The Ross Procedure: Outcomes at 20 Years

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Conflict of Interest

None
The Ross Procedure

• 1990 to 2004
• 212 patients: ♂ 66% ♀ 34%
• Mean age: 34 years (16 - 63 years)
• Previous heart surgery - 17.5%
  AV surgery - 14.2%
• NYHA functional class:
  I  - 19.3%
  II - 63.7%
  III - 12.3%
  IV - 4.7%
The Ross Procedure

Left ventricular ejection fraction

- \( \geq 60\% \) - 60.0%
- 40-59\% - 31.6%
- 20-39\% - 8.5%

Aortic valve lesion:

- Stenosis - 50.4%
- Insufficiency - 36.3%
- Mixed lesion - 13.2%

Bicuspid aortic valve – 82%
The Ross Procedure

Operative technique:

- Aortic annulus and pulmonary STJ measurements
- Aortic annulus reduced to match PV annulus - 45%
- Sinotubular junction aorta reduced - 28%

Implantation technique:

- Inclusion or sub-coronary - 49.0%
- Root replacement - 51%

Other:

- Replacement of the ascending aorta - 12%
- Mitral valve repair - 2%
The Ross Procedure

Follow-up: annual with echocardiography
Median follow-up: 13.8 years
Completeness: 100% clinical
  96% echocardiographic

Statistical analysis:
  Parametric models for time dependent variables
  Logistic regression models
  Univariable associations among variables
The Ross Procedure: Outcomes

- 1 operative death
- 9 late deaths: 3 cardiac and 6 non-cardiac

\[\text{Late after reoperations on PA}\]
The Ross Procedure: Patients’ Survival

20 years

Ross Patients - 93.6%
General Population - 94.5%
The Ross Procedure: Outcomes

- 1 operative death
- 9 late deaths: 3 cardiac and 6 non-cardiac
- 2 strokes (complete recovery) & 2 TIA
- 4 endocarditis on the pulmonary homograft
  2 reoperations & 2 antibiotics alone
The Ross Procedure: Reoperations

• 25 patients had reinterventions
  15 pulmonary autograft
  8 pulmonary homograft
  3 CABG
  1 ascending aorta replacement
The Ross Procedure: Outcomes

Alive and free from any reoperation

Proportion of patients (%)

Years since Ross surgery

N: 203 198 193 186 158 127 91 61 23

78%

15.7%

6.3%
The Ross Procedure: Reoperations

25 patients had reinterventions

15 pulmonary autograft
8 pulmonary homograft
3 CABG
1 ascending aorta replacement

15 pulmonary autograft
12 for AI – all had AVR
1 for aneurysm – had aortic valve sparing
2 for sub-aortic false aneurysm – both repaired
The Ross Procedure
Freedom From REOP on Pulmonary Autograft

Years since Ross surgery

N: 209 204 199 191 165 96 68 25

5 yr - 97.6%
10 yr - 96.5%
15 yr - 93.0%
20 yr - 81.8%
### Multivariable Analysis:

<table>
<thead>
<tr>
<th>Factor</th>
<th>H.R.</th>
<th>95% C.I.</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilated aortic annulus</td>
<td>1.4/mm</td>
<td>1.2-1.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Preoperative AI</td>
<td>6.3</td>
<td>1.3-29.4</td>
<td>0.02</td>
</tr>
<tr>
<td>Male sex</td>
<td>4.8</td>
<td>1.6-14.4</td>
<td>0.005</td>
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The Ross Procedure
Reoperations on the Pulmonary Autograft

Dilated aortic annulus
\[ \geq 28 \text{ mm} \]
\[ \geq 15 \text{ mm/m}^2 \]
The Ross Procedure

26 patients developed AI greater than mild
The Ross Procedure
Freedom From AI >Mild

- 5 yr - 93.1%
- 10 yr - 90.3%
- 15 yr - 88.7%
- 20 yr - 62.6%
The Ross Procedure
Postoperative AI Greater Than Mild

Multivariable analysis

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</tr>
</thead>
<tbody>
<tr>
<td>Preop AI</td>
<td>2.3</td>
<td>0.9-5.5</td>
<td>0.06</td>
</tr>
<tr>
<td>Dilated aortic annulus</td>
<td>1.04/mm</td>
<td>1.02-5.52</td>
<td>0.02</td>
</tr>
</tbody>
</table>
The Ross Procedure

Postoperative AI Greater Than Mild

Dilated aortic annulus
≥28 mm
≥15 mm/m²
The Ross Procedure: Reoperations

25 patients had reinterventions

15 pulmonary autograft
8 pulmonary homograft
3 CABG
1 ascending aorta replacement

15 pulmonary autograft
12 for AI – all had AVR
1 for aneurysm – had aortic valve sparing
2 for sub-aortic false aneurysm – both repaired
The Ross Procedure
Freedom From Reintervention on the PV Homograft

- 5 yr - 100%
- 10 yr - 97.9%
- 15 yr - 95.5%
- 20 yr - 92.7%
The Ross Procedure
PV Homograft Dysfunction

PV homograft dysfunction:
- PI moderate or severe
- PV gradient >40mmHg

25 patients developed PV dysfunction
The Ross Procedure
Freedom From PV Homograft Dysfunction

- 5 yr: 93.0%
- 10 yr: 84.8%
- 15 yr: 74.6%
- 20 yr: 53.8%

Years since Ross surgery
Freedom from pulmonary homograft failure

N: 192 183 174 153 119 96 63 41 10
The Ross Procedure
Dilation of the Aortic Root

Dilatation $\geq 39 - 49$ mm $\rightarrow$ 31 patients
Dilatation $>49$ mm $\rightarrow$ 4 patients

Operative technique:
Aortic root replacement: $0.149 \pm 0.058$ mm/year
Aortic root inclusion: $0.122 \pm 0.060$ mm/year

$p=0.01$
The Ross Procedure
Dilation of the Aortic Root and Late AI
The Ross Procedure
Freedom From Any Reoperation

[Graph showing the percentage of freedom from first reoperation over time since Ross surgery.]
The Ross Procedure: Conclusions

- Survival after the Ross procedure is similar to the general population matched for age and sex
The Ross Procedure: Conclusions

- Survival after the Ross procedure is similar to the general population matched for age and sex

- Dilated aortic annulus ($\geq 28$ mm or $\geq 15\text{mm}^2$) is associated with increased risk of postoperative AI and reoperation
The Ross Procedure: Conclusions

• Survival after the Ross procedure is similar to the general population matched for age and sex

• Dilated aortic annulus (≥28 mm or ≥15mm²) is associated with increased risk of postoperative AI and reoperation

• Preoperative AI and male sex increased the risk of reoperation
The Ross Procedure: Conclusions

- Survival after the Ross procedure is similar to the general population matched for age and sex.
- Dilated aortic annulus (≥28 mm or ≥15mm²) is associated with increased risk of postoperative AI and reoperation.
- Preoperative AI and male sex increased the risk of reoperation.
- The technique of implantation had no effect on reoperation or on the development of AI but the technique of aortic root replacement was associated with higher risk of dilatation of the aortic root.
The Ross Procedure: Conclusions

- Survival after the Ross procedure is similar to the general population matched for age and sex

- Dilated aortic annulus (≥28 mm or ≥15mm²) is associated with increased risk of postoperative AI and reoperation

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- The technique of implantation had no effect on reoperation or on the development of AI but the technique of aortic root replacement was associated with higher risk of dilatation of the aortic root
Thank you