Hemodynamic Assessment of Bicuspid Aortic Valves as a Clinical Diagnostic Tool

2010 Undergraduate Research Kaleidoscope

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Background - The Heart

DIASTOLE

PULMONARY VALVE
MITRAL VALVE

AORTIC VALVE
TRICUSPID VALVE

SYSTOLE
Background- The Aortic Valve

Source: Cleveland Clinic
Valve Geometries

Normal

Bicuspid
Background on BAV

**Diseased valve**
Motivation for Project

Bicuspid Aortic Valves

Asymptomatic for years

Diagnosed late in life

1-2% of population

ECHO as standard of care

Cheaper than PC-MRI
Clinical diagnostic tool for BAV Patients

- Ultrasound for images
- Reconstruct geometries & repeat
- Assess Hemodynamics
Project Overview

- Excise Valve & Mount on ring
- Fix ring in chamber of flow loop
- Use 3D-ECHO to obtain images
- Characterize hemodynamics
How to obtain valves
Excising the aortic root
Suturing & Mounting Valve

Leaflet portion excised

Sinus wall portion excised
Equipment

Ultrasound Machine: iE33, Philips Inc, Andover, MA

Pediatric Probe
2D Image - Normal valve
Full-Volume Images- BAV
# 2D ECHO ASSESSMENT OF VALVES

<table>
<thead>
<tr>
<th></th>
<th>Normal tricuspid AV</th>
<th>BAV1 (Eccentric)</th>
<th>BAV2 (Central)</th>
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</thead>
<tbody>
<tr>
<td><strong>Systole</strong>&lt;br&gt;(Fully open)</td>
<td><img src="image1" alt="Normal tricuspid AV Systole" /></td>
<td><img src="image2" alt="BAV1 (Eccentric) Systole" /></td>
<td><img src="image3" alt="BAV2 (Central) Systole" /></td>
</tr>
<tr>
<td><strong>Diastole</strong>&lt;br&gt;(Fully closed)</td>
<td><img src="image4" alt="Normal tricuspid AV Diastole" /></td>
<td><img src="image5" alt="BAV1 (Eccentric) Diastole" /></td>
<td><img src="image6" alt="BAV2 (Central) Diastole" /></td>
</tr>
</tbody>
</table>

- **NORMAL LEAFLET**
- **BICUSPID LEAFLET**
\[ U = \overline{U} + u' \]

\[ V = \overline{V} + v' \]

\[ \tau_m = \alpha \frac{\sigma_{p1} - \sigma_{p2}}{2} \]

\[ \begin{aligned} \sigma_{p1} &= \rho \left[ \frac{u'u' + v'v'}{2} + \sqrt{\left( \frac{u'u' - v'v'}{2} \right)^2 + (u'v')^2} \right] \\
\sigma_{p2} &= \rho \left[ \frac{u'u' + v'v'}{2} - \sqrt{\left( \frac{u'u' - v'v'}{2} \right)^2 + (u'v')^2} \right] \end{aligned} \]
Kaleidoscope of Mechanical Heart