Management of Difficult Aortic Root, Old and New solutions

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Conflict of Interest

- None
Difficult aortic root?

- Small aortic annulus leading to insertion of a small prosthesis, i.e. possibility of patient prosthesis mismatch (PPM)
- Calcified annulus and sinuses making insertion of prosthesis difficult
**Patient-prosthesis mismatch**

- Effective orifice area index =  
  Effective orifice area/BSA(Sq.m)

  - 2.0 or above: Normal
  - 0.67 : Severe stenosis

Rahimtoola first described 1978

Pibarot and Dumensnil (1998) defined PPM to be effective orifice area indexed to BSA of 0.85m²/m² or less
High residual trans-valvular gradient may result in:

- Decreased LV mass regression
- ↑ Operative mortality
- ↓ Long term survival
- ↓ Symptomatic benefit
Selection of prosthesis:

Pibart and Dumesnil

*JACC 2000;36:1131-1141*

• BSA $\times$ 0.85 cm$^2$/m$^2$ = EOA required to avoid severe PPM.

• Selection of most suitable type and size of prosthesis according to EOA.

*ICVTS 2009;9:518 – 519*
How are valves measured

Manufacturer’s labelled sizes refers inconsistently to:

- Diameter of external sewing ring: mechanical valves
- Diameter of mounting ring: stented xenografts
- Diameter of internal orifice: stentless xenografts and allografts

*JTCVS 2003;126:313 – 6*
GOA is measured in vitro indicating internal diameter of the valve. EOA is validated in clinical practice and calculated using echocardiography.

Heart 2006;92:1022-1029
Not all similarly labeled valves are the same!!
Comparison of EOAs for commonly implanted prosthetic valves.
Comparison of mean pressure gradients for commonly implanted prosthetic valves.

Gradient
Table 1  Theoretical comparison of mean transvalvar pressure gradient in five hypothetical patients receiving the same prosthetic valve but having different body surface areas

<table>
<thead>
<tr>
<th>Patient number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>Body surface area (m²)</td>
<td>1.5</td>
<td>1.75</td>
<td>2.0</td>
<td>2.25</td>
<td>2.5</td>
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<tr>
<td>Cardiac output (l/min)</td>
<td>4.5</td>
<td>5.25</td>
<td>6.0</td>
<td>6.75</td>
<td>7.5</td>
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<tr>
<td>Valve EOA (cm²)</td>
<td>1.3</td>
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<tr>
<td>Mean pressure gradient (mm Hg)</td>
<td>13</td>
<td>17</td>
<td>22</td>
<td>28</td>
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</tbody>
</table>
Operative options for small aortic root

- AVR with mechanical valve
- AVR with sutureless valve
- Posterior annular enlargement: Nicks’ technique. Manouguian technique.
- Anterior annular enlargement: Rastan-Konno operation.

Root replacement
- Homografts
- Stentless xenografts
- Ross operation alone or Konno-Ross operation.

- Apico-aortic conduit.
Decision to enlarge aortic root

It is usually taken by the surgeon operating and on a feeling that the annular size is smaller than required for that patient depending on:

- Pt age
- Comorbid conditions
- Anatomy of the aortic root
- Surgeon’s judgment
- Surgeon’s comfort level
Posterior annular enlargement

Manouguian technique
Nick’s technique
Posterior Root Enlargement
Subaortic Tunnel-like stenosis
Tunnel-like LVOT
Rastan Konno Procedure
Rastan Konno Procedure
Rastan Konno Procedure
Ross Konno

Combine the Rastan-Konno and a pulmonary Autograft like in the Ross procedure.
Actuarial survival in patients with Prosthesis mismatch

EOA/BSA \leq 0.75\text{cm}^2/\text{m}^2

- Large
- Small

p=0.27

<table>
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<tr>
<th>Years</th>
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2981 patients
227 had EOA/ BSA ratio \leq 0.75 \text{cm}^2/\text{m}^2.

Freedom from valve-related mortality in patients with prosthesis mismatch (EOA/BSA≤0.75 cm²/m²)

EOA/BSA ≤ 0.75cm²/m²

- Large
- Small

p=0.004
84±2%
75±5%

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2981 patients
227 had EOA/ BSA ratio ≤ 0.75 cm²/m².
Actuarial survival in patients with prosthesis mismatch as defined by indexed ID ratio of $\leq 10$ mm/m$^2$

Retrospective study

143 patients with EF < 45% or less

PPM was defined as
Non significant if indexed GOA was ≥ 1.2 cm²/m² or indexed EOA ≥ 0.85 cm²/m²
Risk-adjusted survival stratified by patient-prosthesis mismatch (PPM) definition

Risk adjusted overall survival was the same for patients with PPM and without PPM throughout nine years of follow up.

Enlargement of the Small Aortic Root During Aortic Valve Replacement: Is There a Benefit?

Alexander Kulik, MD, Manal Al-Saigh, MD, Vincent Chan, MD, Roy G. Masters, MD, Pierre Bédard, MD, B-Khanh Lam, MD, MPH, Fraser D. Rubens, MD, Paul J. Hendry, MD, Thierry G. Mesana, MD, PhD, and Marc Ruel, MD, MPH

Division of Cardiac Surgery, University of Ottawa Heart Institute, and Department of Epidemiology, University of Ottawa, Ottawa, Ontario, Canada

- 1989 – 2006
- 712 with small aortic roots
  - 540 AVR with <21 mm prosthesis
  - 172 AVR+ARE (50% had 23mm prosthesis)
- F/U for 5.2 y (3730 pt-years)
Aortic cross clamp was 9.9 min longer in AVR+ARE

No difference in reopening, stroke or mortality

Post op

- Lower gradient
- Larger IOA
- Lower PPM
- No difference in survival

Enlargement of the Small Aortic Root During Aortic Valve Replacement: Is There a Benefit?

Conclusions. For patients with small aortic roots, ARE at the time of AVR is a safe procedure that reduces postoperative gradients and the incidence of prosthesis-patient mismatch. However, ARE does not appreciably improve long-term clinical outcomes.

The homograft aortic valve: a 29-year, 99.3% follow up of 1,022 valve replacements

Surgical techniques:
- Subcoronary (n = 635),
- Intraluminal cylinder (n = 35),
- Full root replacement (n = 352).

30-day/hospital mortality = 3%
(falling to 1.13 +/- 1.0% for the 352 homograft root replacements).

- Actuarial late survival = 91%.
  (at 25 years of the total cohort)

O’Brien MF J Heart Valve Dis. 2000 May; 10(3):334-44;
RESULTS, Morbidity

Freedom from reoperation from all causes at 20 Y:
50% (independent of valve preservation).

Freedom from reoperation for structural deterioration at 15 years:
47% (0-20-year-old patients at operation),
85% (21-40 years),
81% (41-60 years),
94% (>60 years).
(very patient age-dependent)

O’Brien MF J Heart Valve Dis. 2000 May;10(3):334-44;
Advantages of sutureless valve

- Complete excision of the diseased valve.
- Anatomical tailoring to individual patient anatomy.
- Atraumatic introduction with minimal or no crimping of the valve leaflets allowing more predictable long term outcomes.
- Valves are self anchoring (no need for sutures), self expanding for easy implantation and good visibility.
- Shorter CPB.
- Permits minimally invasive cardiac surgery procedures while delivering gold standard surgical outcome.
Sutureless valve

- Sutureless valve available:
  - Perceval S
  - Intuity valve system
Fig 1. Valve design features: button holes. Button holes allow correct axial-rotational positioning in the native aortic root.

(LC = left coronary; NC = noncoronary; RC = right coronary.)
Perceval S - Indications

- Subjects of age $\geq 65$ years;
- Subjects with aortic valve stenosis or steno–insufficiency

AVR patients ideal for a Perceval S:

- Small Aorta
- Small Annuli
- Calcified Aortic root
- Compromised pre–operative contractile function
- Higher–risk patients requiring concomitant procedure (CABG)
- Respiratory disorders (COPD)
- Patients previously implanted with “stentless” prosthesis
Clinical experience on 659 patients

<table>
<thead>
<tr>
<th>Demographic Data</th>
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<tbody>
<tr>
<td>Implant period</td>
<td>April 2007 – September 2011</td>
</tr>
<tr>
<td>Mean age</td>
<td>79 ± 5 yrs (63–92 yrs)</td>
</tr>
<tr>
<td>Gender (Female)</td>
<td>67.7%</td>
</tr>
<tr>
<td>EuroScore (%)</td>
<td>11.27 ± 8.44</td>
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<tr>
<td>STS score (%)</td>
<td>9.60 ± 5.85</td>
</tr>
</tbody>
</table>

Age distribution

- <70: 5.8%
- 70-75: 14.7%
- 75-80: 36.3%
- 80-85: 29.9%
- >85: 13.3%

More than 40% of pts older than 80 years
## Surgical timing

<table>
<thead>
<tr>
<th></th>
<th>Median Sternotomy</th>
<th>Mini-Sternotomy</th>
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<tbody>
<tr>
<td></td>
<td>Isolated AVR</td>
<td>Isolated AVR</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>Complex AVR</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>X-clamp (min)</td>
<td>31.0 ± 11.0</td>
<td>37.7 ± 12.2</td>
</tr>
<tr>
<td>Pump time (min)</td>
<td>51.3 ± 19.8</td>
<td>65.6 ± 21.4</td>
</tr>
</tbody>
</table>
Complications

✓ No thrombosis
✓ No post-operative migrations
✓ No SVD
✓ Early cardiac mortality 1.6% (late 0.6%)
✓ Major stroke 1.9% (late 0.6%)
✓ Major PVL 1.1% (late 0.6%)
INTUITY VALVE SYSTEM

Figure 1. Rapid-deployment aortic valve: EDWARDS INTUITY Valve System, Model 8300A (Edwards Lifesciences LLC, Irvine, Calif).
EDWARDS INTUITY Valve System Components

Aortic Valve

Delivery System

Inflation Device
Sutureless AVR experience
King Abdulaziz Cardiac center

May 2011 to July 2014.
52 patients with severe aortic stenosis underwent aortic valve replacement with suture-less bio-prosthesis.
Average age: 72.6 years.
Male : Female ratio: 60% : 40%.
Mean euro score 11.5
Patient Profile
(Suture-less AVR)

- Concomitant diseases:
  - Coronary artery disease: 26 (50%).
  - Severe mitral regurgitation: 4 (7.7%).
  - Severe tricuspid regurgitation: 3 (5.7%).

- Elevated RV systolic pressure: 39 (75%).
- Severe pulmonary hypertension: 11 (21%).
Aortic valve morphology (Echo) (Suture-less AVR)

- Bicuspid aortic valve: 3/52 (5.7%).
- Peak gradient: 45 – 116 mmHg.
- Mean gradient: 24 – 75 mmHg.
- Mean AV area: 0.7 sq.cm.
- Mean aortic annulus (echo): 21.7 mm
  (Range: 19 – 26 mm).
Type of Prosthesis Used (Suture-less AVR)

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceval</td>
<td>32</td>
</tr>
<tr>
<td>Intuity</td>
<td>10</td>
</tr>
<tr>
<td>3f Enable</td>
<td>2</td>
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n = 52
Bypass & Cross-clamp Times (Suture-less AVR)

n = 52
Operative Results (Suture-less AVR)

- Mortality: 1/52 (1.9%), unrelated to valve.
- Average mean trans-prosthetic gradient: 8.9mmHg.
- Prosthetic regurgitation:
  - No regurgitation: 47 (90.4%).
  - Mild regurgitation: 5 (9.6%).
- Para-prosthetic leak:
  - No leakage: 50 (96%).
  - Mild leakage: 2 (4%).
Follow-up Data
(Suture-less AVR)

- Follow-up period:
  Mean follow-up: 10.2 months.
  (Range: 1 month to 28 months).
- Peak gradient (average): 27mmHg.
- Mean gradient (average): 15mmHg.
- Prosthetic regurgitation: Mild 5 (9.6%).
- Para-prosthetic leak: Mild 5 (9.6%).
Freedom from all-cause mortality. (Suture-less AVR)
Freedom from Re-operation.
(Suture-less AVR)
Effect on LV Dimensions (Suture-less AVR)

- $p = 0.023$
- $p = 0.124$
4 Critical Considerations

1. Patients with high risk of PPM are already high risk for surgery due to small aortic root, elderly females (common), severe CAD, impaired ventricular function. It is difficult to discriminate between patient related and prosthesis related confounding factors.

2. IEOA is functional measurement dependant on the characteristics of prosthesis and left ventricular and aortic outflow tract and cardiac output.

3. Difference between IEOA and indexed GOA of the prosthesis and lack of correlation between transvalvular gradients and GOA.

4. Discrepancy between manufacturer labelled and actual diameter of the prosthesis.

(EHJ 2006:27;644 – 646)
Conclusions

- Small aortic roots still poses a difficult problem to the surgeon
- There is no clear objective data to suggest the exact indication for ARE
- The decision to enlarge the root is dependent on the surgeon evaluation and experience
Conclusions

- **In Infants**
  - Small root with no SAS, Ross procedure
  - Small root with SAS, Ross/Konno

- **In Children**
  - Small root with no SAS, Ross procedure
  - Small root with SAS, Ross/Konno or Konno/Rastan

- **In Adults**
  - Small root, large BSA, Ross / homograft or AVR+ARE/ sutureless
  - Small root, small BSA (<1.5), AVR
Thank you