Aortic Valve repair
the journey

Gebrine El Khoury
Department of Cardiovascular and Thoracic Surgery
St. Luc Hospital - Brussels, Belgium
Compare the journey of two valves, neighbors within the heart.

Courtesy of Dr. Muresian.
3 levels of «work» to repair the mitral valve:

- **papillary muscle and chordae,**
- **leaflet tissue**
- **and valve annulus**
  
  *(functional unit)*

while the aortic valve has been looked to as only leaflets

*Functional unit?*
Carpentier's classification of mitral valve dysfunction

<table>
<thead>
<tr>
<th>Dysfunction</th>
<th>Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I: normal motion</td>
<td>• Annular dilatation</td>
</tr>
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</tr>
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<td></td>
<td>• Valve thickening and/or calcification</td>
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</table>
Lesion based approach to valve repair

Etiology
Lesions
Repair strategy

One lesion, one technique
And ...the journey starts
Despite of normal leaflets, root aneurysms (FAA Dilatation) may induce aortic regurgitation, and the restoration or recreation of normal root (FAA) corrects the regurgitation.

Concept:

TREAT THE LESION, CORRECT THE DYSFUNCTION
Reimplantation Technique
Post-repair TEE
The journey continues ... with
Leaflet prolapse: excess length of free margin, shortening (plication) correct prolapse and AR
Aortic valve repair
the basics

-Second « basic »:

Leaflet prolapse: excess length of free margin

shortening (plication) of the free margin correct prolapse and AR

Lesion Dysfunction (Excess length) (AR)
The journey continues ... with
Aortic valve repair
the basics

- third « basic »

Close relationship between FAA and leaflet coaptation and

**MOTION**

*Leaflet motion is extremely important*
The journey continues ... with
Aortic valve repair
the basics

• 4th« basic »

-close relationship between FAA and AR

Like mitral annular dilation associated to any chronic MR
Aortic valve repair

- 5th basic: third disease in BAV
- Leafet/ root
  - VAJ dilation
Aortic valve repair
the basics

-role of the functional aortic annulus: FAA dilation

-role of the free margin of the leaflets: FM elongation
The *functional* aortic valve unit

1. Cusp
2. STJ
3. VAJ

«three» levels of work
Fundamental Characteristics of Functional Unit

- Relationship between: Free Margin Length (FML) = Motion Insertion Length (IL)

→ Optimal for tricuspid > bicuspid > unicuspid

- New Free Margin = shorter than Both Individual leaflet margins

- The annuloplasty should have an “selective “effect on the anterior part !!! The posterior, fibrosis easily moldable!!!
**Fundamental Characteristics of Functional Unit**

*Coaptation:* mid-sinus height, into aortic root

Leaflet motion

Reserve of coaptation:
- bigger the reserve,
- more the dilatation needed to induce AR

Coaptation should usually be at the level of the free margin, instead of the body of the leaflet without free margin contact

→ OVERSHOR TENING !!!
The functional aortic valve unit

1. Cusp
2. STJ
3. VAJ

«three» levels of work
### From Mitral to Aortic Valve Dysfunction

#### Lesions

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<td></td>
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<tr>
<td>Type II: excess leaflet motion</td>
<td>• Cuspal prolapse (spontaneous or surgical)</td>
</tr>
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<td>• Commisural disruption</td>
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<td>Type III: restricted leaflet motion</td>
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Understanding Valve Dysfunction

Classification of Dysfunctions

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<td>Normal cusp motion with FAA dilatation or cusp perforation</td>
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<td>Cusp Restriction</td>
</tr>
<tr>
<td>la</td>
<td>lb</td>
<td>lc</td>
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**Mechanism**

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<tr>
<th>Mechanism</th>
<th>Repair Techniques (Primary)</th>
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<tr>
<td>STJ</td>
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<td>SCA Annuloplasty</td>
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<td>Aortic Valve sparing: Reimplantation or Remodeling with SCA</td>
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<td>Prolapse Repair</td>
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<td>Autologous or bovine pericardium</td>
<td>Triangular resection</td>
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<tr>
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<td>STJ Annuloplasty</td>
<td>Free margin Resuspension Patch</td>
</tr>
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<td></td>
<td>SCA</td>
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STJ – Sino-tubular Junction; SCA – Sub-Commissural Annuloplasty

Dysfunction etiology lesion repair

*JTCVS 2009;137:286-94*
Lesion based approach to valve repair

Etiology

Lesions

Repair strategy

dysfunction

One lesion, one technique
Pathologies amenable to AV repair

1. Congenital/etioloogy

- Moncuspid
- Bicuspid
- Quadricuspid
- Connective tissue disorders
  (Marfan, Loeys-Dietz, Ehler-Danlos, Familial Aneurysmal disease, ...)
- Supra-aortic stenosis
Pathologies amenable to AV repair

1. Acquired/etiology

- Degenerative cusp
- Degenerative aortic aneurysm (Atherosclerosis)
- Traumatic
- Infectious
- Acute aortic dissection
Pathologies amenable to AV repair

3. Redo/etiology

- Ross repair
- Re-repair
# Understanding Valve Dysfunction

## Classification of Dysfunctions

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### Mechanism
- STJ – Sino-tubular Junction; SCA – Sub-Commissural Annuloplasty

### Repair Techniques
- **(Primary)**
  - STJ remodeling
    - Ascending aortic graft
  - Aortic Valve sparing: Reimplantation or Remodeling with SCA
  - Patch Repair
    - Autologous or bovine pericardium
  - Prolapse Repair
    - Plication
    - Triangular resection
    - Free margin Resuspension Patch
  - Leaflet Repair
    - Shaving
    - Decalcification Patch

- **(Secondary)**
  - SCA
  - STJ Annuloplasty
  - SCA
  - SCA
  - SCA

*Dysfunction → etiology → lesion → repair*
Functional classification of aortic regurgitation

Lesions AV dysfunction

Type 1 AR: FAA dilatation

- Type 1a
  (STJ)

- Type 1b
  (STJ+VAJ)

- Type 1c
  (VAJ)
Type I caratteristiques

Type I:
- central jet ≺ LVOT PLAN
- level coaptation all cusps same level
- lack of central coaptation
Type II characteristics

Type II:
- Eccentric jet
- Prolapse
- Lack of coaptation/bend

Lvot PLAN
Fundamental Principles of Valve Repair

- Preserve or restore normal motion
- Create a large surface of coaptation
- Remodel and stabilize the annulus

Leaflets

Close functional relationship (functional unit)
Cusp Repair

- Free-Margin Plication
- Triangular Resection
- Free-Margin Resuspension
- Patch Repair
- Cusp Augmentation
- Commissure Resuspension
Proximal Component = Aorto-Ventricular Junction
- Subcommissural annuloplasty, ring annuloplasty
- Prosthesis-based annuloplasty (Reimplantation)

Distal Component = Sino-Tubular Junction
- Plication native STJ
- Prosthesis-based stabilization, reimplantation, remodeling,
Proximal component annuloplasty

Subcommissural annuloplasty with teflon or pericardium - reinforced sutures
Proximal component annuloplasty

Prosthesis-based annuloplasty using Tirone David's reimplantation technique
Distal component annuloplasty

Sino-tubular junction plication
Distal component annuloplasty

Sino-tubular junction restoration using a tubular prosthesis
Distal component annuloplasty

Prosthesis-based STJ restoration using the reimplantation technique

Gebrine El Khoury - The Functional Approach of the Aortic Valve Repair: From Mitral to the Aortic
Repair Techniques

Normal cusp, FAA dilatation, (cusp perforation)

Type 1

1a

STJ remodeling
(Dacron graft on ascending aorta)
+ Subcom annplsty

1b

AV sparing:
• Reimplant.
  or
• Remodeling
  (+subcom annplsty)

1c

Subcom. annplsty
(+ STJ Annplsty)

1d

• Patch Repair

Type 2

Prolapse

Type 3

Restriction

• Plication
• Triangular resection
• Resusp. (running suture)
• Patch
+ Subcom annplsty

• Shaving
• Decalcif.
• Patch
+ Subcom annplsty
Type Ia repair: Sino-tubular junction remodeling

Sino-tubular junction dilatation

Aortotomy

Sizing

Prosthesis implantation

Final result
Type Ib repair: Aortic root remodeling

- Aortic root remodeling
- Aortic root aneurysm
- Aortotomy
- Root dissection
- Prosthesis implantation
- Final result
Type Ib repair: Aortic root reimplantation

Aortic root aneurysm

Aortotomy

Root dissection

Prosthesis implantation

Prosthesis implantation

Final result
Type II repair

Cuspal prolapse

Triangular ressection
Plication
Free edge reinforcement
Free edge reinforcement

Gebrine El Khoury - The Functional Approach of the Aortic Valve Repair: From Mitral to the Aortic
Type Ia + II repair

Sino-tubular junction dilatation

Valve analysis

Subcommissural annuloplasty

Prosthesis implantation
Type Ib + II repair

Aortic root aneurysm

Evaluation

Resection of the aortic root

Reimplantation

Cusp repair
Reimplantation Technique
Post-repair TEE
AV repair for AI: Actual requirement
Optimal coaptation + Stabilisation

- Effective height (eH) ≥ 9 mm
- Coaptation length ≥ 4 mm
- Circumferential annuloplasty
  VAJ >26 mm
- No residual AR

Pethig K. ATS 2002
le Polain de Waroux JB. JACC Card. Im. 2009
Bierbach BO. EJCTS 2010
Aicher D. Circ. 2011
De Kerchove L. JTCVS 2011
Materials and Methods

• All adult patients who underwent the VSRR-reimplantation (El Khoury – David operation) at St. Luc’s Hospital (Brussels, Belgium) between 1999-2014
• Clinical Follow-up by means of phone calls and physicians’ reports
• Outcomes of interest: early and late death, valve reoperation, systemic thromboembolic and major bleeding events, infective endocarditis
• Morbidity and Mortality reported according to the 2008 STS/AATS/EACTS guidelines
• Survival was estimated with the product-limit method (Kaplan-Meier)
• Proportional Hazard model (Cox regression) to identify significant predictors of outcomes of interest
Results

- 60-day mortality: 0.3% (n=1, sudden death)
- 6 patients (2.2%) lost to follow-up after discharge from Hospital
- 268 patients available for long-term analysis
- Median duration of FU: 4 years (IQR: 2-7)
  - Cumulative FU of 1228 patient-years
- Completeness of FU: 88%
Valve repair and durability

Determinants of durability:

• Quality & quantity of tissue, patient selection

• Appropriate surgical technique
  - Excellent immediate result of repair
    ✓ Leaflet coaptation, motion
    ✓ FAA stabilisation

Long term durability
Valve repair and durability

Determinants of durability:

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  - Excellent immediate result of repair
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    ✔ FAA stabilisation
  Long term durability
Valve repair and durability

**Determinants of durability:**

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  - Excellent immediate result of repair
    - ✔ Leaflet coaptation, motion
    - ✔ FAA stabilisation
  - Long term durability
AV repair for AI: Predictor of recurrent AI
Coaptation length and height

Tips > annulus, No AR
Residual AR, Coapt >4 mm

Tips > annulus
Residual AR
Coapt < 4 mm

Tips < annulus

le Polain JB. JACC Card. Im. 2009
AV repair for AI: Predictor of recurrent AI
Coaptation length and height

Aicher D. Circ. 2011
Valve repair and durability

Determinants of durability:

• Quality & quantity of tissue, patient selection

• Appropriate surgical technique
  - Excellent immediate result of repair
    ✓ Leaflet coaptation, motion
    ✓ FAA stabilisation

Long term durability
AV repair for AI: Predictor of recurrent AI
Large ventriculo-aortic junction

No circumferential annuloplasty

BAV repair

Remodeling

\[ P = 0.009 \]

Aicher D. Circ. 2011

T. Kunihara JTCVS 2012
AV repair for Al: Predictor of recurrent Al
Large ventriculo-aortic junction

Circumferential annuloplasty in VS Reimplantion

De Kerchove L. EJCTS 2015
AV repair for AI: Predictor of recurrent AI
Large ventriculo-aortic junction

Matched comparison VSR vs SCA

Freedom from AR>1+

<table>
<thead>
<tr>
<th>Months</th>
<th>SCA</th>
<th>VSR</th>
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<tr>
<td>0</td>
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<tr>
<td>60</td>
<td>0</td>
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p=0.0006

No. at risk

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<th>Group</th>
<th>Months</th>
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<th>12</th>
<th>24</th>
<th>36</th>
<th>48</th>
<th>60</th>
<th>72</th>
<th>84</th>
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<td>Group 1</td>
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<td>Group 2</td>
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<td>14</td>
<td>10</td>
<td>6</td>
<td>2</td>
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</tr>
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</table>

De Kerchove L. JTCVS 2011
Lessons From Failures

Can we predict the recurrence of AR by immediate post-operative valve analysis?
Immediate post-operative measurements

- Annulus
- Sinuses
- ST junction
- Tubular aorta
- Height of the sinuses
- Coaptation length
- Symmetry of the coaptation
- Tips to annulus
- Cusp’s belly to annulus
- Eccentric Jet
- Vena contracta width

Le Polain de Waroux et al., J Am Coll Cardiol Imag 2009 in press
## Multivariate analysis

<table>
<thead>
<tr>
<th></th>
<th>HR</th>
<th>Cox P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coaptation length &gt; 4mm</td>
<td>0.82</td>
<td>0.05</td>
</tr>
<tr>
<td>Coaptation below the annulus</td>
<td>7.9</td>
<td>0.003</td>
</tr>
<tr>
<td>Annular size</td>
<td>1.18</td>
<td>0.012</td>
</tr>
<tr>
<td>Residual AR</td>
<td>5.3</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Le Polain de Waroux et al., *J Am Coll Cardiol Imag* 2009 in press
Coaptation below the annulus
Coaptation length < 4 mm
Eccentric AR jet

Coaptation above the annulus
Coaptation length > 4 mm
No AR
Lessons From Failures

- Restoration of valve geometry is critical
  - Length and height of coaptation
Lessons From Failures

• Quality of valve tissue determines outcome
  – Rheumatic disease, calcification
Lessons From Failures

• Annuloplasty is a necessary component of repair
  – Functional aortic annuloplasty
conclusions

• Valve repair is not only sparing
• Sparing is like mitral ring
• Valve repair is sparing(ring) plus leaflet repair
• AR induces FAA dilation? »ring » necessary
• Sparing (ring) may distort distort valve ?prolaps
Journey of Mitral Valve Repair

- **Carpentier Classification**

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Journey of Mitral Valve Repair

- Annuloplasty
Journey of Mitral Valve Repair

• Leaflet Repair
Journey of Mitral Valve Repair

- Dissemination of Techniques
Journey of Mitral Valve Repair

• Guidelines: Class 1A Indication
Journey of Aortic Valve Repair

• Annuloplasty

Remodelling

Reimplantation
Journey of Aortic Valve Repair

• Classification of Aortic Insufficiency
Journey of Aortic Valve Repair

• Classification of Aortic Insufficiency
Journey of Aortic Valve Repair

• Leaflet Repair

Triangular resection  Plication  Free edge reinforcement
Journey of Aortic Valve Repair

• Dissemination of Techniques
Journey of Aortic Valve Repair

- Guidelines
Take Home Messages

• Complete understanding of the mechanisms is paramount to a sustainable AV repair
• A variety of techniques are available to address cusp pathology and need to be tailored to the native cusp morphology and disease
• Valve repair involves correction of the cusp pathology and stabilization of the functional aortic annulus
  – Re-implantation / Ring
• Repair of cusp pathology provides stable long term results in both tricuspid and bicuspid aortic valves