Reimplantation is the best root repair

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The origin of valve sparing root replacement operations

Remodeling technique (1983)

Reimplantation technique (1992)

Sir M. Yacoub

Prof. T. David
VSRR was developed to treat aortic root aneurism in TAV!

Root aneurism/no AI

Root aneurism + Al

OK

No?
And the debate started...

Remodeling

- Faster
- Less root dissection
- Only 1 suture line

≠

Reimplantation

- More hemostatic
- More reliable
- Better Stabilisation in Marfan

No long term outcomes!
Several modifications proposed

David’s Operations (1992-2001)

I (Reimplantation in straight tube)
II (= Remodeling)
III (= Remodeling + partial external ring)
IV (Reimplantation with neosinuses)
V

Kari F.A. Circ 2013
Highly selected population

Results of aortic valve-sparing operations
Tirone E. David, Susan Armstrong, Joan Ivanov, Christopher M. Feindel, Ahmad Omran and Gary Webb
*J Thorac Cardiovasc Surg* 2001;122:39-46

- 120 patients
- Reimplantation 53%
- Remodeling 47%
- Marfan 45%
- BAV 2%
- AI 3+ 4+ 40%
- Cusp repair 11%

Figure 3. Freedom from 3+ or 4+ AI.
Analysis of the mechanisms of failure

Valve sparing technique ? Need for cusp repair ?

Pethig K. ATS 2002
# Functional Classification of AI

<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>la</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lb</td>
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<td>lc</td>
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<tr>
<td>ld</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mechanism
- STJ remodeling
- Ascending aortic graft
- Aortic Valve sparing:
  - Reimplantation or
  - Remodeling with SCA
- Patch Repair
- Prolapse Repair
  - Plication
  - Triangular resection
  - Free margin Resuspension Patch
- Leaflet Repair
  - Shaving
  - Decalcification Patch

+ Annuloplasty
Effects of Preoperative Aortic Insufficiency on Outcome After Aortic Valve-Sparing Surgery

- 164 patients
- Reimplantation 75%
- Remodeling 25%
- Marfan 10%
- BAV 32%
- AI 3+ 4+ 60%
- Cusp repair 55%

L. de Kerchove Circ. 2009
Probability of Cusp Repair in VSRR in function of preoperative AI

- No AI
  - Low ± 10%

- Central AI
  - Moderate ± 50%

- Eccentric AI
  - High ± 100%
Cusp configuration in AV repair

Cusp Repair is crucial to achieve good valve configuration!
Cusp configuration in AV repair

G. El Khoury G.

Schäfers HJ. JTCVS 2006

Aicher D. Circ. 2011

G. El Khoury G.
But Al was **NOT** the **ONLY** problem in VSRR

Suggest better repair durability with the Reimplantation technique

- Birks EJ., Yacoub MH. Circulation. 1999
- De Olievera NC., David TE. JTCVS 2003
- Miller DG. JTCVS 2003
- Bethea BT., Cameron D. ATS 2004
- David T. JTCVS 2006
- Erasmi A., Sievers HH. ATS 2007
Annulus dilatation is very bad in remodeling

✓ Hanke T., Sievers H.J. JTCVS 2009:
  • 191 VSRR, 76% TAV
  • 56% Remodeling

✓ Kunihara T., Schäfers H.J. JTCVS 2012:
  • 430 VSRR, 70% TAV,
  • 93% remodeling

✓ Schäfers H.J. JTCVS 2016:
  • 747 Remodeling, 58% TAV,

<table>
<thead>
<tr>
<th>Variable</th>
<th>P value</th>
<th>HR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of AV junction (mm)</td>
<td>&lt;.001</td>
<td>1.43</td>
<td>1.21-1.69</td>
</tr>
<tr>
<td>Use of annuloplasty</td>
<td>.01</td>
<td>1.28</td>
<td>1.89-66.26</td>
</tr>
<tr>
<td>Myocardial ischemia (min)</td>
<td>.04</td>
<td>0.96</td>
<td>0.93-1.00</td>
</tr>
<tr>
<td>Effective height</td>
<td>&lt;.001</td>
<td>0.58</td>
<td>0.43-0.79</td>
</tr>
<tr>
<td>Use of pericardial patch</td>
<td>&lt;.001</td>
<td>6.24</td>
<td>2.30-16.90</td>
</tr>
</tbody>
</table>

AV: Aortoventricular; CI, confidence interval; HR, hazard ratio.
Relationship between chronic AI and annulus dilatation

- 127 pts with chronic AR, 74% TAV, 16% BAV

<table>
<thead>
<tr>
<th></th>
<th>Mild AR (cm/m²) (n = 67)</th>
<th>Moderate AR (cm/m²) (n = 45)</th>
<th>Severe AR (cm/m²) (n = 15)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic anulus</td>
<td>1.29 ± 0.23</td>
<td>1.38 ± 0.23</td>
<td>1.39 ± 0.11</td>
<td>0.055</td>
</tr>
<tr>
<td>Valsalva sinuses</td>
<td>1.89 ± 0.34</td>
<td>2.04 ± 0.31</td>
<td>2.09 ± 0.32</td>
<td>0.025</td>
</tr>
<tr>
<td>Supraaortic ridge</td>
<td>1.49 ± 0.30</td>
<td>1.71 ± 0.35</td>
<td>1.76 ± 0.43</td>
<td>0.001</td>
</tr>
<tr>
<td>Ascending aorta</td>
<td>1.97 ± 0.42</td>
<td>2.16 ± 0.49</td>
<td>2.19 ± 0.47</td>
<td>0.049</td>
</tr>
</tbody>
</table>

- 84 pts BAV with AR


Keane M.G. Circulation. 2000
VAJ dilatation

Normal VAJ

Dilated VAJ
## Annulus size in normal and pathological settings

<table>
<thead>
<tr>
<th></th>
<th>Normal TAV N=32</th>
<th>AI or aneurism TAV N=37</th>
<th>AI or aneurism BAV N=27</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2D echo</strong></td>
<td>22.8 ± 2.4</td>
<td>26.1 ± 4.1&amp;</td>
<td>30 ± 3.9&amp;$</td>
</tr>
<tr>
<td><strong>3D small Ø</strong></td>
<td>21.8 ± 2.5</td>
<td>25.1 ± 4.7&amp;</td>
<td>28.1 ± 3.5&amp;$</td>
</tr>
<tr>
<td><strong>3D long Ø</strong></td>
<td>26.9 ± 2.2</td>
<td>27.6 ± 4.9</td>
<td>30.8 ± 4&amp;$</td>
</tr>
<tr>
<td><strong>Small/long ratio</strong></td>
<td>0.8 ± 0.1</td>
<td>0.9 ± 0.1&amp;</td>
<td>0.9 ± 0.1&amp;</td>
</tr>
</tbody>
</table>

* p < 0.05 vs normal TAV; \& p < 0.001 vs normal TAV; \$ p < 0.001 vs repaired TAV

<table>
<thead>
<tr>
<th></th>
<th>AI or aneurism TAV</th>
<th>AI ≥ 2</th>
<th>AI or aneurism BAV</th>
<th>AI ≥ 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2D echo</strong></td>
<td>23.4 ± 2.5</td>
<td>27.2 ± 3.9*</td>
<td>26.6 ± 2.6*</td>
<td>31.3 ± 3.8$&amp;*</td>
</tr>
<tr>
<td><strong>3D small Ø</strong></td>
<td>22.5 ± 3.4</td>
<td>26.1 ± 4.5*</td>
<td>25.3 ± 2.4</td>
<td>29.2 ± 3.3$&amp;*</td>
</tr>
<tr>
<td><strong>3D long Ø</strong></td>
<td>25.4 ± 3.8</td>
<td>28.3 ± 4.8</td>
<td>27.8 ± 1.7</td>
<td>32.1 ± 4.3$&amp;*</td>
</tr>
<tr>
<td><strong>Small/long ratio</strong></td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.1</td>
</tr>
</tbody>
</table>

* p < 0.05 vs TAV without AR; \$ p < 0.05 vs TAV with significant AR; \& p < 0.05 vs BAV without AR

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C. Watremez, St-Luc, Brussels
# VAJ size in normal and pathological settings

<table>
<thead>
<tr>
<th>Study</th>
<th>AI or Ao aneurism TAV (mm)</th>
<th>AI or Ao aneurism BAV (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navarra E. EJCTS 2013</td>
<td>-</td>
<td>28 mm (2D echo)</td>
</tr>
<tr>
<td>de Kerchove L. EJCTS 2015</td>
<td>25.2 mm (2D echo)</td>
<td>-</td>
</tr>
<tr>
<td>Lansac E. EJCTS 2016</td>
<td>(2/3 TAV, 1/3 BAV) 28.3 mm (Hegar dilator)</td>
<td></td>
</tr>
<tr>
<td>Schäfers H.J. JTCS 2013</td>
<td>27.6 (2D echo) 30.2 (Hegar dilator)</td>
<td>29.7 (2D echo) 31.8 (Hegar dilator)</td>
</tr>
</tbody>
</table>

→ 2D echo measure ≈ Hegar dilator measures +2-3 mm
Evolution of the Remodeling technique

- Partial external band: T. David 1996
- Circumferential external band: E. Lansac 2006
- Suture Annuloplasty: HJ. Schäfers 2013
Evolution of the Reimplantation technique

Reimplantation

David V

Stanford Modification

C. Miller

Valsalva®

Cardioroot®

Uni-Graft® Sinus

R. De Paulis 2002
Deep External Root dissection for VSR or External Ring

TAV

BAV
Brussels AV repair: **Why is VSR so efficient?**

1. Circumferential prosthetic annuloplasty → **Stable over time**

2. Remodel BAV geometry to 180°

3. Optimal Coaptation
Role of VAJ size and annuloplasty in AV repair

- VSR technique

(Hospit. mortality: 0%)

FF AR >1+

VAJ <30mm

p = 0.93

VAJ ≥30mm

FF AR >1+

VAJ <28mm

p = 0.38

VAJ ≥28mm

p = 0.0001

(Hospit. mortality: 0.6%)

Navarra E. EJCTS 2013

De Kerchove L. EJCTS 2015
Role of VAJ size and annuloplasty in AV repair

- SCA versus VSR technique (matched groups)

**BAV**

![Graph showing FF AR >1+ for BAV with SCA and VSR](De Kerchove L. JTCS 2010)

**TAV**

![Graph showing FF AR >1+ for TAV with SCA and VSR](De Kerchove L. EJCTS 2015)
VAJ dilatation occurs in most patients with SCA in TAV repair

De Kerchove L. EJCTS 2015
Brussels AV repair: *Why is VSR so efficient?*

1. Circumferential prosthetic annuloplasty → *Stable over time*

2. Remodel BAV geometry to 180°

3. Optimal Coaptation

"*Assymetric annuloplasty*"
Brussels AV repair: *Why is VSR so efficient?*

1. Circumferential prosthetic annuloplasty  
   - Stable over time

2. Remodel BAV geometry to 180°  
   - Durable configuration

3. Optimal Coaptation

---

![Graph showing commissural orientation](image)

- Commissural orientation < 160°
- Commissural orientation ≥ 160°

*P* < 0.0001

*D. Aicher Circ. 2011*
Brussels’ BAV repair: *Why is VSR so efficient?*

1. Circumferential prosthetic annuloplasty  ➔ *Stable over time*
2. Remodel BAV geometry to 180°  ➔ *Durable configuration*
3. Optimal Coaptation  ➔ *Reduce the need of patch*
Brussels’ BAV repair: **Why is VSR so efficient?**

1. Circumferential prosthetic annuloplasty → **Stable over time**
2. Remodel BAV geometry to 180° → **Durable configuration**
3. Optimal Coaptation → **Reduce the need of patch**

- Tips < annulus, No AR
- Resid. AI, Coapt > 4 mm

- Tips > annulus
- Residual AR
- Coapt < 4 mm
- Tips < annulus

**Pethig K. ATS 2002**
**le Polain JB. JACC Card. Im. 2009**

**Aicher D. Circ. 2011**
Rate of VS Reimplantation over year at St-Luc, Brussels
Fifteen-Year Experience with Valve Sparing — Reimplantation Technique for the Treatment of Aortic Aneurysm and Aortic Regurgitation

Mastrobuoni S. MD MPH, de Kerchove L. MD PhD, Navarra E. MD, Astarci P. MD PhD, Poncelet A. MD PhD, Rubay J. MD, Noirhomme P. MD, El Khoury G. MD

Departement of Cardiothoracic and Vascular Surgery
Cliniques Universitaires St-Luc, IREC, UCL, Brussels, Belgium
Materials and Methods

- Between 1999-2017, 923 patients underwent AV repair at St. Luc’s Hospital;
- 440 patients (47.7%) were treated with VSRR and are the Study Cohort;
- Patients were divided into 3 groups according to the indication for surgery:
  - Root aneurysm without AR (Conventional Indication)
    Group 1 = 139 patients (31.6%)
  - Root aneurysm with significant AR (“debated” indication)
    Group 2 = 212 patients (48.2%)
  - Isolated AR (non-conventional indication)
    Group 3 = 76 patients (17.3%)
  - Further 13 patients (2.7%) presented with acute type-A aortic dissection
Results: Freedom from AV reop by Group

4 in Group Aneurysm (3%)
9 in Group Aneurysm+AR (4.4%)
4 in Group isolated AR (5.9%)

89.6% (95% CI: 82.2-94.0) at 10-year
Results: Freedom from AV reop by valve phenotype

4 in BAV (2.4%)
13 in TAV (5.1%)
Freedom from recurrent severe AR (≥3) by Group

3 in Group Aneurysm (2.4%)
7 in Group Aneurysm + AR (3.6%)
4 in Group isolated AR (5.9%)

91.9% (95% CI: 84.9-95.7) at 10-year
Brussels approach of root repair in regurgitant BAV

- Normal Root (<40 mm)
- VAJ <28 mm
- Subcom. annuloplasty
  - small VAJ/cusp
  - Endocarditis
  - Old patient
  - VAJ 26-27

- Normal Root (<40 mm)
- VAJ ≥28 mm
- External Ring Annuloplasty

- Dilated Root (>40mm)
- Reshape BAV geometry → 180°

- Dilated Root (>40mm)

- VS Reimplantion
Why Reimplantation should be preferred

- Reimplantation techniques:
  - Safe and reproducible, disseminated worldwide
  - Proven long term durability in TAV, BAV, Marfan, dissection and in AI!
  - One sizing, one device (graft)
  - Ability to modify valve geometry (→ 180° symmetric configuration)

- Remodeling alone ok if no CTD, no or few central AI, no annulus dilatation!
VSRR: Whatever the technique you choose, **do a Reimplantation!**
Thank you
Indications for VAJ annuloplasty

Aortic valve repair for AI

Normal Root (<45 mm)
- Normal VAJ (<26 mm)
  - No Annuloplasty
- Large VAJ (>26 mm)
  - Ring annuloplasty

Dilated Root (≥45 mm)
- Large VAJ (>28 mm)
- Root wall disease, +>40 mm
- Modify valve geometry (BAV)
- Exception:
  - Small VAJ/cusp
  - Endocarditis
  - Old patient
  - VAJ 26-28
- Reimplantation
- Remod. + Anpl
- Remodeling
## Demographics

<table>
<thead>
<tr>
<th></th>
<th>Aneurysm n=139</th>
<th>Aneurysm + AR n=212</th>
<th>Isolated AR n=76</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean age ± SD (years)</strong></td>
<td>47±14</td>
<td>51±15</td>
<td>42±13</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Male, n (%)</strong></td>
<td>128 (92.1)</td>
<td>191 (90.1)</td>
<td>70 (92.1)</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Bicuspid AV, n (%)</strong></td>
<td>49 (35.2)</td>
<td>76 (55.9)</td>
<td>52 (68.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Grade of Aortic regurgitation, n (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1</td>
<td>139 (100)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>70 (33.0)</td>
<td>0 (7.9)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>103 (48.6)</td>
<td>58 (76.3)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>39 (18.4)</td>
<td>12 (15.8)</td>
<td></td>
</tr>
<tr>
<td><strong>NYHA Functional Class (%):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>112 (80.6)</td>
<td>105 (93.7)</td>
<td>41 (53.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>II</td>
<td>23 (16.5)</td>
<td>79 (37.3)</td>
<td>30 (39.5)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>3 (2.2)</td>
<td>28 (13.2)</td>
<td>5 (6.6)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>1 (0.7)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>LV Ejection Fraction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;50%</td>
<td>132 (95)</td>
<td>175 (82.5)</td>
<td>69 (90.8)</td>
<td>0.03</td>
</tr>
<tr>
<td>31-49</td>
<td>7 (5)</td>
<td>33 (15.6)</td>
<td>7 (9.2)</td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>0</td>
<td>4 (1.9)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>LVEDD (mm), mean ± SD</strong></td>
<td>53±5</td>
<td>61±8</td>
<td>63±7</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>VAJ (mm), mean ± SD</strong></td>
<td>27 ± 3*</td>
<td>28 ± 4</td>
<td>29 ± 4*</td>
<td>0.007*</td>
</tr>
<tr>
<td>Previous Ross operation, n (%)</td>
<td>3 (2.1)</td>
<td>4 (1.9)</td>
<td>5 (6.6)</td>
<td>0.09</td>
</tr>
<tr>
<td>Connective Tissue Disorder, n (%)</td>
<td>19 (13.7)</td>
<td>14 (6.6)</td>
<td>1 (1.3)</td>
<td>0.004</td>
</tr>
</tbody>
</table>
### Results: intra- and post-op data

<table>
<thead>
<tr>
<th></th>
<th>Aneurysm n=139</th>
<th>Aneurysm + AR n=212</th>
<th>Isolated AR n=76</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Graft size mm, median</strong></td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>CPB Time (min) mean ( \pm SD )</strong></td>
<td>145±35</td>
<td>150±34</td>
<td>151±26</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Concomitant Procedures, n(%):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitral Valve Repair</td>
<td>37 (26.6)</td>
<td>54 (25.5)</td>
<td>13 (17.1)</td>
<td>0.2</td>
</tr>
<tr>
<td>Hemi-arch</td>
<td>5 (5.0)</td>
<td>13 (6.1)</td>
<td>6 (7.9)</td>
<td></td>
</tr>
<tr>
<td>CABG</td>
<td>4 (2.9)</td>
<td>12 (5.6)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 (0.7)</td>
<td>9 (4.2)</td>
<td>4 (5.2)</td>
<td></td>
</tr>
<tr>
<td><strong>Cusp Repair Patch</strong></td>
<td>76 (54.7)</td>
<td>170 (80.2)</td>
<td>74 (97.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>1 (0.7)</td>
<td>15 (7.1)</td>
<td>4 (5.2)</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Re-exploration fro bleeding, n (%)</strong></td>
<td>21 (15.1)</td>
<td>23 (10.9)</td>
<td>8 (10.5)</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Permanent Pacemaker Insertion, n (%)</strong></td>
<td>9 (6.5)</td>
<td>7 (3.3)</td>
<td>5 (6.6)</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>30-days death</strong></td>
<td>1 (0.7)</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Lost to Follow-up, n(%)</strong></td>
<td>4 (2.9)</td>
<td>8 (3.8)</td>
<td>10 (13.1)</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Follow-up years, Median (IQR)</strong></td>
<td>4.7 (2-8.5)</td>
<td>5.5 (2.2-9.7)</td>
<td>3.5 (1.7-5.8)</td>
<td></td>
</tr>
</tbody>
</table>
Results: Long-term survival by Group

34 late deaths (10 cardiac related)

22 in Group Aneurysm (16.5%)

11 in Group Aneurysm + AR (5.8%)

1 in Group isolated AR (1.5%)

Mortality rate: 1.5% patient-year [Bentall: 2.02%]

Alive: 81.3%  (95% CI: 72.9-87.3) at 10-year