Concomitant Aortic Valve Procedures in Patients Undergoing Implantation of Continuous-Flow LVADs: An INTERMACS Database Analysis

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Disclosures: Robertson – none; Naftel – none; Prasad - none; Itoh – none; Myers – none; Mertz – none; Kirklin – none; Silvestry – Consultant for Thoratec and HeartWare

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Aortic insufficiency (AI) compromises device support by creating a short circulatory loop, resulting in:

- Diminished systemic perfusion
- Elevated left heart filling pressures
- Increased LVAD flows

Existing mechanical valves may predispose to stroke.

Even minor AI worsens over time with device support.

Strategies to overcome these problems include:

- AV repair (AVr)
- AV closure
- AV replacement (AVR)

Deo SV, et al. ASAIO J. 2014;60:183-188
Types of Aortic Valve Procedures

Suture Repairs: Park’s/Frater’s Stitch, etc.
Closures: Suture-Based or Patch Closures
Aortic Valve Replacement

Outcomes Following Aortic Valve Procedures

- Previous studies are split on whether or not mortality is increased after concomitant aortic valve procedures.

- The largest of these analyzed data from the HeartMate II BTT and DT Trials (n=1,106), including:
  - 30 AVRs
  - 32 AV closures
  - 18 AV repairs

- Long term survival was significantly reduced with concomitant AV procedures compared to HMII implant alone:
  - 1-year Survival: 57% vs. 75%, p=0.001
  - 2-year Survival: 43% vs. 64%, p=0.001

Adamson RM, et al. JHLT. 2011; 30: 576-582
The purpose of this study is to compare outcomes between three strategies for management of the aortic valve: AV Closure, AV Repair and AV Replacement.

The Interagency Registry of Mechanically Assisted Devices (INTERMACS) was utilized.

Data on AV closures was obtained retrospectively through a database audit.
**Question 1:**
Did patients with documented moderate/severe AI without a documented aortic valve procedure (AVP) in fact have an AVP?

<table>
<thead>
<tr>
<th>Queried:</th>
<th>patients=113</th>
<th>hospitals=59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responded:</td>
<td>patients=86 (76%)</td>
<td>hospitals=47 (80%)</td>
</tr>
</tbody>
</table>

**Question 2:**
Did patients with documented AV repairs undergo closure or repair?:

<table>
<thead>
<tr>
<th>Queried:</th>
<th>patients=213</th>
<th>hospitals=62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responded:</td>
<td>patients=143 (67%)</td>
<td>hospitals=40 (65%)</td>
</tr>
<tr>
<td>Unconfirmed:</td>
<td>patients=70 (33%)</td>
<td>hospitals=19 (31%)</td>
</tr>
</tbody>
</table>

Total Patients queried = 326  
Total Hospitals queried = 88  
Total Patients with response = 229 (70%)  
Total Hospitals responded = 63 (72%)

All patients implanted as of 12/31/2012
N=7,887

Pediatric Patients: N=79
(patients < 19 yrs of age at time of implant)

Adults: N=7,808

Pulsatile Flow: N=1,087

Continuous Flow: N=6,721

Bi VAD: N=179
LVAD: N=6,542

BiVAD: N=301
TAH: N=158
LVAD: N=628

Reduced Cohort:
Bi VAD: N=140
LVAD: N=5,204

Mean Follow-up = 12.3 months

Total Cohort: N=5,344
Aortic Valve Closure
- Total=125
- LVAD=121
- BiVAD=4

Aortic Valve Repair
- Total=95
- LVAD=93
- BiVAD=2

Aortic Valve Replacement
- Total=85
- LVAD=83
- BiVAD=2

No AV Procedure
- Total=5,039
- LVAD=4,907
- BiVAD=132
## Preimplant Characteristics

<table>
<thead>
<tr>
<th>Preimplant Characteristics</th>
<th>No AVP N=5,039</th>
<th>AV Closure N=125</th>
<th>AV Repair N=95</th>
<th>AVR N=85</th>
<th>P (AVP vs. No AVP)</th>
<th>P (comparing interventions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>56.21</td>
<td>62.4</td>
<td>63.8</td>
<td>63.6</td>
<td>&lt;0.0001</td>
<td>0.58</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28.7</td>
<td>27.2</td>
<td>25.2</td>
<td>27.9</td>
<td>&lt;0.0001</td>
<td>0.006</td>
</tr>
<tr>
<td>PASP (mmHg)</td>
<td>50.5</td>
<td>47.6</td>
<td>54.7</td>
<td>55.4</td>
<td>0.15</td>
<td>0.003</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>1.42</td>
<td>1.52</td>
<td>1.60</td>
<td>1.46</td>
<td>0.02</td>
<td>0.58</td>
</tr>
<tr>
<td>Bridge to Transplant (listed, %)</td>
<td>27.3</td>
<td>19.2</td>
<td>28.4</td>
<td>23.5</td>
<td>0.12</td>
<td>0.28</td>
</tr>
<tr>
<td>Destination Therapy (%)</td>
<td>32.3</td>
<td>44.8</td>
<td>47.4</td>
<td>45.9</td>
<td>&lt;0.0001</td>
<td>0.93</td>
</tr>
<tr>
<td>INTERMACS Level 1 (%)</td>
<td>14.7</td>
<td>15.2</td>
<td>10.5</td>
<td>9.4</td>
<td>0.22</td>
<td>0.38</td>
</tr>
<tr>
<td>INTERMACS Level 2 (%)</td>
<td>40.5</td>
<td>36.8</td>
<td>48.4</td>
<td>34.1</td>
<td>0.77</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Survival by Type of Aortic Valve Procedure Performed

- No AV Procedure: n=5039, deaths=1078 (78.6%)
- AV Replacement: n=85, deaths=24 (71.8%)
- AV Repair: n=95, deaths=22 (76.8%)
- AV Closure: n=125, deaths=46 (61.6%)

Overall p = 0.0003
Survival for INTERMACS Level 1-2 Patients by Type of AVP

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>events</th>
<th>6 months</th>
<th>1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV Closure</td>
<td>65</td>
<td>25</td>
<td>67%</td>
<td>56%</td>
</tr>
<tr>
<td>AV Repair</td>
<td>56</td>
<td>16</td>
<td>85%</td>
<td>76%</td>
</tr>
<tr>
<td>AV Replacement</td>
<td>37</td>
<td>11</td>
<td>76%</td>
<td>67%</td>
</tr>
<tr>
<td>No AVP</td>
<td>2780</td>
<td>652</td>
<td>85%</td>
<td>79%</td>
</tr>
</tbody>
</table>

Overall p=0.003
Survival for INTERMACS Level 3-7 Patients by Type of AVP

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>events</th>
<th>6 months</th>
<th>1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV Closure</td>
<td>60</td>
<td>21</td>
<td>85%</td>
<td>73%</td>
</tr>
<tr>
<td>AV Repair</td>
<td>39</td>
<td>6</td>
<td>86%</td>
<td>82%</td>
</tr>
<tr>
<td>AV Replacement</td>
<td>48</td>
<td>13</td>
<td>87%</td>
<td>75%</td>
</tr>
<tr>
<td>No AVP</td>
<td>2258</td>
<td>426</td>
<td>89%</td>
<td>84%</td>
</tr>
</tbody>
</table>

Overall $p = 0.04$
Multivariate Model for Death After Implant

- Demographics
- Pre-implant laboratory analyses
- Degree of AV regurgitation
- Type of AV intervention
- INTERMACS Profile Levels
- Pre-implant support: ventilator requirement, IABP, ICD, dialysis
- Comorbidities
- Pre-implant hemodynamic variables: LVEF, RV failure, CI, inotrope requirement, cardiac output, RA pressure, LVEDD, PAWP, PASP, PADP, PVR, blood pressure
- Implant information: concomitant surgery, BiVAD, hospital effect
## Multivariate Model for Death After Implant

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Hazard Ratio</th>
<th>Confidence Interval</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic Regurgitation</td>
<td>0.98</td>
<td>0.87-1.10</td>
<td>0.75</td>
</tr>
<tr>
<td>AV Repair</td>
<td>0.83</td>
<td>0.54-1.27</td>
<td>0.39</td>
</tr>
<tr>
<td>AVR</td>
<td>1.36</td>
<td>0.84-2.19</td>
<td>0.21</td>
</tr>
<tr>
<td>Closure</td>
<td><strong>1.87</strong></td>
<td><strong>1.39-2.53</strong></td>
<td><strong>&lt;0.0001</strong></td>
</tr>
<tr>
<td>INTERMACS Level 1</td>
<td>1.23</td>
<td>1.01-1.51</td>
<td>0.04</td>
</tr>
<tr>
<td>Preop Dialysis</td>
<td>1.85</td>
<td>1.32-2.58</td>
<td>0.0003</td>
</tr>
<tr>
<td>BiVAD</td>
<td><strong>2.34</strong></td>
<td><strong>1.8-3.05</strong></td>
<td><strong>&lt;0.0001</strong></td>
</tr>
</tbody>
</table>
Competing Outcomes for Patients without an AVP

<table>
<thead>
<tr>
<th>Outcome</th>
<th>% at 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alive (device in place)</td>
<td>60%</td>
</tr>
<tr>
<td>Transplanted</td>
<td>23%</td>
</tr>
<tr>
<td>Dead</td>
<td>17%</td>
</tr>
<tr>
<td>Recovery</td>
<td>1%</td>
</tr>
</tbody>
</table>
Competing Outcomes for Patients with an AV Procedure

**AVR or AVr Patients (n=180)**

- **Dead**: 23%
- **Alive (device in place)**: 58%
- **Transplanted**: 19%
- **Recovery**: 0%

**AV Closure Patients (n=125)**

- **Dead**: 34%
- **Alive (device in place)**: 52%
- **Transplanted**: 14%
- **Recovery**: 0%
Other Postoperative Outcomes

Rehospitalization

$\ p = 0.32$

Right Heart Failure

$\ p = 0.10$

Stroke

$\ p = 0.58$

AV Closure
AV Repair
AV Replacement
No AV Procedure
Time to First Renal Dysfunction by Group

% First Renal Dysfunction

Groups    n        events       at 1 year post implant
AV Closure  125 21    83%
AV Repair    95 14    85%
AV Replacement   85 16    82%
No AV Procedure      5039           568    89%

% Freedom from Renal Dysfunction at 1 year post implant

Overall $p = .02$

$p$ (comparing interventions) = 0.79
Recurrence of Aortic Insufficiency Postoperatively by Group

Aortic Closure, n=112
Aortic Repair, n=85
Aortic Replacement, n=67
No AV Procedure, n=4,061

Note: If the total n for the group is < 20 then it is not plotted in this figure.

p (6 months) < 0.0001

Note: If the total n for the group is < 20 then it is not plotted in this figure.
### Causes of Death

#### ≥3 months post-implant:

<table>
<thead>
<tr>
<th>Primary Cause of Death</th>
<th>Closure % (n)</th>
<th>Repair % (n)</th>
<th>Replacement % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory Failure</td>
<td>4.6 (1/22)</td>
<td>0.0 (0/13)</td>
<td>0.0 (0/14)</td>
</tr>
<tr>
<td>Major Bleeding</td>
<td>13.6 (3/22)</td>
<td>0.0 (0/13)</td>
<td>7.1 (1/14)</td>
</tr>
<tr>
<td>Device Malfunction</td>
<td>4.6 (1/22)</td>
<td>0.0 (0/13)</td>
<td>7.1 (1/14)</td>
</tr>
<tr>
<td>Sudden Unexplained Death</td>
<td>13.6 (3/22)</td>
<td>30.8 (4/13)</td>
<td>0.0 (0/14)</td>
</tr>
<tr>
<td>Neurological Dysfunction</td>
<td>9.1 (2/22)</td>
<td>7.7 (1/13)</td>
<td>7.1 (1/14)</td>
</tr>
<tr>
<td>Withdrawal of Support</td>
<td>13.6 (3/22)</td>
<td>0.0 (0/13)</td>
<td>0.0 (0/14)</td>
</tr>
<tr>
<td>MSOF</td>
<td>4.6 (1/22)</td>
<td>7.7 (1/13)</td>
<td>0.0 (0/14)</td>
</tr>
<tr>
<td>Major Infection</td>
<td>0.0 (0/22)</td>
<td>7.7 (1/13)</td>
<td>14.3 (2/14)</td>
</tr>
</tbody>
</table>
• Intraoperative echocardiographic data is not available

• We do not have information on management algorithms or why individual surgeons selected one aortic valve procedure over another

• We are unable to comment on who should receive an aortic valve procedure
Conclusions

• Aortic valve closure is an independent predictor of increased postoperative mortality, particularly for INTERMACS level 1-2 patients

• This results in fewer patients with AV closure reaching transplant

• The reasons for increased mortality are unclear but may be related to respiratory failure or major bleeding

• Aortic valve repairs, while associated with the lowest mortality, are less durable postoperatively