The Ross Procedure: When and How?

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Conflict of interests:
Royalties from Braun Melsungen for vascular prostheses
(Sinus prosthesis, curved prosthesis)
The problem, the calcified aortic valve in this case a type I L/R bicuspid aortic valve needing replacement
Surgical goal

The surgical goal is to achieve normal conditions.

Therefore the native aortic valve is the blueprint for a perfect aortic valve substitute.

Theoretically these criteria can be met most likely with the autologous pulmonary valve. ➔ Ross principle
The pulmonary autograft is autologous, living and has a similar development, anatomy and histology of the aortic valve giving reason to use the pulmonary valve for aortic valve replacement – The Ross operation

But there are some special issues to be considered:

a) The autograft has no fibrous annulus. → manageable (intra-annular implantation)
b) The pulmonary valve is transplanted from low pressure circulation to systemic pressure. → adaptation seems possible
b) The pulmonary valve is surgically manipulated.
c) The Ross operation necessitates the replacement of the pulmonary valve with a homograft converting a one valve disease to a potential two valve problem. → How big is the risk?
Adaptation of pulmonary leaflets to systemic pressure

Immunophenotype of endothelial cells of normal valves and autograft explants.

\( \text{x: Arterial endothelial cell marker} \)

For the leaflets there seems to be some kind of adaptation.


Proteolytic enzyme expression in pulmonary autografts compared with that seen in normal valves.
Ross Techniques in the Ross Registry (n=1945)

- Subcoronary (n=797)
  - SC

- Root inclusion (n=72)
  - RI

- Root Replacement (n=465)
  - RR

- Reinforced Root Replacement (n=611)
  - RR+R
Results:

Survival benefit of the Ross procedure

Log-rank p=0.002

<table>
<thead>
<tr>
<th>Time since aortic root surgery (years)</th>
<th>Autograft</th>
<th>Homograft</th>
<th>Matched population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>98% (1)</td>
<td>96% (2)</td>
<td>99.8%</td>
</tr>
<tr>
<td>5 years</td>
<td>97% (2)</td>
<td>92% (3)</td>
<td>98.8%</td>
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<tr>
<td>10 years</td>
<td>97% (2)</td>
<td>83% (4)</td>
<td>97.0%</td>
</tr>
<tr>
<td>13 years</td>
<td>95% (3)</td>
<td>78% (5)</td>
<td>95.5%</td>
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</table>

Is the survival advantage bias? (Patient solution or real Ross-related?)

Probability of survival of the Ross patients compared with the general German population; 17 patients with <30 day mortality were excluded.

Autograft + Homograft Reoperation – Adult population
Stratification by technique (n=1779, Registry¹)

Age (years):
- **SC**: 45.1 ± 11.2 (SC)
- **Ross**: 45.7 ± 11.3 (RR-R)
- **RR**: 40.3 ± 12.8 (RR)

LOR: ~ 1% / ptyear

Xenograft

Projections for the Need for a Reoperation

E.g. for a patient at 45 years of age at first operation the probability to be alive with ReOP at 75 years of age is 19%; to be alive without ReOP is 41%.

The probability to be dead without ReOP is 33% and to be dead with ReOP 7%.

(Left) The time course of transvalvular mean and maximum homograft gradients.
(Right) Longitudinal probability of being in each pulmonary regurgitation grade with time.


Longitudinal probability of being in each autograft regurgitation grade with time. AR: aortic regurgitation.

AS: 3.5 mmHg mean dP
Flow velocity through the aortic valve – Normal flow after the Ross-Procedure

Spatiotemporal velocity maps. Representative spatiotemporal velocity maps for 4 groups.

She wrote: „After the Ross operation (previously mechanical valve) my life really began and became perfect with the uncomplicated birth of my daughter.“
Conclusion

The Ross operation up to 24 years

- is a complex operation, however the hospital mortality is relatively low (last 500 cases no death, 2 in all 700)
- is performed in selected patients, preferably with aortic stenosis, <55 years
- provides excellent survival
- provides near normal hemodynamics in the majority of patients (blood pressure control!)
- needs no anticoagulation, has no noise, low thromboembolism (minor and major)
- has a linear risk of reoperation of ~ 1% / ptyear (endocarditis)

Nevertheless the Ross operation does not provide 100% normal results, but what is better especially in young patients?
Long-Term Outcomes of the Ross Procedure Versus Mechanical Aortic Valve Replacement: Propensity-Matched Cohort Study.

Mazine A, David TE, Rao V, Hickey EJ, Christie S, Manlhiot C, Ouzounian M


What Are the Clinical Implications?

• The clinical implication of this study is that young and middle-aged adults requiring AVR may benefit from a Ross procedure.

• The long-term freedom from stroke and major hemorrhage should be considered in discussions of valve replacement options.

• Findings from this study suggest that in specialized centers, the Ross procedure represents an excellent option and should be considered for young and middle-aged adults undergoing AVR.
Future of the Ross operation

• The Ross operation remains a surgical challenge and does not have an easy time in our current cardiovascular world (focus on TAVI, minimal invasive). Nevertheless the Ross operation will survive in experienced centres for special indications and in selected patients. Results can be improved:
  - Standardization and optimization of operative techniques
    (SOP of all experienced centres, what have we learned?)
  - PostOp blood pressure control
  - Awareness and prophylaxis of endocarditis
  - Improving of homograft (tissue engineering, interventional replacement)
  - Training programs (trainee school)

• In the meantime alternatives will improve:
  - New bioprostheses with longer durability and pressure gradient < 10 mmHG (surgery + product)
• Bioprosthesis first and later TAVI
• Novel mechanical prostheses without anticoagulation
• Whatever we do we must direct our decision making to a personalized treatment strategy (patient and surgeon), and
• It is our responsibility to follow all patients carefully and lifelong
- Thank you for your attention -