Prosthesis Selection

*When repair is not feasible*

Harold M. Burkhart, M.D
Disclosure

No personal equity, licensing or consulting agreements with the medical device or pharmaceutical industry to disclose
Risk Factors and Early Outcomes of Multiple Reoperations in Adults With Congenital Heart Disease

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Back ground. Despite increasing numbers of adult congenital heart disease surgery, the number of reoperation(s) persists, and there are few outcome data. Increased time from previous sternotomy to adult congenital heart disease surgery is associated with increased early mortality.

Methods. This study was a retrospective review of adult congenital heart disease surgery between 2006 and 2009. Data were obtained from the Mayo Clinic Perioperative Database. Surgical outcomes were abstracted and reviewed.

Results. Overall early mortality was 3.6%, including 2%, 6%, 7%, and 0% at sternotomy 2 (n = 597), 3 (n = 284), 4 (n = 174), and 5 (n = 167), respectively.

Conclusions. Subsequent sternotomy showed increased early mortality, yet neither sternotomy number nor time from previous sternotomy was predictive of early mortality. Increased early mortality was associated with failure of cardiac repair, monocular vein, and other diagnosis (6%); African-American race (2%); Marfan syndrome (1%); and previous sternotomy.

984 pt reoperations ACHD
85% valve-related
25% multi-valve
Reoperations ACHD, n=984

<table>
<thead>
<tr>
<th>Valve</th>
<th>Repair</th>
<th>Replace</th>
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</thead>
<tbody>
<tr>
<td>Pulmonary</td>
<td>4</td>
<td>423</td>
</tr>
<tr>
<td>Aortic</td>
<td>22</td>
<td>234</td>
</tr>
<tr>
<td>Tricuspid</td>
<td>162</td>
<td>144</td>
</tr>
<tr>
<td>Mitral</td>
<td>71</td>
<td>114</td>
</tr>
</tbody>
</table>

Holst et al., ATS 2011
Multivalve reoperations, ACHD n=235

<table>
<thead>
<tr>
<th>Valve</th>
<th>n</th>
<th>Rep %</th>
<th>Repl %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricuspid</td>
<td>186</td>
<td>72</td>
<td>28</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>160</td>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>Mitral</td>
<td>86</td>
<td>41</td>
<td>59</td>
</tr>
<tr>
<td>Aortic</td>
<td>71</td>
<td>24</td>
<td>76</td>
</tr>
</tbody>
</table>

2 valves in 203 pt (86%)
3-4 valves in 32 pt (14%)

Holst et al., ATS 2013
The ideal prosthetic valve

- Long-term patency
- Availability in range of sizes
- Excellent handling
- Long-term function
- Growth potential
- Low cost
- Low infectious potential
- Nonthrombogenic

Forbess, Ped Sem TCVS 2004
What matters to the surgeon?

- Age
  - Lifestyle
  - Pregnancy contemplated
- Ventricular function, R & L
- Previous number operations
  - More than one prior valve intervention
  - Track record with valves
- Anticoagulation
AVR, congenital diagnoses

- Congenital aortic valve stenosis
- Tetralogy of Fallot, PA
- Truncus arteriosus
- Transposition
- Aneurysmal disease
AVR in children, n=160
Freedom from reoperation

Karamlou et al, Circ 2005
Ross operation: 16-year experience
Ronald C. Elkins, David M. Thompson, Mary M. Lane, C. Craig Elkins and Marvin D. Peyton

- 1986-2002
- 487 pts
- 92% 10 yrs
Ross Survival

Brown et al., ATS 2011
Ross vs General Population

El-Hamamsy et al., Circ 2001
Autograft Survival

Elkins et al., JTCVS 2008
The Ross Procedure Performed for Aortic Insufficiency Is Associated With Increased Autograft Reoperation

William H. Ryan, MD, Syma L. Prince, RN, BSN, Dan Culica, MD, PhD, and Morley A. Herbert, PhD

- 1994-2008
- AI 93 pts
- AS 67 pts

ATS 2011
Autograft Modifications

- Fix STJ and aortic annulus if > 20 mm
- Reduce annulus if 4mm > PA
- Replace AA if >3.5 cm
- Aggressive HTN control post-op

Brown et al., ATS 2011
Prevention of Autograft Dilatation

Slater et al. Semin TCVS 2005
A Critical Reappraisal of the Ross Operation
Renaissance of the Subcoronary Implantation Technique?

Hans H. Sievers, MD; Thorsten Hanke, MD; Ulrich Stierle, MD; Matthias F. Bechtel, MD; Bernhard Graf, MD; Derek R. Robinson, DPhil; Donald N. Ross, MD

1994-2005
347 pts
Majority with AI
Mean f/u 4 yrs
Plea for subcoronary technique

Circulation 2011
Ross vs Homograft

Knott-Craig et al ATS 2000

Abnormal PV
Extensive endocarditis
Aortic bioprosthesis in young adults

Older females
Noncompliant
Dilated annulus

Stentless?
Valve in valve?

Ruel et al, Eur JCTS 2004
Ross vs Mechanical

Cumulative Survival

- Mechanical AVR with optimal anticoagulation therapy
- Ross-procedure

Log rank test: $p=0.29$

Survival at 7 years:
- Mechanical AVR: 97%
- Ross procedure: 95%

Time (years since operation)

# Patients at risk
- M. AVR: 252, 251, 251, 250, 226, 176, 95, 21
- Ross: 236, 206, 177, 147, 114, 95, 74, 50

Older males
Dilated roots

Mokhles et al. Circulation 2011
MVR/LAVV, congenital diagnoses

- Congenital MV anomalies
- Atrioventricular septal defects
- Cleft mitral valve
- MV prolapse
- Rheumatic MV disease
- L-TGA
MVR prosthesis

- Mechanical
  - Smaller sizes
  - Lower profile
  - Lower reoperation rates
Mitral valve replacement

- PCCC 45 centers
- 139 pt ≤5 yrs
- 98% mechanical
- 18% mortality

- AVSD
- Shone
- Valve size/wt

Caldarone et al, Circ 2001
Mechanical MVR children, n=307

- Younger age
- Longer AoCx
- Valve/weight

Alsoufi et al, JCTS 2011
Tissue MVR children, n=87

- Older female
- Issues taking warfarin

Alsoufi et al, Eur JCTS 2009
MVR surgical considerations

• Avoid over sizing
  • Subaortic obstruction
  • AV block
  • Circumflex stretching
  • Pulmonary vein obstruction
  • Tricuspid distortion

• Prosthesis too big
  • Supraannular
  • Close LAA
  • Atrial septal sutures
MVR surgical considerations

- Preserve subvalvar apparatus
  - Anterior leaflet?

- Reoperation on tissue prosthesis
  - Strut in-growth
  - Valve in valve?
MVR, surgical considerations
PVR, congenital diagnoses

- PV stenosis/regurgitation
- Tetralogy of Fallot, PA
- Truncus arteriosus
- Transposition
Choice of Pulmonary Prosthesis

- Homograft
  - Pulmonary, aortic
- Heterograft
  - Stented, stentless
- Bovine jugular-valved vein
- Dacron porcine-valved conduit
- PTFE
  - Mono, bicuspid
- Mechanical
- Percutaneous porcine
Pulmonary Valve Replacement

Mayo Clinic
Jan 1972 - Jan 2006 (n=2,265)

- Bioprosthesis 1,540
- Homograft 697
- Mechanical 28

Bovine jugular vein, PTFE monocusp
Reoperation for Conduit Failure
Effect of Conduit Type (n=1,095)

Survivability (%)

0 100

Years since surgery

0 15

Cryo-preserved homograft
Hancock
Irradiated homograft

P<0.001

Dearani, et al. 2003
Table 4. Results of Surgical Treatment in Patients with RVOT Allograft Implantation: Literature Review

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of Patients</th>
<th>Age</th>
<th>Early Death</th>
<th>Late Death</th>
<th>Follow-up (Mean)</th>
<th>Explant Conduit</th>
<th>Freedom From ACF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bando and colleagues, (Mayo) 1995 [7]</td>
<td>326 (non-Ross)</td>
<td>12.9 yrs (mean)</td>
<td>22 (6%)</td>
<td>24 (7%)</td>
<td>3.2 yrs</td>
<td>32 (11%)</td>
<td>–</td>
</tr>
<tr>
<td>Niwaya and colleagues, (Oklahoma) 1999 [15]</td>
<td>369 (all)</td>
<td>14 yrs (median)</td>
<td>38 (%)</td>
<td>13 (4%)</td>
<td>3.8 yrs</td>
<td>30 (9%)</td>
<td>62% at 8 yrs</td>
</tr>
<tr>
<td>Tweddell and colleagues, (Milwaukee) 2000 [5]</td>
<td>178 (all)</td>
<td>6.9 yrs (mean)</td>
<td>22 (11%)</td>
<td>6 (4%)</td>
<td>3.6 yrs</td>
<td>42 (27%)</td>
<td>53% at 8 yrs</td>
</tr>
<tr>
<td>Tweddell and colleagues, (Milwaukee) 2000 [5]</td>
<td>178 (all)</td>
<td>6.9 yrs (median)</td>
<td>22 (11%)</td>
<td>6 (4%)</td>
<td>3.6 yrs</td>
<td>42 (27%)</td>
<td>54% at 10 yrs</td>
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<tr>
<td>Bielefeld and colleagues, (Denver) 2001 [16]</td>
<td>223 (non-Ross)</td>
<td>2.8 yrs (mean)</td>
<td>31 (14%)</td>
<td>3 (9%)</td>
<td>6.0 yrs</td>
<td>38 (20%)</td>
<td>22% at 10 yrs</td>
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<tr>
<td>Sinzobahamyva and colleagues, (St. Augustin, Germany) 2001 [4]</td>
<td>76 (non-Ross)</td>
<td>46 d (median)</td>
<td>7 (9%)</td>
<td>3 (4%)</td>
<td>54 mo</td>
<td>14 (20%)</td>
<td>65% at 10 yrs</td>
</tr>
<tr>
<td>Gerstein and colleagues, Rotterdam, 2001 [17]</td>
<td>297 (all)</td>
<td>18 yrs (mean)</td>
<td>12 (4%)</td>
<td>15 (5%)</td>
<td>4 yrs</td>
<td>24 (8%)</td>
<td>10% at 10 yrs</td>
</tr>
<tr>
<td>Brown, Indianapolis, 2005 [10]</td>
<td>117 (non-Ross)</td>
<td>7.3 yrs (mean)</td>
<td>16 (14%)</td>
<td>7 (6%)</td>
<td>6.1 yrs</td>
<td>43 (46%)</td>
<td>43% at 15 yrs</td>
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</table>

ACD = allograft conduit dysfunction defined as a peak gradient >40 mm Hg or >2+ regurgitation; ACF = allograft conduit failure defined as a need for cath-lab or surgical reintervention or death.
Homografts in the young

Tweddell et al: Circulation 2000
Pulmonary conduits ≤ 2yrs

Karamlou, CHSS: JTCVS 2006
Freedom from conduit failure

- Pediatric Ross patients (n=70)
- Non-Ross homograft patients (n=117)
- Contegra patients (n=40)

Brown, AATS ACHD 2011
Conduit reoperation
Peel technique
Freedom from Reoperation

![Graph showing freedom from reoperation over years since surgery for two groups: Peel operation and all conduits. The graph indicates the percentage of survival over time, with a clear distinction between the two groups with different sample sizes (n=102 for Peel operation and n=1,095 for all conduits).](ATS_graph.png)
Homograft vs heterograft

- No difference in failure rates in adolescents

Batlivala et al, ATS 2012
Mechanical PVR

Freedom from reoperation (%)

Follow-up (years)

Multiple prior operations
Receiving AC for other reasons
Premature bioprosthetic degeneration

p=0.018

Mechanical PVR

Stulak et al, ATS 2010
Surgical considerations, PVR

• Beating heart
• Exclude shunts
• Aortic root vent
• PAP, run-off
• Stented heterograft
  • Ease of implant
  • Minimal dissection
  • Valve in valve?
• Conduit
  • BJV vs homograft
• Monocusp
TVR/RAVV, congenital diagnoses

- Congenital tricuspid anomalies
- Ebstein anomaly
- Conotruncal anomalies
- Atrioventricular septal defects
TVR Bioprosthesis

Kiziltan et al, ATS 1998
Tricuspid valve

Brown et al, Am J Cardiol 2009
Mechanical TVR

>moderate RV dysfunction

Said et al., In press
Ebstein

Non-Ebstein Congenital TR

Suture line in atrium

Suture line in native TV
TVR, surgical considerations

- Avoid over sizing
  - RCA
  - Conduction
- Struts should straddle membranous septum/conduction tissue
- Beating heart
Multivalve reoperations
Common grouping

<table>
<thead>
<tr>
<th>Valve Configuration</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricuspid, pulmonary</td>
<td>108</td>
<td>46</td>
</tr>
<tr>
<td>Tricuspid, mitral</td>
<td>38</td>
<td>16</td>
</tr>
<tr>
<td>Aortic, pulmonary</td>
<td>22</td>
<td>9</td>
</tr>
<tr>
<td>Aortic, mitral</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>46</td>
<td>20</td>
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</table>
INR, Time In Range

<table>
<thead>
<tr>
<th></th>
<th>Usual Care</th>
<th>Self-Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>33%</td>
<td>6%</td>
</tr>
<tr>
<td>Therapeutic</td>
<td>50%</td>
<td>89%</td>
</tr>
<tr>
<td>High</td>
<td>17%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Lafata JE. J Gen Intern Med 2000
# Risk Factors and Early Outcomes of Multiple Reoperations in Adults With Congenital Heart Disease

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<table>
<thead>
<tr>
<th>Sternotomy #</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5+</th>
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<tbody>
<tr>
<td>N=</td>
<td>630</td>
<td>298</td>
<td>78</td>
<td>34</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Resp failure (%)</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Pacemaker (%)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Stroke (%)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Renal failure (%)</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Sternal infect (%)</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

*Ann Thorac Surg 2011*
Conclusions

The majority of reoperations in ACHD are secondary to valvular heart disease.

There are many valve substitutes with good performance records, must individualize.

Think about future operations and plan accordingly.
Division of
Cardiovascular Surgery