The Effect of Ventriculo-Aortic Junction Dilatation on Aortic Insufficiency

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No disclosures
# Aortic Valve Repair

## Type I

<table>
<thead>
<tr>
<th>Class</th>
<th>Mechanism</th>
<th>Repair Techniques (Primary)</th>
<th>Repair Techniques (Secondary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>Normal cusp motion with FAA dilatation or cuspllet perforation</td>
<td>STJ remodeling Ascending aortic graft</td>
<td>SCA</td>
</tr>
<tr>
<td>Ib</td>
<td>Aortic Valve sparing: Reimplantation or Remodeling with SCA</td>
<td>Aortic Valve sparing: Reimplantation or Remodeling with SCA</td>
<td>SCA</td>
</tr>
<tr>
<td>Ic</td>
<td></td>
<td></td>
<td>STJ Annuloplasty</td>
</tr>
</tbody>
</table>

## Type II

<table>
<thead>
<tr>
<th>Class</th>
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<th>Repair Techniques (Primary)</th>
<th>Repair Techniques (Secondary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Id</td>
<td>Cusp Prolapse</td>
<td>Patch Repair Autologous or bovine pericardium</td>
<td>Leaflet Repair Shaving Decalcification Patch</td>
</tr>
</tbody>
</table>

## Type III

<table>
<thead>
<tr>
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<th>Mechanism</th>
<th>Repair Techniques (Primary)</th>
<th>Repair Techniques (Secondary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Id</td>
<td>Cusp Restriction</td>
<td>Prolapse Repair Plication Triangular resection Free margin Resuspension Patch</td>
<td>Leaflet Repair Shaving Decalcification Patch</td>
</tr>
</tbody>
</table>

(Boodhwani et al., 2009)
FIGURE 2. Harvested aortic root with incorporated diamond-shaped patches.
Objectives:

• Evaluate the effect of VAJ dilatation:
  1. AI
  2. Leaflet coaptation and dynamics
  3. Leaflet stresses
How to accomplish this model?

1. Baseline

2. VAJ Dilatation

3. VAJ + STJ Dilatation
Measurements of Valve and Ventricular Dynamics:

- Left Heart Simulator:
  - Regurgitant fraction
  - Left ventricular work
  - Regurgitant orifice area
  - Geometric orifice area
  - Valve opening velocity
  - Valve closing velocities
Measuring aortic valve coaptation surface area using three-dimensional transesophageal echocardiography
Finite Element Modeling (FEM):

- Computer based algorithm to generate total von Mises stresses after graded VAJ dilatation followed by VAJ and STJ dilatation

- Statistical analysis was performed using STATA v12. Significance was set at $P < 0.05$. 

Stress Patterns

Leaflet Motion
Results

![Graph showing results for VAJ and STJ dimensions.](image)

- STJ Dimension (mm):
  - Control
  - VAJ+
  - VAJ + STJ

- VAJ Dimension (mm):
  - Control
  - VAJ+
  - VAJ + STJ

* Indicates statistical significance.
Results

- LV Work (l)
  - Control
  - VAJ+
  - VAJ + STJ

- Regurgitant Fraction (%)
  - Control
  - VAJ+
  - VAJ + STJ

*Significant difference
Results: 3D-ECHO

<table>
<thead>
<tr>
<th></th>
<th>Coaptation Surface Area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.5</td>
</tr>
<tr>
<td>VAJ+</td>
<td>1.7</td>
</tr>
<tr>
<td>VAJ + STJ</td>
<td>1.2</td>
</tr>
</tbody>
</table>

* Significant difference
Inverse Linear Relationship between Coaptation Surface Area and VAJ dilatation

$R^2 = 0.70$
$p$-value = 0.001
Finite Element Modelling

Von Mises Stress (MPa)

Control  VAJ+  VAJ + STJ
Summary

• VAJ dilatation produces a graded decrease in leaflet coaptation surface area
• This is further increased with STJ dilatation
• Total leaflet stresses increase with more VAJ dilatation
• VAJ reduction should be addressed during aortic valve repair
• Need for development of techniques and devices to facilitate this.
Thank you.
Questions & Comments
Phenotypes of the ascending aorta

- Aortic root aneurysm
  - Valsalva ≥ 45 mm
- Supra-coronary aneurysm
  - Valsalva < 40 mm
  - Supracoronary Aorta > 45
- Isolated AI
  - Valsalva < 40 mm
  - Supracoronary Aorta < 40

Standardized and physiological approach to aortic valve repair

Root reconstruction

- Remodeling + sub-valvular annuloplasty
- Supra-coronary graft + sub-valvular annuloplasty
  - (annulus ≥ 25 mm)
- Sub-valvular annuloplasty
  - (annulus ≥ 25 mm)

Cusp repair

- Alignment of cusp free edges
- Resuspension of cusp effective height
- Subvalvular external aortic annuloplasty
FIGURE 2. Illustration of the Von Mises stresses on the replaced cusps (noncoronary cusp [NCC]) with finite element modeling demonstrating (A) native unrepaired valve; B, autologous porcine pericardium (APP), and (C) Hemashield (HEM). Blue areas represent minimal to no stress (0 kPa); light blue, green, and yellow represent increasing levels of stress (maximum 7.774 kPa). Increased maximal stress was seen at the suture lines in the replaced NCCs for (B) APP, and (C) HEM compared with the (A) native unrepaired valve.
The Future

- More valve cusp pathology models (neo-commissural reconstruction, combinations) [ongoing]
- STJ and/or VAJ dilatation followed by repair [ongoing]
- Modeling aortic stenosis, Bicuspid aortic valve [soon]

Finding the ideal biomaterial for aortic valve repair with ex vivo porcine left heart simulator and finite element modeling

Published in the Journal of Thoracic and Cardiovascular Surgery, 2014

**Priority Theme 1:**

**Personal Tailored Health Solutions**

**Patient Measurements**  ➔ **Valve Model**  ➔ **Optimal Instructions**
Impact of aortic annular geometry on aortic valve insufficiency: Insights from a preclinical, ex vivo, porcine model

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Benjamin Sohmer, MD, MEd, b Michel Labrosse, PhD, c and Munir Boodhwani, MD, MMSc a
Higher stress increases probability of calcification