AV repair vs replacement: advantages and limitations

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Disclosure

Speaker name: Hans-H. Sievers

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I have the following potential conflicts of interest to report:

☐ Consulting
☐ Employment in industry
☐ Stockholder of a healthcare company
☐ Owner of a healthcare company
☒ Other(s)

☐ I do not have any potential conflict of interest
Anatomy of the aortic valve


eine Einheit = Leaflet + Sinus
A: Endoscopic view into the sinus of Valsalva of a pressurized porcine aortic root.

B: Near the annulus strong collagen fibers bear thin hammock-shaped membranes (Insert of A).

C: Smaller collagen fibers are embedded in these membranes (arrows).
Collagenous Cords in the Aortic/Pulmonary Valve

red = collagenous fibres
wavy configuration/ stress absorption

Fastenrath, S. Texture of collagenous fibres of the Aortic/Pulmonary Valve, Thesis 1995 University of Kiel.
A Photomicrograph of a porcine aortic valve leaflet

Scanning electron micrograph of a human aortic valve interstitial cell on collagen fiber showing 3D shape and long cellular extensions

Double-label immunofluorescence micrographs of cultured VICs from ovine heart valve

a Typical micrograph of early contacts of two ovine VICs (green cytoplasmic filament meshwork stained with antibody against vimentin), forming contacts with their opposing processes.

b Battery of AJs, visualized by immunostaining with antibodies to N-cadherin (red, transmembrane glycoprotein), at the end of a cell process and forming an extended AJ-rich area with the middle segment of a long cell process (exceeding 150 µm).

c, d Established batteries of AJs (adhering junctions) (red staining with antibodies against N-cadherin) between adjacent VICs are presented either as a punctate series (c) or as a group of AJ-positive cell-cell bridges (d). Bars 100 µm (a), 25 µm (b-d).

Aortic Valve Function
ventricular – atrial – valvular coupling

Continuous plot of leaflet motion, sinus height, commissure radius, and a base radius vs. time. Each data point on first two curves was obtained from a single video field.


All structures are distensible and functionally connected.
Conclusion

Nature is the optimal solution for the aortic valve to warrant lifelong function.

⇒ This is a call for REPAIR whenever possible.
Patients outcome after aortic valve replacement with a mechanical or biological prosthesis: Weighing lifetime anticoagulation-related event risk against reoperations risk

Life expectancy in men of different ages in British Columbia (BC), Canada, the United Kingdom (UK), and the United States (US) versus life expectancy after AVR in British Columbia and the United States. LE, Life expectancy; MP, mechanical prosthesis; BP, biological prosthesis

Lifetime risks of reoperation and bleeding after AVR with mechanical and bioprostheses.
BP, Bioprosthesis; MP, mechanical prosthesis

Advantages and limitations of repair compared to replacement

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Repair

Complex operation

Topics of repair
- Understanding anatomy and function
- Decide which technique
- Surgical technique itself
- Material
- Assessment of leaflet quality

Aims
- Normal leaflet mobility
- Adequate coaptation area
- Stable annulus + STJ
Optimal valve (Thubrikar)

\[
H \text{ Man: } 12 - 14 \text{ mm}
\]
\[
Rc \text{ Man } \sim 10 \text{ mm}
\]

\[
Rc^2 + \left( \frac{H}{2} \right)^2 = x^2
\]
\[
Rc = R = 10
\]
\[
H \sim 6,5 R \approx 6,5 \times 10 = 65 \text{ mm}
\]
\[
R^2 + (0,65R)^2 = x^2
\]
\[
1,43R^2 = x^2
\]
\[
x = 1,2 R
\]
\[d. h. \ x \text{ ist ca. } 20\% \text{ länger als } R\]

\[
x \approx \frac{1}{2} TL \text{ (Taschenlänge)}
\]
\[
2x = 1TL = 2 \times 1,2R
\]

**TL \sim 2,4R = 1,2D**

gemessen mit 2,4 – 2,6 R

Swanson et al.
Sands et al.
Silver et al.
Understanding anatomy and function

Annahme: BAV Anatomie = TAV Anatomie

\[ TL = 2,4R = 1,2D \]

Diastole:  
Klappe suffizient

Systole:  
+ ca. 10% STJ-Expansion  
d.h.: \( B = \frac{1,1D \pi}{2} = 1,73D \)  
\( TL = 2,4R = 1,2D \)  
\( B = 1,73D; TL = 1,2D \) ➔

Wenn die bicuspid Klappe nicht stenotisch sein soll und eine Distensibility von 10% vorliegt, muss TL~1,7D sein, d.h. die Koaptationsfläche liegt eher in Annulusnähe wenn der freie Rand symmetrisch ohne Faltenbildung gestaltet wird.

D.h. bikuspid ist immer stenotisch, um so mehr je höher der freie ungefaltete Taschenrand in der STJ-Ebene zu liegen kommt.

sehr kleine Koaptationsfläche  
prä-Prolaps Zustand  
extrem empfindlich auf Annulusdilatation (wichtig: Annulus-reduktion + Stabilisierung)
Techniques of repair depending on the primary lesion

- Leaflets only
- STJ ± leaflet
- Sinus ± leaflet → Remodeling (Yacoub) Diameter < 28 mm
- Sinus + annulus ± leaflet → Reimplantation (David) Diameter > 28 mm
Two valve sparing root replacement techniques

Remodeling (Yacoub)  Reimplantation (David)
Yacoub more physiological than David

Material

- Straight tube
- Sinus prosthesis
Is a Sinus in the prosthesis necessary?
Role of Sinuses of Valsalva

• Proper and timely valve opening and closure \(^{[1-2]}\)
• Stabilize leaflets in open position\(^{[3]}\)
• Minimize leaflet stress\(^{[4]}\)
• Minimize transvalvular pressure gradients\(^{[5]}\)
• Promote coronary flow\(^{[6]}\)


Uni-Graft® W SINUS,
Braun Melsungen, Germany
Normal Sinus vortices with Uni-Graft® W SINUS prosthesis

**FIGURE 3.** Sinus vortices. *Top row:* particle paths at peak systole delineate hemodynamics in the thoracic aorta of 60-year-old patient with SP (A), of a healthy 53-year-old VOL-A (B), and a 30-year-old VOL-Y (C). *Bottom row:* sinus vortices in the right and left coronary sinus as visualized by instantaneous streamlines. Sinus vortices develop behind the opened valve cusp in each coronary sinus during systole and persist until early diastole. Vortices in patients had a similar configuration than those in volunteers. *Dashed lines* are used to emphasize sinus borders and *dotted lines* to underline vortex direction. *SP,* Sinus prosthesis; *VOL-A,* age-matched volunteers; *VOL-Y,* young volunteers; *Vmax,* peak velocity.

Sinus reduces bending deformation stress on leaflets

Less bending deformation of the leaflets in the Sinus prosthesis compared to a straight tube.
Crucial issue:
Assessment of leaflet quality

• Echo
• MRI
• **Mainly eyeballing during operation (Decision of the surgeon)**
Repair

Normal looking leaflets, Tricuspid valve
Type 1 L/R BAV

Repair

Post endocarditis hole

Repair
Type 2/unicuspid BAV

? 
→ rather replace

Figure 5. Intraoperative picture of a bicuspid aortic valve type 2, L/R-R/N, S (see text and Table 1 for explanation) with two raphes (arrows) but developmental anlagen of three cusps with a high degree of stenosis.

Type 1 BAV
Replacement
Ross
Fenestration?
Thinned leaflets?
Techniques

Central plication
Replacement of raphe with pericardium
Techniques

Intraoperative photographs showing basal cusp enlargement with pericardial patch in patients operated on using single patch technique (A through C) and reimplantation technique (D).

Basic leaflet elongation

A, Incision at base of cusp; B, pericardial patch sewn into cusp; C, aortic valve view after completion of cusp enlargement; D, cusp enlargement before reimplantation of valve into tube.

Techniques

Tricuspidalization of BAV

Figure 1. A, Bicuspid aortic valve type I with restrictive raphe between the right and the left coronary cusps (left) and tricuspidization of the bicuspid aortic valve with the single-patch commissural reconstruction technique (right). A bovine pericardial patch is used to create a new commissure at the place of the raphe.

Techniques

5/0 Gore suture for prolapse correction

FIGURE 2. A, Intraoperative photograph of a repaired noncoronary aortic cusp with polytetrafluoroethylene (Gore-Tex) suture 12.7 years after reimplantation of the aortic valve. The polytetrafluoroethylene (Gore-Tex) is invisible. The left cusp is prolapsing. B, The left cusp is repaired with a double layer of 6-0 polytetrafluoroethylene (Gore-Tex) suture.

Bicuspid aortic valve repair by complete conversion from "raphe'd" (type 1) to "symmetric" (type 0) morphology.

A, The appearance of the pathologic “raphe'd” (type 1) bicuspid aortic valve. B, The repaired valve with its complete conversion to a symmetric (type 0) bicuspid aortic valve.

Techniques

Sinus prosthesis in place
Techniques

Yacoub operation

Left panel: Intraoperative situs after excision of sinuses in root aneurysm with insufficiency. Right panel: Replacement of sinuses (S) with prosthetic material prior to implantation of coronary buttons (CB)
Failures

Aortic valve repair
Failures

9 years later after David - bicuspid valve
Results

Survival (Lübeck)

All patients more than 10 years after the operation.

$p>0.05$ (David vs. Yacoub) but $p<0.05$ for David vs. normal

Numbers at risk

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<th>Yacoub</th>
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Results

Freedom from reoperation (Lübeck)

All patients more than 10 years after the operation.

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Results

Actuarial survival freedom from AI > grade 2 (a) and freedom from AV reoperation (b) in the study population n=298

Total repair n= 488

Freedom from ReOP by AoV Leaflet Score

score=Number of interventions on leaflets

Patients at risk

Time since operation (years)

No leaflet Intervention
Score=1
Score=2-4
Score=5-6

Freedom from prosthetic aortic valve replacement

Multicenter study
N = 1015

Very Long-Term Outcomes of the Carpentier-Edwards Perimount Valve in Aortic Position


Combined AG HG Reoperations – Adult population
Stratification by technique

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Risk factors for reoperation
Freedom from recurrent AI (≥3+) or reoperation in patients who underwent cusp repair by pericardial patch use

Pericardial patch

Ram E et al. EACTS Daily News, 2016:Issue 2, Sunday 2 October: page 44
Actuarial freedom from reoperation after aortic valve repair in patients with a BAV depending on postoperative achieved eH

Coaptation height

$P=0.003$


Klinik für Herz- und thorakale Gefäßchirurgie, Lübeck
VSSR vs. Simple BAV repair (SCA) with dilated annulus (>27 mm): SCA Fails in short term N=83

For larger diameters > 27 mm no subcommissural annuloplasty!
Advantages and limitations of repair compared to replacement

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Conclusion I

Special issues of Aortic valve repair:

- Technique is still in the developing process
- Leaflet tissue of good quality
- Consider risk factors for reoperation
- Gain adequate coaptation area (~6mm)
- Stabilize annulus and STJ if dilated
- Experienced centers
- Don’t overstress the method (It is different from MV repair!)
- Surgeons variability of surgical techniques, no standardization, generalizability?
- Longer than 10 years follow-up are rare and most important
Conclusion II

Aortic valve replacement
- Ross in experienced centers, excellent results
- Bioprosthetic
  - As large as possible (every millimeter counts, every effort is a must!)
  - Must have the potential for alter ViV
- Mechanical Valve
  - Optimal anticoagulation should be warranted (self-management)

Patients must be informed, repair should not be overstressed (negative for patient and method, alternatives also have their advantages), longer-term follow-up, standardization, experienced centers for repair and Ross, need for longer term follow-up and elastic prosthetic material
After David-OP