Aortic Valve Repair: A Modular (Standardized) Approach

H.-J. Schäfers
Dept. of Thoracic and Cardiovascular Surgery
Saarland University Medical Center
Homburg/ Saar, Germany
Limitations:

- Purely echocardiographic, does not directly relate to morphology/pathology

- Does not provide morphologic cut-offs for decision making

- Insensitive in defining cusp prolapse in presence of marked aortic dilatation

- Type III does not differentiate between restriction due to aortic dilatation and restriction due to cusp degeneration/retraction
Aortic Valve Repair Using a Differentiated Surgical Strategy

Frank Langer, MD; Diana Aicher, MD; Anke Kissinger, Olaf Wendler, MD; Henning Lausberg, MD; Roland Fries, MD; Hans-Joachim Schäfers, MD

Background—Reconstruction of the aortic valve for aortic regurgitation (AR) remains challenging, in part because of not only cusp or root pathology but also a combination of both can be responsible for this valve dysfunction. We have systematically tailored the repair to the individual pathology of cusps and root.

Methods—Between October 1995 and August 2003, aortic valve repair was performed in 282 of 493 patients undergoing surgery for AR and concomitant disease. Root dilatation was corrected by subcommissural plication (n=59), supracommissural aortic replacement (n=27), root remodeling (n=175), or valve reimplantation within a graft (n=24). Cusp prolapse was corrected by plication of the free margin (n=157) or triangular resection (n=36), cusp defects were closed with a pericardial patch (n=16). Additional procedures were arch replacement (n=114), coronary artery bypass graft (n=60) or mitral repair (n=24). All patients were followed-up (follow-up 99.6% complete), and cumulative follow-up was 8425 patient-months (mean, 33±27 months).

Results—Eleven patients died in hospital (3.9%). Nine patients underwent reoperation for recurrent AR (3.3%). Actuarial freedom from AR grade ≥II at 5 years was 81% for isolated valve repair, 84% for isolated root replacement, and 94% for combination of both; actuarial freedom from reoperation at 5 years was 93%, 95%, and 98%, respectively. No thromboembolic events occurred, and there was 1 episode of endocarditis 4.5 years postoperatively.

Conclusions—Aortic valve repair is feasible even for complex mechanisms of AR with a systematic and individually tailored approach. Operative mortality is low and mid-term durability is encouraging. The incidence of valve-related morbidity is low compared with valve replacement. (Circulation. 2004;110[suppl II]:II-67–II-73.)
Aortic root dilatation may alter the dimensions of the valve leaflets

Mano J. Thubrikar, Michel R. Labrosse, Kenton J. Zehr, Geoffrey G. Gong, Brett L. Fowler

#Helenman Medical Research Laboratory, Department of Thoracic and Cardiovascular Surgery, Mayo Clinic, Rochester, MN, USA.
#Division of Cardiovascular Surgery, Mayo Clinic, Rochester, MN, USA.

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Abstract

Objective: Valve-sparing surgery can be used in patients with dilated aortic roots and aortic insufficiency. Our goal was to study how the dimensions of the aortic root may change in such patients. Methods: Fourteen patients with dilated aortic root and AI were examined. Results: There was no significant change in the average diameter of the aortic root. The mean diameter of the dilated aortic roots was larger than normal. The leaflet free-edge length, the leaflet height, and the sinus height were found to be altered in the dilated aortic root. Therefore, during valve sparing, it may be necessary to consider altering the leaflet free-edge length to achieve a competent valve.

Keywords: Aortic valve; Aortic root; Leaflets; Dimensions; Aneurysm; Insufficiency
Reduction of STJ and Cusp Prolapse

\[ C_E = \pi \times [\frac{3}{2} \times (a+b) - \sqrt{a \times b}] \]

\[ b \approx r_{\text{aorta}} \]
\[ a \approx r_{\text{cusp}} \]

\[ r_{\text{cusp}} \approx \frac{1}{r_{\text{aorta}}} \]
Standardized Aortic Valve Repair

Assessment

Root pathology

Correction

Valve morphology

Cusp pathology
Root Assessment

Echo:
Maximum sinus diameter ▶ >40 / 45 mm?
ST diameter ▶ >35 (?)
Annular diameter (?)

Intraoperative:
Annular diameter (!) ▶ >25 / 28 mm?
Root dimensions

AV morphology (bi-/tricuspid)

Prolapse

Calcification?
Cusp Assessment

Echo:
Valve morphology?
Eccentricity of jet?

Intraoperative:
Valve Morphology?
Cusp height/configuration?
Cusp substance?
AI und TTE/TEE

Root dimensions

AV morphology (bi-/tricuspid)

Prolapse

Calcification?
AI und TTE/TEE

Root dimensions

AV morphology (bi-/tricuspid)

Prolapse

Calcification?
Bicuspid Aortic Valve (BAV) Morphology

Pattern of fusion

Degree of fusion

Commissural orientation

Aortic Valve Repair - Assessment

Configuration of cusps

Swanson, Circ Res 1974

A new approach to the assessment of aortic cusp geometry
Hans-Joachim Schäfers, MD, PhD, Benjamin Bierbach, MD, and Diana Aicher, MD, Homburg/Saar, Germany
Cusp Configuration

Schäfers HJ et al, JTCVS 2006
eH Measurement Error
Configuration of cusps
Aortic Valve Repair - Assessment Solutions

Configuration/coaptation of cusps

Cusp height in aortic valve

Hans-Joachim Schäfers, MD, Wolfram So

Objectives: Successful aortic valve repair is available on the normal dimensions of the valve.

Methods: The cusp height was measured. A tricuspid anatomy was present in 329 subjects. The height, weight, preoperative degree of aortic regurgitation, and the age of the patient were analyzed for possible interrelation between these variables.

Results: In the bicuspid valves, the geometry of the cusps was measured. Significant correlations were found between the height of the noncoronary and left coronary cusps. The noncoronary cusp height varied from 12 to 25 mm (mean, 20.0 ± 2.1). The noncoronary cusp height was analyzed separately and the mean value was 20.0 ± 2.1. No difference was found between the geometric height and the clinical degree of aortic regurgitation.

Conclusions: We found that the cusp height correlates with the clinical variables. The cusp height was measured in bicuspid and tricuspid valves.

FIGURE 3. Distribution of geometric height in bicuspid (n = 289; nonfused cusps) and tricuspid (n = 332; mean of all 3 cusps) aortic valves.
Aortic Valve Repair - Assessment

Configuration/coaptation of cusps

TAV: 17-22 mm
BAV: 20-25 mm
Root Correction

If

Sinus > 40 -45 mm

Root remodeling
(Valve reimplantation)

Sinus < 40-45

STJ remodeling
Root Repair – Technical Options

ST Junction Remodelling

(Frater 1986)
(Sinus < 40-45 mm)

Root Remodeling

(Yacoub 1993)
(Sinus > 45 mm)

Reimplantation of Aortic Valve

(David 1992)
(AVJ ≥ 30 mm)
Valve Sparing: Our Routine

1. Measure gH and proceed with VPS if gH ≥ 18 mm

2. (Root remodeling) Take graft according to patient size
   - BSA < 1.8 m²  24 mm
   - 1.8 to 2.2 m²  26 mm
   - >2.2 m²  28 mm (?)

   if gH ≤ 20 mm consider graft 1 size less
AORTIC VALVE REPAIR

n=1832

- Reimplantation
- Remodeling
- AV repair
- STJ remodeling ± AVR
**Cusp Correction**

If

prolapse ($eH \leq 8 \text{ mm}$)
structural defect
anatomical variant

Plication of free margin / triangular resection
Patch correction
Conversion of anatomy (BAV, TAV constant)

UAV ➤ BAV
QAV ➤ TAV
Reconstructive Techniques

Cusp Pathology

Prolapse

Plication of Cusp Margin
Reconstructive Techniques

Cusp Pathology

Fibrosis, Calcium, Redundancy

Triangular Resection
Reconstructive Techniques

Cusp Pathology

Fenestration

Stabilisation of cusp (pericardium)
Bicuspidization of the Unicuspid Aortic Valve

Anderson RA, JHVD 2001
# Aortic Valve Anatomy

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Incidence</th>
<th>Mean Age of Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unicuspid</td>
<td>&lt; 1%</td>
<td>20s</td>
</tr>
<tr>
<td>Bicuspid</td>
<td>2%</td>
<td>60s</td>
</tr>
<tr>
<td>Tricuspid</td>
<td>97% (?)</td>
<td>?</td>
</tr>
<tr>
<td>Quadricuspid</td>
<td>&lt; 1 %</td>
<td>40s</td>
</tr>
</tbody>
</table>

Roberts WC, Circulation
Bicuspidization of the Unicuspid Aortic Valve

Schäfers HJ, ATS 2008
Bicuspidization of the Unicuspid Aortic Valve II
Reconstructive Techniques

Cusp Pathology

Anomaly

Conversion of configuration

Schmidt et al., Ann Thorac Surg 2007
Annuloplasty

If

Basal diameter > 26-27 mm

Annular reduction

► 25 mm for BSA > 2 m²
► 23 mm for BSA < 2 m²

Reduce by 2 mm for
gH < 19 (TAV) / 22 (BAV) mm
Repair – Technical Options

Aortoventricular Stabilisation
(AVJ > 27mm)
Freedom from Re-OP (BAV)

- PTFE Annuloplasty
- w/o Annuloplasty

p = 0.019
Standardized Aortic Valve Repair

1. No relevant calcification, geometric cusp height > 17-20 mm

Decision for valve preservation

2. Sinus diameter > 40 -45 mm (and /or BAV < 150° ?)

Root replacement
Reduction of STJ and Cusp Prolapse

\[ C_E = \pi \times \left[ \frac{3}{2} \times (a+b) - \sqrt{a \times b} \right] \]

\[ b \approx r_{aorta} \]

\[ a \approx r_{cusp} \]

\[ r_{cusp} \approx 1 / r_{aorta} \]
Standardized Aortic Valve Repair

3. If root + cusp necessary,

Root repair first (interaction between intercommissural distance and cusp configuration)

4. Annular stabilization (AI, durability)

5. Correction of cusp prolapse (eH)
Conclusions

• Systematic analysis + correction of pathologic components

• Many strategies defined

• Normalize cusp configuration (effective height)!

• Specific valve configurations require tailored approach
Aortic Valve Reconstruction