Ex-vivo assessment of material characteristics in ascending aortic aneurysm tissue for bicuspid and trileaflet valve groups

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Why do Aneurysms Rupture?

Risk stratification of Aortic Aneurysms – *Indolent but Catastrophic*

Size & growth rate poor predictors of rupture/dissection

Need more science to risk profile
Why is understanding aortic behaviour important?

Dilemma: Young patients with small aneurysms are running into trouble vs.
Many patients have large aortic aneurysms that are stable for prolonged periods of time

If we operated on every dilated aorta, we may do more harm than benefit
Is there a Role for Biomechanical Engineering in Helping to Elucidate the Risk Profile of the Thoracic Aorta?
Ongoing Research Project: “Aorta at Risk”

Elective patients undergoing surgery for ascending aortic aneurysms
Intraop Speckle Tracking
Histopath quantification
Uni-axial Tensile Strength Testing
Bi-axial Tensile Strength Testing

Ultimate Goal: Noninvasive risk profiling of ascending aortic aneurysms
Fundamental Engineering Principle:

Any material breaks because stress on a specific point > strength of material at that point
Methods

27 patients with ascending aortic aneurysms undergoing elective OR

56 circumferential samples cut: 22 trileaflet valves & 34 bicuspid valves

Stretched to failure (in one direction)
Data Analysis

The material strength is obtained by identifying the first point of failure (yield point).
## Patient Population

<table>
<thead>
<tr>
<th></th>
<th>Bicuspid n=34</th>
<th>Trileaflet n=22</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Avg. Age (years)</strong></td>
<td>56 (30-75)</td>
<td>63 (36-76)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Avg. Max Diameter (cm)</strong></td>
<td>5.2 (4.3-6.5)</td>
<td>5.5 (4.6-8.0)</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

*4.3cm Ao in patient with severe AI and small BSA*
Results:  

I. Material Strength of Bicuspid vs. Trileaflet specimens

1.16 vs. 0.73 MPa  
P<0.05
Results: II. Material Strength vs. Patient Age

$R^2 = 0.17$
Correlation Coefficient $-0.41$
P $< 0.05$
III. Material Strength vs. Maximum Aortic Diameter

R² = 0.035
Correlation coefficient: -0.186
P = 0.169
Conclusions

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2. Aortic aneurysm tissue associated with bicuspid aortic valve was stronger than trileaflet aortic valve
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3. Material strength decreased with increasing age
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2. Aortic aneurysm tissue associated with bicuspid aortic valve was stronger than trileaflet aortic valve

3. Material strength decreased with increasing age

1. Material strength not related to maximal aneurysm diameter

   Aneurysms may be weaker than normal aortic tissue, but once aneurysmal, strength doesn’t necessarily decrease with aneurysmal diameter
“In seeking absolute truth we aim at the unattainable, and must be content with finding broken portions.”

William Osler – Aequanimitas, Valedictory Address, University of Pennsylvania
May 1, 1889
Future Directions:

More patients – control for diameter and age to truly compare BAV vs. TAV
index diameter to BSA
index diameter to normal aorta in that patient

Assessment and comparison of material properties from biaxial tests (more physiologic) – info on stiffness in two directions

Non invasive assessment of material properties to help risk profile ascending aortic aneurysms
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