How to Perform a Valve Sparing Root Replacement

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Session 6: Technical Aspects of Open Surgery on the Aortic Valve
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## Disclosure

<table>
<thead>
<tr>
<th>Company</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medtronic, Inc</td>
<td>PI Clinical Trials Consultant</td>
</tr>
<tr>
<td>Vascutek</td>
<td>Consultant</td>
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<td>PI Clinical Trials</td>
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<td>branched graft</td>
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<tr>
<td>Edwards Lifesciences</td>
<td>PI Clinical Trials</td>
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</tbody>
</table>
AORTIC ROOT ANEURYSM

NORMAL OR NEAR NORMAL AORTIC VALVE LEAFLETS
Aortic Root Replacement: Valve-sparing Technique (AVS)

Yacoub et al
JTCVS 1998;115:1080-90

Technique introduced in 1979
Aortic Root Replacement: Valve-sparing Technique (AVS)

David-I Original Reimplantation Using a Straight Tube Graft

David & Feindel
JTCVS 1992;103:617-22
Original David procedure
10 patients; 5 with MFS
AORTIC VALVE SPARING

- Experience
- Coaptation
- No prolapse
- Echocardiography
Aortic Valve Sparing Reimplantation

I. Aortic valve exposure and assessment
II. Root preparation and dissection
III. Graft sizing and selection
IV. Proximal suture line
V. Graft preparation and fixation
VI. Valve reimplantation
VII. Valve testing and leaflet management
VIII. Coronary artery reimplantation
Experience

“The surgeon’s experience remains the most important facet of aortic root repair and Valve Sparing”

Tirone David, MD
Aortic Valve Sparing Reimplantation

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External Exposure

- Aortotomy is performed 1 cm above the sinotubular junction
  - Above the RCA
  - Ascending aorta is pulled cranially
  - Valve leaflets, sinuses, annulus
Leaflet Inspection: BAD

Leaflet tissue quality
Stress fenestration
Leaflet prolapse
Assessment of Leaflets

• Poor quality leaflets may not be salvageable

Fenestration of aortic valve leaflet in patients with Marfan syndrome
Aortic Valve Sparing Reimplantation

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Root Preparation/Dissection

- Begin at the level of the non-coronary sinus and non/left commissure
  - As low as possible
  - **Anatomic limit:** plane passing through the nadir of leaflet insertion
Root dissection at the level of the non-coronary sinus and N/L commissure

- *The external anatomical limit of the dissection is composed by the roof of the left atrium*
Root Preparation/Dissection

- Harvest right coronary artery
- Continue towards base of non-coronary/Right commissure
  - *Isolate RCA before external dissection of right sinus*
Root Preparation/Dissection

- Limit of dissection right coronary sinus and N/R commissure
  - Anatomic limit of dissection
  - Muscular septum in relation to the right sinus
  - Membranous septum in regards to the non/right commissure

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Root Preparation/Dissection

- **External limit of dissection does not reach the plane passing through the nadir of the leaflet insertion**
Root Preparation/Dissection

- **Anatomical limit of dissection** is roof of left atrium (left sinus) and muscular septum and RV outflow tract muscle (R/L commissure)
External limit of dissection is plane passing through the nadir of leaflet insertion at the level of LC leaflet but not at R/L commissure.
Aortic Valve Sparing Reimplantation

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III. Graft Size Selection

• Feindel-David formula
  - $Diameter = \left[ \frac{(height \times 2) \times 2}{3} \right] + (2 \times \text{thickness of aortic wall})$

• El Khoury technique
  - $Height \ of \ interleaflet \ triangle$

• De Paulis approach
  - $Annulus \ diameter + 5 \ mm$
III. Graft Size Selection

- Feindel-David formula
  - Diameter = \(\left(\frac{\text{height} \times 2}{3}\right) + 2 \times \text{thickness of aortic wall}\)

- El Khoury technique
  - Height of interleaflet triangle

- De Paulis approach
  - Annulus diameter + 5 mm

- Gender/body size based
  - 28 mm women / 30 mm male
III. Graft Selection

Base of interleaflet triangle to Top of commissure (Non/Left) is equal to the diameter of the STJ

Diameter = Height

Vascutek Valsalva graft

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### Graft Number: Benefits of 2

| David-V Stanford Modification | David V + using 2 grafts: a larger proximal graft (6-8 mm) and smaller distal graft + narrowed annular end “necked down” |

- Large proximal + small distal
- Straight with “necked” ends
- Customizable
Aortic Valve Sparing Reimplantation

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V. Graft preparation and fixation
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VIII. Coronary artery reimplantation
IV: Proximal Suture Line

Variation in Subannular Sutures
Subannular Sutures (n=12)

- 12 sutures w pledgets

Avoid contact between pledgets and leaflet:
2 mm distance safe
Heart Block

- Risk of heart block when placing subannular sutures near Bundle of His
  - Left bundle branch
Aortic Valve Sparing Reimplantation

I. Aortic valve exposure and assessment
II. Root preparation and dissection
III. Graft sizing and selection
IV. Proximal suture line
V. **Graft preparation and fixation**
VI. Valve reimplantation
VII. Valve testing and leaflet management
VIII. Coronary artery reimplantation
Graft Fixation: Tailoring

Adjustment for differences in height between Non/Right and Right/Left commissures

Here, graft is split. Alternates include cutting a notch out.
Graft Fixation: Parachute
Aortic Valve Sparing Reimplantation

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Valve Reimplantation

- Firmly pull the 3 commissures
- Attach high on the tube graft
- Reduce risk of leaflet prolapse when using a relatively small graft
Valve Reimplantation

- Begin with commissures:
  - 4-0 polypropylene suture
  - Running suture around valve apparatus
  - Stay close to annulus

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Aortic Valve Sparing Reimplantation

I. Aortic valve exposure and assessment

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IV. Proximal suture line

V. Graft preparation and fixation

VI. Valve reimplantation

VII. Valve testing and leaflet management

VIII. Coronary artery reimplantation
Testing and Management

• After valve reimplantation, crucial to evaluate for:
  ▪ Prolapse
  ▪ Symmetry
  ▪ Height and depth of coaptation
Testing and Management

• Water test
  - Place leaflets in closed position
  - Flush valve with syringe
  - Observe after suction
  - Focus on mid-portion of free margin

Prolapse is present when the level of free margin differs from the adjacent cusp
Leaflet Repair to Aid Coaptation

Shorten the free margin as needed

Reduce Prolapse

Tirone David; Sabiston & Spencer 2015 (Chapter 67)
Improve Coaptation

• Sufficient coaptation needed

• Repair leaflets
  - Reinforce free margin with double layer of suture
  - Plication of free margin to shorten leaflet

Tirone David; Sabiston & Spencer 2015 (Chapter 67)
Leaflet Repair

Reinforcement of the free margin of the aortic cusp with a double layer of suture
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Coronary Artery Reimplantation

Coronary button
Coronary ostia
Pathway of running suture

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Echocardiography

- Accurately evaluate aortic valve function after repair
  - Residual regurgitation
  - Coaptation length
  - Prolapse
Obrigado!
Thank You!
Valve-sparing Aortic Root Replacement

- Single-surgeon experience
- 131 valve-sparing ARR
- March 2000 – September 2015
# Valve-sparing Aortic Root Replacement

## Preoperative characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>52 (38-61)</td>
</tr>
<tr>
<td>Male</td>
<td>97 (74%)</td>
</tr>
<tr>
<td>Acute aortic dissection</td>
<td>3 (2.3%)</td>
</tr>
<tr>
<td>Chronic aortic dissection</td>
<td>9 (6.9%)</td>
</tr>
<tr>
<td>Aortic aneurysm only</td>
<td>119 (90.8%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>90 (68.7%)</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>44 (33.6%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>2 (1.5%)</td>
</tr>
</tbody>
</table>

*Median (IQR)*

REQUESTED UPDATED DATA
## Valve-sparing Aortic Root Replacement

<table>
<thead>
<tr>
<th>Preoperative characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptomatic</td>
<td>71 (54.2%)</td>
</tr>
<tr>
<td>Genetic disorder</td>
<td>50 (38.2%)</td>
</tr>
<tr>
<td>Marfan syndrome</td>
<td>40 (30.5%)</td>
</tr>
<tr>
<td>Bicuspid aortic valve</td>
<td>12 (9.2%)</td>
</tr>
<tr>
<td>History of stroke</td>
<td>7 (5.3%)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>29 (22.1%)</td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>35 (26.7%)</td>
</tr>
<tr>
<td>Maximum sinuses diameter (cm)</td>
<td>5.1 ± 0.7</td>
</tr>
</tbody>
</table>

REQUESTED UPDATED DATA
Valve-sparing Aortic Root Replacement

<table>
<thead>
<tr>
<th>Operative characteristics</th>
<th>Requested Updated Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elective</td>
<td>126 (96.2%)</td>
</tr>
<tr>
<td>Urgent</td>
<td>3 (2.3%)</td>
</tr>
<tr>
<td>Emergent</td>
<td>2 (1.5%)</td>
</tr>
<tr>
<td>ARR, reimplantation</td>
<td>130 (99.2%)</td>
</tr>
<tr>
<td>ARR, Florida sleeve</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Hemiarch</td>
<td>66 (50.4%)</td>
</tr>
<tr>
<td>Full arch (with elephant trunk)</td>
<td>6 (4.6%)</td>
</tr>
</tbody>
</table>
### Valve-sparing Aortic Root Replacement

#### Operative characteristics

<table>
<thead>
<tr>
<th>Operative characteristic</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascending</td>
<td>20 (15.3%)</td>
</tr>
<tr>
<td>Mitral valve repair</td>
<td>4 (3.1%)</td>
</tr>
<tr>
<td>CABG</td>
<td>15 (11.5%)</td>
</tr>
<tr>
<td>Redo sternotomy</td>
<td>4 (3.1%)</td>
</tr>
<tr>
<td>CPB time (minutes)</td>
<td>168 (147-201)*</td>
</tr>
<tr>
<td>Aortic clamp time (minutes)</td>
<td>110 (98-134)*</td>
</tr>
<tr>
<td>Cardiac ischemic time (minutes)</td>
<td>119 (106-143)*</td>
</tr>
</tbody>
</table>

*Median (IQR)
Valve-sparing Aortic Root Replacement

<table>
<thead>
<tr>
<th>Outcome characteristics</th>
<th>1 (0.8%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative (early) death</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>30-day death</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Hospital death</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Permanent stroke</td>
<td>3 (2.3%)</td>
</tr>
<tr>
<td>Permanent renal failure/dialysis</td>
<td>2 (1.5%)</td>
</tr>
<tr>
<td>Permanent paraplegia</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Adverse event*</td>
<td>3 (2.3%)</td>
</tr>
<tr>
<td>Vocal cord paralysis</td>
<td>1 (0.8%)</td>
</tr>
</tbody>
</table>

*Early death; Permanent stroke; renal failure; paraplegia; paraparesis
# Valve-sparing Aortic Root Replacement

<table>
<thead>
<tr>
<th>Outcome characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac complications</td>
<td>55 (42.0%)</td>
</tr>
<tr>
<td>Pulmonary complications</td>
<td>25 (19.1%)</td>
</tr>
<tr>
<td>Bleeding requiring reoperation</td>
<td>11 (8.4%)</td>
</tr>
<tr>
<td>Postop ICU LOS (days)</td>
<td>2 (2-4)*</td>
</tr>
<tr>
<td>Postop LOS (days)</td>
<td>7 (6-10)*</td>
</tr>
</tbody>
</table>

*Median (IQR)

REQUESTED UPDATED DATA
### AVOOMP 1-Year Outcomes

**Early outcomes**

<table>
<thead>
<tr>
<th></th>
<th>AVR (n=77)</th>
<th>AVS (n=239)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality</strong></td>
<td>1 (1%)</td>
<td>1 (&lt;1%)</td>
<td>.4</td>
</tr>
<tr>
<td><strong>Stroke</strong></td>
<td>0</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Valve-related events</strong></td>
<td>152</td>
<td>195</td>
<td>&lt;.01</td>
</tr>
<tr>
<td><strong>Nonstructural valve defect</strong></td>
<td>1 (1%)</td>
<td>7 (2%)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Embolism</strong></td>
<td>1 (1%)</td>
<td>3 (1%)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Bleeding</strong></td>
<td>2 (3%)</td>
<td>3 (1%)</td>
<td>.6</td>
</tr>
<tr>
<td><strong>Permanent pacemaker by 14th d</strong></td>
<td><strong>2 (3%)</strong></td>
<td><strong>3 (1%)</strong></td>
<td><strong>.6</strong></td>
</tr>
<tr>
<td><strong>Valve-related morbidity</strong></td>
<td>4 (5%)</td>
<td>12 (5%)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>MAVRE</strong></td>
<td>6 (8%)</td>
<td>15 (7%)</td>
<td>.6</td>
</tr>
</tbody>
</table>

**Objective:** To compare the 1-year results after aortic valve sparing (AVS) or valve-replacing (AVR) aortic root replacement in a prospective, international registry of 316 patients with Marfan syndrome (MFS).

**Methods:** A total of 316 patients with MFS were enrolled between 2000 and 2012. Patients were followed for a median of 9 years.

**Results:** A total of 316 patients were enrolled, with 77 undergoing AVR and 239 undergoing AVS. The 1-year outcomes showed a lower rate of valve-related events in the AVS group compared to the AVR group (195 vs. 152, P < .01). No significant differences were found in mortality, stroke, nonstructural valve defect, embolism, bleeding, or permanent pacemaker use.

**Conclusion:** The AVS group had a lower rate of valve-related events compared to the AVR group, with no significant differences in other outcomes.
### 83 Patients with VSARR

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td><strong>Operative (Early) Death</strong></td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Stroke</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Cardiac complications</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>23</td>
<td>28%</td>
</tr>
<tr>
<td>Atrial arrhythmia</td>
<td>20</td>
<td>24%</td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Renal failure (hemodialysis)</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>

*Early death occurred in patient with acute aortic dissection*
Conclusions

Avoid late dilatation or leaftlet prolapse

• Commissural stretching
• Leaflet reduction
• Elongation
• Free margin
  - Plication to create ideal coaptation plane
  - Over or under correction
• Annulus
  - Undersizing
Conclusions

- Maintain vigilance for annulus stabilization and leaflet coaptation
- Importance of postoperative echo cannot be overstated
  - Do not leave the OR with >mild aortic valve regurgitation
Thank you!
Valve-sparing Aortic Root Replacement
Valve-sparing Aortic Root Replacement

- 41 year-old woman
- Marfan syndrome
- Prior aortic dissection
  - DeBakey type III dissection at age 36
Valve-sparing Aortic Root Replacement

- Recent extensive distal aortic repair
  - Extent II TAAA repair
  - 4 months prior to VSARR
  - No major complications
Valve-sparing Aortic Root Replacement

- Returns for proximal aortic repair
  - Mildly dilated aortic root (4.5 cm)
  - Annuloaortic ectasia
  - Trace aortic valve insufficiency
  - Normal diameter of aortic arch (2.2 cm)
Valve-sparing Aortic Root Replacement

• Left ventricle ejection fraction greatly reduced (<20%)
• Severe global LV hypokinesis
Valve-sparing Aortic Root Replacement

• Aortic root replacement needed
  ▪ VSARR preferred by patient
• Leaflets evaluated intraoperatively
  ▪ Thin-walled, consistent with Marfan syndrome
  ▪ Small, minor fenestrations
  ▪ Reasonably competent
Valve-sparing Aortic Root Replacement

• Recovery
  ▪ Normal aortic valve function
  ▪ LVEF improved to 50-55%
  ▪ Unremarkable
  ▪ Discharged postoperative day 6 to home

• Follow up
  ▪ Patient remains well 14 months later