusp or Leaflet)

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