Management of Ventricular Arrhythmias in Patients with Ventricular Assist Devices

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Disclosures:

Speaking/consulting fees

- Biosense Webster
- St. Jude Medical
- Boston Scientific
- Medtronic
- Biotronik

Questions to address:

- What are the clinical implications and predictors of ventricular arrhythmias after continuous flow LVAD implant?
- What happens to the ICD after LVAD implant – does the patient really need it?
- How safe and efficacious is mapping and ablation of VT after LVAD implant?
- What measures can be taken before or during LVAD implant to prevent ventricular arrhythmias?
Continuous flow LVAD: HeartMate II

HeartMate II implant

HeartMate II implant

Continuous flow LVAD: HeartWare HVAD
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Do these ventricular arrhythmias matter?

“I just feel a little funny”
VA post-LVAD is associated with higher morbidity

- Pain/trauma of ICD shocks
- RV failure
  - From VA: incidence of RV failure 45% in patients with early VA (versus 23% without) in one cohort
  - From shocks: multiple ICD shocks associated with dramatically higher incidence of acute RV failure, compared with ATP alone or single shock (50 v. 4%)

Frequent need for RVAD, inhaled pulmonary vasodilator, inotrope

“Stable” VT is not tolerated indefinitely

VA post-LVAD is associated with more re-admissions

VA post-LVAD is associated with higher risk of death
VA post-LVAD is associated with higher risk of death

![Graph showing probability of death over follow-up years](image)

**Table 3** Multivariate analysis: Predictors of death in LVAD patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>HR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-LVAD VTAs</td>
<td>7.28</td>
<td>3.50–15.15</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>3.04</td>
<td>1.45–6.33</td>
<td>.003</td>
</tr>
<tr>
<td>Left ventricular ejection fraction</td>
<td>1.06</td>
<td>1.02–1.11</td>
<td>.002</td>
</tr>
</tbody>
</table>

Variables included in this model were age, atrial fibrillation, left ventricular ejection fraction, hypertension, male sex, blood urea nitrogen level, history of ischemic cardiomyopathy, diabetes mellitus, and post-LVAD VTAs.

CI = confidence interval; HR = hazard ratio; LVAD = left ventricular assist device; VTA = ventricular tachyarrhythmia.

Possible precipitants of early post-op events (Columbia)

![Pie chart showing possible precipitants](image)

Events with no clear precipitant: 79% occurred in patients with pre-operative VA
Ischemia Pre-LVAD VT/VF predicts early post-op VA

Garan AR et al. J Heart Lung Transplant 2015; 34(12): 1611-6

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.64</td>
<td>1.02-2.64</td>
<td>0.04</td>
</tr>
<tr>
<td>Non-ischemic</td>
<td>2.47</td>
<td>1.05-5.83</td>
<td>0.040</td>
</tr>
<tr>
<td>INTERVENT 1 or 2</td>
<td>3.48</td>
<td>0.76-16.50</td>
<td>0.09</td>
</tr>
<tr>
<td>Pre-LVAD VT/VF</td>
<td>3.78</td>
<td>0.99-14.59</td>
<td>0.05</td>
</tr>
</tbody>
</table>

*CI = confidence interval; VT/VF = ventricular tachycardia/ventricular fibrillation; INTERVENT = intervention.

Pre-LVAD VT/VF also predicts late post-op VA

Garan AR et al. JACC 2013; 61(25): 2542-50

<table>
<thead>
<tr>
<th>Variable</th>
<th>HR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior VT/Atrial fibrillation</td>
<td>3.06</td>
<td>1.57-5.96</td>
<td>.001</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>3.13</td>
<td>1.60-6.11</td>
<td>.008</td>
</tr>
</tbody>
</table>

Variables included in this model were as follows: prior VT/A, atrial fibrillation, age, blood urea nitrogen level, diabetes mellitus, history of ischemic cardiomyopathy, left ventricular ejection fraction, and history of stroke/transient ischemic attack.

CI = confidence interval; HR = hazard ratio; LVAD = left ventricular assist device; VTA = ventricular tachyarrhythmia.
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ICD sensing in the RV decreases after LVAD implant

- 21% of patients had R-wave sensing <5 mV post-LVAD

Defibrillation threshold may increase

- Disruption of ICD lead
- Re-orientation of heart relative to shock vector
- Amiodarone use
- Shunting of energy away from myocardium*
- Natural history of end-stage cardiomyopathy?

*Thomas IC, Moss JD et al; PACE 2014; 37:464-72
Potential remedies for high DFT

1. **ICD reprogramming**
   - Higher initial energy
   - Different shock vector
   - “Tuned” waveform

Flatley EE...Moss JD et al. In preparation 2016

2. **Device revision**

Flatley EE...Moss JD et al. In preparation 2016

3. **LVAD optimization**

Hemodynamic Ramp Tests in Patients With Left Ventricular Assist Devices

Nel Sip, MD, MSc; Gabriel Sayer, MD; Karina Abdullia, MD; Savirni Fedoren, MD; Gene H. Kim, MD; Daniel Rodgers, BA; Eric Kneer, RDCS; Keith Collins, RDCS; Sairat Adhaya, MD; Mishu Samavat, MD; Ulrich P. Jorde, MD; Colleen Jurick, RN; Takeshi Ota, MD, PhD; Yuhrae Jeewondeun, MD; Daniel Bushlof, MD, PhD; Roberto M. Lang, MD

*Am Coll Cardiol HF* 2016; 4(3): 208-17

1. **ICD reprogramming**
2. **Device revision**
3. **LVAD optimization**

8000 RPM

12000 RPM
Do ICDs reduce mortality? Needs further study…

Survival

Days

85 patients, 1996-2003
ICD
No ICD

P = 0.009

478 patients, 1991-2008
ICD
No ICD

P = 0.024

80 patients, 1996-2003
ICD
No ICD

P = 0.01

478 patients, 1991-2008
ICD
No ICD

P = 0.024

Absence of pre-op VA confirmed low risk of post-op VA (4.0% vs. 45.5%, p < 0.001)

Pre-existing ICD?

Yes

No

Pre-Operative VA

Yes

No

Maintain ICD

No Generator Replacement

2nd Prevention ICD

No ICD Implantation

Do ICDs reduce mortality? Needs further study…

Controversies in Arrhythmia and Electrophysiology

Is Defibrillation Testing Necessary for Implantable Transvenous Defibrillators?

Defibrillation Testing Should Not Be Routinely Performed at the Time of Implantable Cardioverter Defibrillator Implantation

Jeff S. Healey, MD, MSc; Michelle Brunetti, MD

Circ Arrhythm Electrophysiol 2014; 7: 337-46 and 347-51
University of Chicago practice

**Clinical**
1. Pre- and post-operative device interrogation
2. Elective DFT testing at time of first post-op ramp study (~30-90 days post-implant)
3. Device reprogramming and/or revision on an individual patient basis

**Research**
1. DFT registry
   - Pre- and post-op CXR
   - Device interrogation
2. Animal studies on shock energy distribution with LVAD being planned

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Therapeutic options for late ventricular arrhythmias

- Medical therapy

Therapeutic options for late ventricular arrhythmias

- Medical therapy
- Sympathetic denervation
Therapeutic options for late ventricular arrhythmias

- Medical therapy
- Sympathetic denervation
- Transplant (if it’s an option)

Ablative therapy for VT post-LVAD

Procedural considerations

- Access:
  - Difficult retrograde aortic access and/or exacerbation of aortic insufficiency
  - Trans-septal puncture into decompressed LA
  - Barriers to epicardial ablation
- Mapping
  - Fluoroscopic barriers
  - Electromagnetic interference
- Minimization of peri- and post-procedural risks
  - Continuous anticoagulation (esp. venous-only access)
  - Surgical backup
Access – retrograde considerations

Access – ICE guided trans-septal

Access – ICE guided trans-mitral

Ablative therapy for VT post-LVAD

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Mapping – fluoroscopic barriers

LV lead
Trans-septal sheath
RA lead
ICE catheter
Ablation catheter
Sternal transverse
Temporary RV pacing catheter
Driveline
HeartWare HVAD
RV ICD lead

Mapping – ICE guided

First 22 patients
Inducible VT’s

LVAD facilitates VT ablation…

Management of Ventricular Arrhythmias in Patients with VADs

Ventricular Arrhythmias after LVAD

Moss JD et al. In preparation

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LVAD facilitates VT ablation…
(78% of patients free from any ICD shock at 6 months)
…but prognosis may be poor for those who need it

Facilitation of rapid VT entrainment

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Reports of intra-operative ablative therapy

  - 2 patients with intractable VA despite AAD & ablation referred for LVAD
  - Epicardial ablation based on pre-operative mapping and EKG analysis
  - Endocardial lesions via apical ventriculotomy on 1 of 2
  - No VT over 4 months

  - 14/50 patients undergoing HM II LVAD with recurrent pre-operative VA
  - 7 underwent cryoaablation (epi, endo via ventriculotomy); 7 did not
  - Cryo group had decreased post-operative “resource” use and complications. No recurrent post-op VA in any ablation patients.

Intra-operative epicardial mapping – hypotheses:

- Open-chest epicardial electroanatomic mapping at the time of LVAD implant will facilitate prediction of post-implant ventricular arrhythmias
- Empiric epicardial ablation, guided by intraoperative mapping, will reduce post-LVAD arrhythmia burden

Intra-operative epicardial mapping – protocol:

1. EnSite Velocity™ mapping system (St. Jude Medical) used
   - Patch pairs placed around abdomen (rather than chest)

2. Sterile gel or warmed saline used for improved conductivity between electrode catheter and epicardial surface
Findings: feasibility and technique

- 21 patients mapped in first 10 months; 0 complications

<table>
<thead>
<tr>
<th>Development Cohort</th>
<th>Analysis Cohort</th>
</tr>
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<tbody>
<tr>
<td>Number of patients</td>
<td>11 (mean f/u 222 days)</td>
</tr>
<tr>
<td>Ischemic etiology</td>
<td>1/11 (9%)</td>
</tr>
<tr>
<td>Median locations sampled</td>
<td>779 (IQR 225-1001)</td>
</tr>
<tr>
<td>Mean mapping time</td>
<td>9.1 minutes</td>
</tr>
</tbody>
</table>

Findings: clinical observations

<table>
<thead>
<tr>
<th>VT/VF post-LVAD</th>
<th>No VT/VF post-LVAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>2/10</td>
</tr>
<tr>
<td>Area of abnormal epicardial voltage</td>
<td>0-2 cm²</td>
</tr>
<tr>
<td>Burden of scar with fractionation or LPs</td>
<td>0%</td>
</tr>
</tbody>
</table>

Late potential (LP)
Conclusions

1. Ventricular arrhythmias (VA) post-LVAD are associated with increased morbidity and mortality
2. The major predictor of VA post-LVAD is pre-operative VA
   - Electrolyte disturbances, inotropes, and cannula issues should be considered
3. Changes in ICD function post-LVAD are common
   - Diminished R-wave sensing, possible DFT elevation
   - Institutional protocols important, but ICD management can and should be individualized
4. VT ablation after LVAD implant is safe and effective when performed by experienced operators
5. Pre- and intra-operative mapping and ablation may help reduce post-LVAD morbidity and mortality...
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5/9/2016