Right Ventricular Failure: Prediction, Prevention and Treatment

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Disclosures: None

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<td>I have received (a) research grant(s) / in kind support</td>
<td>I have been a speaker or participant in accredited CME/CPD ...</td>
<td>I have been a consultant / strategic advisor etc. ...</td>
<td>I am a holder of (a) patent / shares / stocks or ownership...</td>
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**SCORE: 2**
RV Failure Following LVAD

- Pre-implant diagnosis is challenging
- Definition
  - Need for inotropic support > 14 days
  - Need for RVAD
- Limits device function by reducing pre-load
- Associated with end-organ dysfunction and prolonged LOS
- Important cause of post-implant morbidity and mortality
- New description of “late” RV failure, etiology unknown

Events/100 pt-month in first 12 months follow-up

J Heart Lung Transplant 2013;32:141-56
J Thorac Cardiovasc Surg 2010;139: 1316-24
Predictors of Post-LVAD RV Failure

- Clinical
  - Pre-implant mechanical ventilation
  - Pre-implant renal or hepatic dysfunction
  - Need for vasopressors

- Hemodynamic
  - High RA, low PA
  - CVP:PCWP pressure > 0.63
  - RVSWI < 300 mmHg x SV/m²

- Echocardiographic
  - RV size and function
  - Tricuspid insufficiency
  - TAPSE
  - RV Strain
Predictors of RV Failure during LVAD Support

**FIGURE 2.** Relative risk ratios of univariate and multivariate predictors of RVF during LVAD support.
Multivariable Models

### Table 6: Right Ventricular Failure Risk Score and Likelihood of RV Failure by Score Strata

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>n</th>
<th>RV Failure (n)</th>
<th>No RV Failure (n)</th>
<th>Likelihood Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤3.0</td>
<td>142</td>
<td>29</td>
<td>113</td>
<td>0.49 (0.37-0.64)</td>
</tr>
<tr>
<td>4.0-5.0</td>
<td>25</td>
<td>15</td>
<td>10</td>
<td>2.8 (1.4-5.9)</td>
</tr>
<tr>
<td>≥5.5</td>
<td>30</td>
<td>24</td>
<td>6</td>
<td>7.6 (3.4-17.1)</td>
</tr>
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</table>

Risk Score is derived by summing points awarded for the presence of a vasopressor requirement (4 points), AST ≥ 80 IU/L (2 points), bilirubin ≥ 2.0 mg/dL (2.5 points), and creatinine ≥ 2.3 mg/dL (3 points).

<table>
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<tr>
<th>Feature</th>
<th>OR (95% CI)</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vasopressor Requirement</td>
<td>3.9 (1.5-9.8)</td>
<td>4</td>
</tr>
<tr>
<td>AST ≥ 80 IU/L</td>
<td>2.1 (0.96-4.5)</td>
<td>2</td>
</tr>
<tr>
<td>Bilirubin ≥ 2.0 mg/dL</td>
<td>2.4 (1.1-5.2)</td>
<td>2.5</td>
</tr>
<tr>
<td>Cr ≥ 2.3 mg/dL</td>
<td>2.9 (1.1-7.7)</td>
<td>3</td>
</tr>
</tbody>
</table>

J Am Coll Cardiol 2008; 51:2163-72
Predicting Right Ventricular Failure in the Modern, Continuous Flow Left Ventricular Assist Device Era

Pavan Atluri, MD, Andrew B. Goldstone, MD, Alex S. Fairman, BA, John W. MacArthur, MD, Yasuhiro Shudo, MD, Jeffrey E. Cohen, MD, Alexandra L. Acker, William Hiesinger, MD, Jessica L. Howard, BS, Michael A. Acker, MD, and Y. Joseph Woo, MD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p Value</th>
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<tbody>
<tr>
<td>Severe right ventricular dysfunction</td>
<td>3.7</td>
<td>1.7 - 8.1</td>
<td>0.001</td>
</tr>
<tr>
<td>Severe tricuspid regurgitation</td>
<td>4.1</td>
<td>1.4 - 12.4</td>
<td>0.011</td>
</tr>
<tr>
<td>Preoperative mechanical ventilation</td>
<td>4.3</td>
<td>1.9 - 9.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Central venous pressure &gt;15 mm Hg</td>
<td>2.0</td>
<td>0.9 - 4.2</td>
<td>0.089</td>
</tr>
<tr>
<td>Heart rate &gt;100 beats/min</td>
<td>2.0</td>
<td>0.9 - 4.3</td>
<td>0.086</td>
</tr>
<tr>
<td>Constant</td>
<td>0.04</td>
<td></td>
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Hemodynamic Predictors of RV Failure during LVAD support

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Desirable Value</th>
</tr>
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<tbody>
<tr>
<td>RVSWI (mPA-mCVP) x SV/BSA</td>
<td>$&lt; 300 \text{ mmHg} \times \text{ mL/m}^2$</td>
</tr>
<tr>
<td>CVP</td>
<td>$&gt;15 \text{ mmHg}$</td>
</tr>
<tr>
<td>PVR and TPG</td>
<td>PVR $&gt;4$ Woods Units and TPG $&gt;15 \text{ mmHg}$</td>
</tr>
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</table>

*J Heart Lung Transplant 2010;29:S1-39*
Tricuspid Annular Motion as a Predictor of Severe Right Ventricular Failure After Left Ventricular Assist Device Implantation

Sarinya Puwanant, MD, Karen K. Hamilton, MD, Charles T. Klodell, MD, James A. Hill, MD, MS, Richard S. Schofield, MD, Timothy S. Cleeton, ARNP, Daniel F. Pauly, MD, PhD, and Juan M. Aranda Jr, MD

- Retrospective of 33 patients
  - 11 patients with RV failure
- TAPSE < 0.75 cm significant predictor

J Heart Lung Transplant 2008;27:1102-7
Addition of Strain Imaging to Risk Prediction

Grant, et al. JACC 2012; 60:521-528.
RV Management Pre-VAD

• Know the hemodynamics
• Critical to get CVP below 20 mmHg
• Treat pulmonary hypertension and RV failure:
  • Nitroprusside
  • Milrinone
  • Ultrafiltration
• 24 hrs pre-op an elective IABP *may* reduce need for RVAD
  • LV unloading
  • Less ischemia
  • Improved pulsatility
MCS with Concomitant Tricuspid Valve Repair

137/176 CF VAD patients with complete pre- and post-implant echo data

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<th>p Value</th>
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<tr>
<td>RVAD implantation, %</td>
<td>0</td>
<td>9.7</td>
<td>0.003</td>
</tr>
<tr>
<td>Post-LVAD inotropic infusion, median days</td>
<td>5</td>
<td>8.5</td>
<td>0.02</td>
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<tr>
<td>Post-LVAD hospital stay, median days</td>
<td>20</td>
<td>27</td>
<td>0.03</td>
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Logrank = 0.05

Ann Thorac Surg 2011;91:1342-7
Managing RV Failure After LVAD

- Inotropes
  - PDE inhibitors
- Pulmonary vasodilators
  - NO
  - Prostacycline
  - PO phosphodiesterase inhibitors
- Careful volume management
- Avoid “over pumping”
Impella RP: Percutaneous Right Ventricular Assist Device (RVAD)

- Transfemoral venous insertion
- 3D shaped cannula
- 22 Fr motor housing
- Pump mounted on a 11Fr catheter
- Flow: 4 L/min @ 33,000 rpm
- Anticoagulation: ACT ~ 160-180 sec
Primary Endpoint
Survival to 30 Day, Discharge or Next Therapy

Benchmark Reference:
Survival Rates observed in the Surgical HDE approved RVAD device*

N=18
N=12
Mechanical Right Heart Support

RECOVER RIGHT
The use of Impella RP Support System in Patients with Right Heart Failure:
A Clinical Safety and Probable Benefit Study
HVAD TAH
HVAD TAH
HVAD TAH
Strategies for Biventricular Support

30-day survival 82%

Circulation 2011; 124 (suppl1):s179-s186
The Prognostic Implications of RV Failure

J Heart Lung Transplant 2014;33:555-64
Summary and Conclusions

• RV failure prior to LVAD is very difficult to predict
  • Integrate multiple data elements
• RV failure after LVAD will happen – be prepared
• Treatment typically relies on a combination of inotropes and vasodilators
• VAD management plays an important role in RV geometry and function
• Right sided MCS may be required. Don’t wait too long to implement.