The Impact of Bicuspid Aortic Valve Morphology on Outcomes After TAVI

Sung-Han Yoon, MD
On Behalf of Bicuspid AS TAVR Registry
Speaker's name:

☐ I do not have any potential conflict of interest
Background

- TAVI indication is expanding into a lower-risk population
- The prevalence of bicuspid aortic valve is higher in a younger population
- Bicuspid AS has been excluded from randomized trials
- There is limited data assessing the outcomes of TAVI in Bicuspid AS
Outcomes in Transcatheter Aortic Valve Replacement for Bicuspid Versus Tricuspid Aortic Valve Stenosis

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Study Design

Exclusion
- 15 patients with missing data

Bicuspid AS (n = 561)

Exclusion
- 1330 patients with missing data

Tricuspid AS (n = 4546)

Bicuspid AS (n = 576)

Tricuspid AS (n = 5876)

Propensity-Score Matching

Bicuspid AS (n = 546)

Tricuspid AS (n = 546)
Procedural Outcomes
Early Generation Devices

- **Aortic Root Injury**: 2.2% (Bicuspid AS) vs. 0.0% (Tricuspid AS)
- **Second Valve Implantation**: 7.2% (Bicuspid AS) vs. 2.2% (Tricuspid AS)
- **Paravalvular Leak**: 15.9% (Bicuspid AS) vs. 10.3% (Tricuspid AS)
- **New Pacemaker**: 14.7% (Bicuspid AS) vs. 13.7% (Tricuspid AS)

- *p = 0.02* (Aortic Root Injury)
- *p = 0.003* (Second Valve Implantation)
- *p = 0.03* (Paravalvular Leak)
- *p = 0.72* (New Pacemaker)

*(n = 320)* (Bicuspid AS) vs. *(n = 321)* (Tricuspid AS)
Procedural Outcomes
New Generation Devices

Incidence (%)

Aortic Root Injury
Second Valve Implantation
Paravalvular Leak
New Pacemaker

Bicuspid AS
Tricuspid AS

(n = 226)  (n = 225)

0.9  0.0
1.3  0.4
2.7  1.8

p = 0.50  p = 0.62  p = 0.53  p = 0.69
1-year All-cause Mortality
Overall Propensity Matched Cohort

![Graph showing 1-year All-cause Mortality for Bicuspid AS and Tricuspid AS. The graph includes a line chart with two lines representing the mortality rates for each group, and a table showing the number of at-risk patients at different time points. The p-value for the difference in mortality rates is 0.28.]
We aimed to investigate the association between Bicuspid AS morphology and clinical outcomes after TAVI.
Methods

- The Bicuspid AS TAVR multicenter registry was used to evaluate procedural and clinical outcomes.
- Bicuspid aortic valve morphology was defined by independent analysis of computed tomography images.
- Procedural and clinical outcomes were assessed according to VARC-2 criteria.
## Participating Institutions (n=33)

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution (cases)</th>
<th>Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>Cedars-Sinai Heart Institute (110)</td>
<td>Rahul Sharma, Tarun Chakravarty, Raj Makkar</td>
</tr>
<tr>
<td>France</td>
<td>Institute Cardiovasculaire Paris Sud (62)</td>
<td>Takahide Arai, Bernard Chevalier, Thierry Lefevre</td>
</tr>
<tr>
<td>Germany</td>
<td>German Heart Center (46)</td>
<td>Johannes Ziegelmueller, Sabine Bleiziffer</td>
</tr>
<tr>
<td>Canada</td>
<td>St. Paul’s Hospital (36)</td>
<td>Danny Dvir, Philipp Blanke, Jonathon Leipsic, John G. Webb</td>
</tr>
<tr>
<td>U.S.</td>
<td>Columbia University Medical Center (26)</td>
<td>Omar Khalique, Susheel Kodali, Martin Leon</td>
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<td>Denmark</td>
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<td>Germany</td>
<td>Heart Center Brandenburg (20)</td>
<td>Hidehiro Kaneko, Christian Butter</td>
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<td>San Raffaele Scientific Institute (19)</td>
<td>Azeem Latib, Antonio Colombo</td>
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<td>Germany</td>
<td>University Freiburg (18)</td>
<td>Philipp Ruile, Gregor Pache, Franz-Josef</td>
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<td>Korea</td>
<td>Asan Medical Center (18)</td>
<td>Seung-Jung Park</td>
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<tr>
<td>Germany</td>
<td>Hamburg University Heart Center (17)</td>
<td>Florian Deuschl, Niklas Schofer, Ulrich Schaefer</td>
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<td>U.S.</td>
<td>Intermountain Heart Institute (17)</td>
<td>Brian K. Whisenant</td>
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<td>France</td>
<td>Centre Hospitalier Unicersitaire Henri Modor (16)</td>
<td>Masao Takahashi, Emmanuel Teiger</td>
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<td>Erik W. Holy, Mohamed Abdel-Wahab</td>
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<td>Francesco Bedgoni, Luca Testa</td>
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<td>U.K.</td>
<td>Sussex Cardiac Center (13)</td>
<td>Smriti Saraf, David Hildick-Smith</td>
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<td>Tobias Schmidt</td>
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<td>Thomas Modine</td>
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<td>S. Chiu Wong</td>
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<tr>
<td>Switzerland</td>
<td>University Hospital Zurich (5)</td>
<td>Fabian Nietlispach</td>
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</table>
Study Design

Bicuspid AS with MDCT available (n = 418)

Raphe?

No

Type 0 (No Raphe)  
 n = 62

Yes

Calcified raphe?

No

Type 1 (Raphe)  
 n = 130

Yes

Type 1 (Calcified Raphe)  
 n = 226
### Baseline Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Type 0 No raphe (n = 62)</th>
<th>Type 1 Raphe (n = 130)</th>
<th>Type 1 Calcified raphe (n = 226)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>75 ± 8</td>
<td>77 ± 9</td>
<td>76 ± 9</td>
<td>0.18</td>
</tr>
<tr>
<td>Male</td>
<td>65%</td>
<td>56%</td>
<td>66%</td>
<td>0.15</td>
</tr>
<tr>
<td>NYHA class III / IV</td>
<td>69%</td>
<td>80%</td>
<td>79%</td>
<td>0.24</td>
</tr>
<tr>
<td>LVEF, %</td>
<td>50.9 ± 16.1</td>
<td>54.1 ± 15.4</td>
<td>50.8 ± 15.9</td>
<td>0.15</td>
</tr>
<tr>
<td>Mean gradient, mmHg</td>
<td>52.8 ± 21.9</td>
<td>48.9 ± 17.2</td>
<td>50.6 ± 17.6</td>
<td>0.39</td>
</tr>
<tr>
<td>STS score, %</td>
<td>4.5 ± 5.6</td>
<td>4.1 ± 3.2</td>
<td>5.2 ± 5.3</td>
<td>0.09</td>
</tr>
<tr>
<td>Logistic EuroSCORE, %</td>
<td>12.7 ± 11.8</td>
<td>15.4 ± 11.1</td>
<td>14.3 ± 12.3</td>
<td>0.50</td>
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</table>
### Baseline Characteristics (cont’d)

<table>
<thead>
<tr>
<th></th>
<th>Type 0 No raphe (n = 62)</th>
<th>Type 1 Raphe (n = 130)</th>
<th>Type 1 Calcified raphe (n = 226)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
<td>24%</td>
<td>22%</td>
<td>24%</td>
<td>0.95</td>
</tr>
<tr>
<td>Hypertension</td>
<td>68%</td>
<td>74%</td>
<td>74%</td>
<td>0.63</td>
</tr>
<tr>
<td>Chronic pulmonary disease</td>
<td>21%</td>
<td>24%</td>
<td>20%</td>
<td>0.68</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>21%</td>
<td>19%</td>
<td>13%</td>
<td>0.23</td>
</tr>
<tr>
<td>Prior PCI</td>
<td>16%</td>
<td>19%</td>
<td>21%</td>
<td>0.67</td>
</tr>
<tr>
<td>Prior CABG</td>
<td>15%</td>
<td>12%</td>
<td>11%</td>
<td>0.70</td>
</tr>
<tr>
<td>Prior CVA</td>
<td>19%</td>
<td>14%</td>
<td>17%</td>
<td>0.59</td>
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</table>
## Procedural Data

<table>
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<tr>
<th></th>
<th>Type 0 No raphe (n = 62)</th>
<th>Type 1 Raphe (n = 130)</th>
<th>Type 1 Calcified raphe (n = 226)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfemoral access</td>
<td>81%</td>
<td>88%</td>
<td>89%</td>
<td>0.18</td>
</tr>
<tr>
<td>Device</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early generation devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CoreValve</td>
<td>69%</td>
<td>50%</td>
<td>53%</td>
<td>0.03</td>
</tr>
<tr>
<td>Sapien XT</td>
<td>23%</td>
<td>32%</td>
<td>29%</td>
<td>0.44</td>
</tr>
<tr>
<td>New generation devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sapien 3</td>
<td>31%</td>
<td>50%</td>
<td>47%</td>
<td>0.03</td>
</tr>
<tr>
<td>Lotus</td>
<td>8%</td>
<td>7%</td>
<td>5%</td>
<td>0.55</td>
</tr>
<tr>
<td>Evolut R</td>
<td>0%</td>
<td>3%</td>
<td>4%</td>
<td>0.23</td>
</tr>
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</table>
## Procedural Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Type 0 No raphe (n = 62)</th>
<th>Type 1 Raphe (n = 130)</th>
<th>Type 1 Calcified raphe (n = 226)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device success</td>
<td>87.1%</td>
<td>90.8%</td>
<td>83.6%</td>
<td>0.17</td>
</tr>
<tr>
<td>Second valve implantation</td>
<td>6.5%</td>
<td>1.5%</td>
<td>5.8%</td>
<td>0.14</td>
</tr>
<tr>
<td>Conversion to surgery</td>
<td>1.6%</td>
<td>1.5%</td>
<td>2.7%</td>
<td>0.89</td>
</tr>
<tr>
<td>Coronary obstruction</td>
<td>3.2%</td>
<td>0.8%</td>
<td>0.9%</td>
<td>0.29</td>
</tr>
<tr>
<td>New permanent pacemaker</td>
<td>11.3%</td>
<td>16.2%</td>
<td>19.0%</td>
<td>0.34</td>
</tr>
<tr>
<td>PVL ≥ moderate</td>
<td>6.5%</td>
<td>7.7%</td>
<td>11.1%</td>
<td>0.40</td>
</tr>
<tr>
<td>Annulus rupture</td>
<td>0.0%</td>
<td>0.8%</td>
<td>2.7%</td>
<td>0.36</td>
</tr>
<tr>
<td>Procedure-related mortality</td>
<td>1.6%</td>
<td>0.0%</td>
<td>2.7%</td>
<td>0.17</td>
</tr>
</tbody>
</table>
30-day Clinical Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Type 0 No raphe (n = 62)</th>
<th>Type 1 Raphe (n = 130)</th>
<th>Type 1 Calcified raphe (n = 226)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-day mortality</td>
<td>1.6%</td>
<td>0.0%</td>
<td>6.2%</td>
<td>0.003</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.0%</td>
<td>3.1%</td>
<td>2.2%</td>
<td>0.52</td>
</tr>
<tr>
<td>Life-threatening bleeding</td>
<td>0.0%</td>
<td>0.0%</td>
<td>2.7%</td>
<td>0.13</td>
</tr>
<tr>
<td>Major vascular complication</td>
<td>0.0%</td>
<td>2.3%</td>
<td>4.9%</td>
<td>0.15</td>
</tr>
<tr>
<td>AKI (stage 2 or 3)</td>
<td>1.6%</td>
<td>2.3%</td>
<td>1.8%</td>
<td>0.89</td>
</tr>
</tbody>
</table>
Outcomes According to Device Type
Paravalvular Leak

- **CoreValve**
  - No Raphe: 6.9%
  - Raphe: 16.7%
  - Calcified Raphe: 29.6%
  - \( p = 0.017 \)\(^{(N = 107)}\)

- **Sapien XT**
  - No Raphe: 14.3%
  - Raphe: 12.2%
  - Calcified Raphe: 9.2%
  - \( p = \text{NS} \)\(^{(N = 120)}\)

- **Sapien 3**
  - No Raphe: 0.0%
  - Raphe: 1.9%
  - Calcified Raphe: 1.2%
  - \( p = \text{NS} \)\(^{(N = 152)}\)
Second Valve Implantation

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoreValve</td>
<td>13.8</td>
</tr>
<tr>
<td>Sapien XT</td>
<td>8.3</td>
</tr>
<tr>
<td>Sapien 3</td>
<td>2.3</td>
</tr>
</tbody>
</table>

- **CoreValve**: (N = 107)
- **Sapien XT**: (N = 120)
- **Sapien 3**: (N = 152)

**p = NS**
Annulus Rupture

- CoreValve (N = 107)
- Sapien XT (N = 120)
- Sapien 3 (N = 152)

Incidence (%): No Raphe, Raphe, Calcified Raphe

- p = NS
- p = NS
- p = NS
New Permanent Pacemaker

Incidence (%)

- No Raphe
- Raphe
- Calcified Raphe

- CoreValve: 6.9, 20.8, 29.6
- Sapien XT: 14.3, 4.9, 12.3
- Sapien 3: 21.4, 17.3, 16.3

p = 0.017

p = NS

(N = 107) (N = 120) (N = 152)
### Device Success

**CoreValve**
- No Raphe: 82.8%
- Raphe: 75.0%
- Calcified Raphe: 59.3%
  - Sample Size: (N = 107)

**Sapien XT**
- No Raphe: 78.6%
- Raphe: 87.8%
- Calcified Raphe: 86.2%
  - Sample Size: (N = 120)

**Sapien 3**
- No Raphe: 100.0%
- Raphe: 98.1%
- Calcified Raphe: 96.5%
  - Sample Size: (N = 152)

Statistical Significance:
- No Raphe vs. Calcified Raphe: *p* = 0.029
- Other comparisons: *p* = NS
30-day Mortality

Incidence (%)

CoreValve
Sapien XT
Sapien 3

No Raphe
Raphe
Calcified Raphe

CoreValve
(N = 107)
Sapien XT
(N = 120)
Sapien 3
(N = 152)

p = NS
p = 0.045
p = NS

No Raphe: 0.0%
Raphe: 7.1%
Calcified Raphe: 2.3%
1 Year Survival
Cumulative Survival at 1 Year
Overall Cohort

Overall log-rank p = 0.01

No. at Risk

<table>
<thead>
<tr>
<th>Group</th>
<th>Days</th>
<th>No at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Raphe</td>
<td>42</td>
<td>62</td>
</tr>
<tr>
<td>Raphe</td>
<td>73</td>
<td>130</td>
</tr>
<tr>
<td>Calcified Raphe</td>
<td>123</td>
<td>226</td>
</tr>
</tbody>
</table>

No Raphe: 95.0%
No Raphe: 92.2%
Calcified Raphe: 83.8%
Cumulative Survival at 1 Year
Early-generation Devices

Overall log-rank p = 0.027

No. at Risk
No Raphe 43
Raphe 65
Calcified Raphe 119

Days
No Raphe 32 27
Raphe 48 42
Calcified Raphe 82 67
Cumulative Survival at 1 Year
New-generation Devices

Overall log-rank p = 0.23

<table>
<thead>
<tr>
<th>No. at Risk</th>
<th>Days</th>
<th>Days</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Raphe</td>
<td>19</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Raphe</td>
<td>65</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Calcified Raphe</td>
<td>107</td>
<td>41</td>
<td>20</td>
</tr>
</tbody>
</table>
Conclusions

• Overall, TAVI in Bicuspid AS was safe and feasible

• Bicuspid AS with calcified raphe was associated with more frequent adverse events after TAVI when using the early generation devices

• However, when using the new generation devices, bicuspid AS with calcified raphe showed similar outcomes across raphe type

• Bicuspid AS with calcified raphe showed lower 1-year survival rate when using the early generation devices, but 1-year survival rates were similar across raphe type when using the new generation devices
Acknowledgement

**Cedars-Sinai Heart Institute**
Raj Makkar, MD

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**Asan Medical Cener, Korea**
Seung-Jung Park, MD

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