Geometric Orientation of the Aortic NeoRoot in Type 1 Bicuspid Aortic Valve Repair: BAV AI Reimplantation for Proximal Aneurysm

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Bicuspid Valve: Cusp Anatomy

Pictures courtesy of G. El-Khoury

Type 0 (true)

Type 1 (prolapsing)

Type 1 (restrictive)

(Sievers et al. JTCVS 2007)
David V/ Bicuspid Valve: Sievers o 180/180 ..... Beautiful Valve!!
2002 to 2015: 1083 patients with **Bicuspid Aortic Valve Disease** (the surgical practice BAV universe)

*AS ± AI or AI for isolated AVR (N=754) EXCLUDED

**Valve Pathology (N= 1084)**

AI ± aortic root aneurysm (N=330)

Total BAV Repair = 132

- **Primary Leaflet Repair ± Ascending Aorta Replacement (N=79)** Since 2005
- **Primary Leaflet Repair + Root Reimplantation (N=53)** Since 2006
- **Bentall or Proximal Aortic Reconstruction (N=198)**

2006-2014

Bavaria, JE 4/2016
What about AI?

BAV Repair Philosophy: The Basics for AI

In Evolution
Einstein: Make everything as simple as possible ...... But No Simpler!!
Surgical Repair BAV AI Classification:
Fundamentally we are discussing lb and c with II

Most Common combination

<table>
<thead>
<tr>
<th>Al Class</th>
<th>Type I Normal cusp motion with FAA dilatation or cusp perforation</th>
<th>Type II Cusp Prolapse</th>
<th>Type III Cusp Restriction</th>
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</thead>
<tbody>
<tr>
<td>lb</td>
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<tr>
<td>lc</td>
<td><strong>Ring</strong></td>
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<td>ld</td>
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<tr>
<td>Repair Techniques (Primary)</td>
<td>Ascending aortic graft</td>
<td>Aortic Valve sparing: Reimplantation or Remodeling with SCA</td>
<td>Patch Repair</td>
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<tr>
<td>STJ remodeling</td>
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<td>Prolapse Repair</td>
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<tr>
<td>(Secondary)</td>
<td>SCA</td>
<td>STJ Annuloplasty</td>
<td>Autologous or bovine pericardium</td>
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<td></td>
<td>SCA</td>
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<td>Resuspension Patch</td>
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<tr>
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<td>Ring</td>
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<td>Leaflet Repair</td>
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<tr>
<td></td>
<td>SCA</td>
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<td>Shaving Decalcification Patch</td>
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</tbody>
</table>

BAV lb + II usually associated with 15-25% larger annulus than standard for BSA

Ascending Aorta - Root (Sinus segment) Phenotype

- **Root aneurysm**
  - Valsalva ≥ 45 mm

- **Supra coronary aneurysm**
  - Valsalva ≤ 40-45 mm

- **Isolated AI**
  - All diameters ≤ 40 mm

Adapted From E. Lansac, Paris France

Carpentier et al. JTCVS 1983, El Khoury et al curr opin cardiol 2005, Lansac et al EJCTS 2008; Adapted from E. Lansac
Principles of Bicuspid Aortic Valve Repair: The Mitral Logic in 3D

The Goal is to Restore Coaptation Surface

At this time we almost never replace an insufficient Mitral Valve – Repair

- So …. For AI Aortic Valves
- Repair and Preserve Native Cusp (leaflet) tissue
- Restore the “Normal” 3D Geometry of the Root or the “Functional Aortic Annulus” (the Annulus and STJ)
Bicuspid Aortic Valve AI and the 3 Main presentations

- BAV with AI and relatively normal Root diameters
- BAV with AI and relatively normal Root diameters but Ascending Aneurysm
- BAV with AI and Root Dilation

- Problem: different therapeutical procedures for each presentation??
BAV AI with Normal Sinus and STJ Diameters: very dilated annulus
Preoperative TEE: BAV, Severe AI, Normal Aorta Diameters but Very Large annulus
Bicuspid Aortic Valve AI and the 3 Main presentations

- BAV with AI and relatively normal Root diameters
- BAV with AI and relatively normal Root diameters but Ascending Aneurysm
- BAV with AI and Root Dilation

- Problem: different therapeutic procedures for each presentation??
So .... We still have a Major Dilemma: What do we do with THIS!!!! .... To "Root" or "Not to Root"
Bicuspid Aortic Valve AI and the 3 Main presentations

- BAV with AI and relatively normal Root diameters
- BAV with AI and relatively normal Root diameters but Ascending Aneurysm
- BAV with AI and Root Dilation

Problem: different therapeutic procedures for each presentation??
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
Ascending Aorta - Root (Sinus segment) Phenotype

Root aneurysm
Valsalva ≥45 mm

Supra coronary aneurysm
Valsalva ≤ 40-45 mm

Isolated AI
All diameters ≤ 40 mm

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Implantation of the neoroot

A V-shaped “Cut” in the NeoRoot to account for the Left/Right Aorto-PA Conus fixation

Completion of El Khoury leaflet repair – David V reimplantation and graft-to-graft proximal aortic reconstruction
Supra coronary aneurysm
Valsalva $\leq 40-45$ mm

Isolated Al
All diameters $\leq 40$ mm

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Do We have a New Solution??
360 Sub-Annular Ring

Repair of the Valve WITHOUT a Root Procedure
Place Sub-annular exactly like the Reimplantation (DV) but for external ring only: The Root is normal.
Tie the Sutures down for an annular stabilization:
This is a 28 to 26 mm Ring
Can we really spare or Repair something like this??

Bicuspid Valve Type 1? or 2?
So, ....... When I Proposed that we try to Repair Bicuspid valves to my Division colleagues, The Response .......

But ....What kind of Leaflet Repair Reconstrucrive Re-implantation Operation are we Talking about?
Measuring the Amount of excess leaflet to resect (or plicate) for **Leaflet Free Margin Equality**

**Treating the Prolapse**
Leaflet Repair with plication (sometimes resection) of prolapsed segment
Free Margin Equalization

Use 7-0 prolene to mark the leaflet edges and therefore “define” the necessary redundant segment.
BAV Repair with Resection (not Plication) of calcified thickened Raphe
Raphe Release

Usually done at beginning.
Post-Repair Evaluation: For Margin Equality, Perimeter assessment

This is when we make 210/150 vs 180/180 decision!
Raphe Release, Equalization of Free Margin, and Plication/Resection of Redundant leaflet

Coronary Buttons are cut. 210/150 perimeter and Leaflet surface area ratios.
Another Example
3D Echo: Contribution of Circumference in Degrees (Unfused Leaflet to Fused Leaflet)

- David V + El-Khoury leaflet repair

David V + El-Khoury Repair using a $150^\circ : 210^\circ$ approaches more physiologic geometry of many normal BAVs with a raphe (Sievers type I)
Quantitative Comparison of Post-Repair Valves

- **SCA + El-Khoury**
  - Unfused Surface Area: 292.3 mm²
  - Fused Surface Area: 312.5 mm²
  - Coapt Surface Area: 145.6 mm²
  - Annular Area: 520.3 mm²
  - Annular reduction: 26.2%

- **David V + El-Khoury**
  - Unfused Surface Area: 215.7 mm²
  - Fused Surface Area: 284.4 mm²
  - Coapt Surface Area: 105.4 mm²
  - Annular Area: 392.1 mm²
  - Annular reduction: 46.2%
Preparation of the Root for Subannular Suture Placement and Re-Implanation Procedure
Subannular Suture Placement:
Note Arch procedure, Conduct of operation

2mm below the leaflet insertion; Special attention to Right Cusp.
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

In BAV: Size the annulus for “the normal annular diameter” for each individual

210°/150° Neo ValSalva Root (Raphed BAV)
Institutional Approach to BAV syndrome with Aortic Insufficiency (AI)

Type I BAV

Nonaneurysmal root  Aneurysmal root

Repair + SCA  Repair + RR

About 50:50 in our practice
The 210/150 Orientation and “Billowing”:
It is really an Asymmetric Leaflet Surface Area Issue
BAV 180/180 Repair for Sievers 1 (undeveloped Raphe)
Goal: Great Coaptation Zone with good symmetry, no “billowing”
SCA BAV repair: mild billowing, asymmetric leaflet surface area
Echo Evaluation of BAV Repair

• Annular Diameter; In the OR – How much of a REDUCTION in Annular Diameter (15-20%)

• Coaptation Zone Length (> 5 mm, best is 10 mm)

• Leaflets (and Coaptation) in relation to Valve plane (Above, Same level, or Below)

• STJ to Annular Ratio

• Description of AI jet(s), LVESD/LVEDD
Outcomes with BAV Repair + Root Reimplantation:

How do they compare to our institutional tricuspid aortic valve root reimplantation?
Freedom from AI >2+ (%)

100% of BAV VSRR had Leaflet Repair

Data thru 5/2014 Aortic Surgery Symposium; Bavaria, et al; JTCVS 2014
LV Remodeling: Excellent in Both groups

- BAV: 57 to 51 mm, \( p = <0.01 \)
- TAV: 53 to 50 mm, \( p = <0.01 \)
BAV Root Operations with AI: Comparison of Bentall Root Procedures vs Reimplantation BAV Repair (100%)

![Graph showing comparison of Bentall root procedures and reimplantation BAV repair.](image)

- **BAV VSRR**: 96 ± 4%
- **Biological Root Replacement**: 100%
- **Mechanical Root Replacement**: 100%

*p = 0.3*

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<th>Years since surgery</th>
<th>Number at risk</th>
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<tr>
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<td>BAV VSRR</td>
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<tr>
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BAV 180 vs 210 results: Freedom from AI >1+ (%)

- **BAV 180°/180°**: 87 ± 8%
- **BAV 210°/150°**: 95 ± 5%

*p*=0.5

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Conclusions: Bicuspid Aortic Valve Repair with Reimplantation

- BAV repair is very feasible with very good mid-term outcomes
  - With minimal leaflet Calcification
  - Either 210/150 or 180/180 orientation is reasonable depending on pre-operative perimeter assessment
- Annular Stabilization is **Critical**
- Re-Implantation (or Sub-annular Ring) accomplishes this goal.
- Simple SCA in pre-op Annular diameters >27 should be abandoned
- **Reconstructive principles need to be vigorously upheld**
Thomas Eakins: Gross Clinic (1878 @ JEFF) and Agnew Clinic (1888 @ PENN)

Great Progress in 10 years!

Thank You