Medical Management of VAD Patients

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I will discuss off label use and/or investigational use of products.

The following relevant financial relationships exist: None.
Prevalence of Heart Failure

Current Estimate of Stage D Patients

310 million US population

2% with HF => ~ 6 million

55% with DHF
~ 3-3.5 million

45% with SHF
~ 2.5-3 million

NYHA class IIIB/IV and < 75 years
~ 150,000 pts

VADs as BTT/ DT

35% NYHA class I
35% NYHA class II
20% NYHA class IIIA
5% NYHA class IIIB
5% NYHA class IV

Longterm Assist Devices

- Pulsatile flow with valve volume displacement (Heart Mate XVE, Novacor)
- Continuous axial flow (Heart Mate II)
- Continuous centrifugal flow (HeartWare)
Longterm Assist Devices

Impact on Organ Function

- 309 pts in HMII BTT and CAP
- Baseline:
  - ~50 yo
  - EF 16%, LVEDD 70 mm
  - 89% on inotrope
  - 44% on IABP
  - CI 2.1, PCW 25

QOL and Functional Capacity

QOL and Functional Capacity

**KCCQ**

**Clinical Summary | Overall Summary**

- **Δ** = +77%
- **Δ** = +106%
- **Δ** = +106%
- **Δ** = +91%

**EQ-5D VAS**

- **Δ** = +106%

**6 Min Walk**

- **Δ** = +91%

Mean Distance (m)

- Baseline: 43
- 3 Months: 76
- Baseline: 33
- 3 Months: 68
- Baseline: 33
- 3 Months: 68
- Baseline: 124
- 3 Months: 237

All paired differences p<0.001

VAD pulls blood from LV -> pumps in ascend Ao

RV functions to fill the VAD

LV becomes giant atrium

VAD Physiology: Heart Mate II

- Power: amount of energy required to rotate the impeller (watts) – measured.
- RPM: speed of the impeller – set by operator.
- Flow: pump output (L/min) – assumed, not measured.
- Pulsatility index (PI): indirect measure of contribution of native ventricular contraction to VAD filling – assumed, not measured.
Physiologic Goals for VAD Function

- Maximize output (days)
- Reduce LV filling pressures (days)
- Decrease LV size (over time)
- Reduce PA pressures (over time)
- Avoid suction events
- Keep aortic valve
Physiologic Goals for VAD Function

• Maximize output (days)
• Reduce LV filling pressures (days)
• Decrease LV size (over time)
• Reduce PA pressures (over time)

• Avoid suction events

• Keep aortic valve open/ closed/ partially open?
VAD Knowhow

• Low end of speed
  – AoV opens with every beat
  – No HF symptoms

• High end of speed
  – Septal flattening
  – AoV closed

• Optimal speed
  – Mid point
  – Intermittent AoV opening

Adverse Events with VADs

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Continuous-Flow LVAD (N=133) (211 patient-yr)</th>
<th>Pulsatile-Flow LVAD (N=59) (41 patient-yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no. (%)</td>
<td>no. of Events/Patient-Yr</td>
</tr>
<tr>
<td>Pump replacement</td>
<td>12 (9)</td>
<td>0.06</td>
</tr>
<tr>
<td>Stroke</td>
<td>24 (18)</td>
<td>0.13</td>
</tr>
<tr>
<td>Ischemic</td>
<td>11 (8)</td>
<td>0.06</td>
</tr>
<tr>
<td>Hemorrhagic</td>
<td>15 (11)</td>
<td>0.07</td>
</tr>
<tr>
<td>LVAD-related infection</td>
<td>47 (35)</td>
<td>0.48</td>
</tr>
<tr>
<td>Local non-LVAD infection</td>
<td>65 (49)</td>
<td>0.76</td>
</tr>
<tr>
<td>Sepsis</td>
<td>48 (36)</td>
<td>0.39</td>
</tr>
<tr>
<td><strong>Bleeding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleeding requiring PRBC</td>
<td>108 (81)</td>
<td>1.66</td>
</tr>
<tr>
<td>Bleeding requiring surgery</td>
<td>40 (30)</td>
<td>0.23</td>
</tr>
<tr>
<td>Other neurologic event</td>
<td>29 (22)</td>
<td>0.17</td>
</tr>
<tr>
<td><strong>Right heart failure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managed with extended use of inotropes</td>
<td>27 (20)</td>
<td>0.14</td>
</tr>
<tr>
<td>Managed with RVAD</td>
<td>5 (4)</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Cardiac arrhythmia</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managed with extended use of inotropes</td>
<td>75 (56)</td>
<td>0.69</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>50 (38)</td>
<td>0.31</td>
</tr>
<tr>
<td>Renal failure</td>
<td>21 (16)</td>
<td>0.10</td>
</tr>
<tr>
<td>Hepatic dysfunction</td>
<td>3 (2)</td>
<td>0.02</td>
</tr>
<tr>
<td>LVAD thrombosis</td>
<td>5 (4)</td>
<td>0.02</td>
</tr>
<tr>
<td>Rehospitalization</td>
<td>107 (94)</td>
<td>2.64</td>
</tr>
</tbody>
</table>

RV Failure: Identification/ Avoidance

• Pre implant risk prediction of RV failure is difficult.
• RV failure post VAD implant:
  – Higher length of stay, higher ICU stay.
  – End organ dysfunction, higher mortality.
• Measures of RV function:
  – Echo: RV size, fractional area change, RVESD, TAPSE
  – Cath: CVP, PAP, RVSWI [(PAM-CVP) x SVI]
• Multivariate models of risk prediction of post op RV failure/ need for RVAD (Michigan, Penn).
# RV Failure: Avoidance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Desirable value(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVSWI</td>
<td>(&gt; 300 \text{ mm Hg} \times \text{ml/m}^2)</td>
</tr>
<tr>
<td>Central venous pressure</td>
<td>(&lt; 15 \text{ mm Hg})</td>
</tr>
<tr>
<td>Tricuspid regurgitation</td>
<td>Minimal to moderate</td>
</tr>
<tr>
<td>Pulmonary vascular resistance</td>
<td>(&lt; 4 \text{ Woods units})</td>
</tr>
<tr>
<td>Transpulmonary gradient</td>
<td>(&lt; 15 \text{ mm Hg})</td>
</tr>
<tr>
<td>RV size</td>
<td></td>
</tr>
<tr>
<td>RVEDV</td>
<td>(&lt; 200 \text{ ml})</td>
</tr>
<tr>
<td>RVESV</td>
<td>(&lt; 177 \text{ ml})</td>
</tr>
<tr>
<td>Need for pre-op ventilator support</td>
<td>None</td>
</tr>
</tbody>
</table>

RV Failure: Identification

• Clinical diagnosis:
  – Hypotension, low urine output, high JVP

• Hemodynamics:
  – Poor VAD flows (< 3 L/min)
  – Low CO, high CVP on Swan-Ganz cath.

• Echo:
  – RV enlargement, RV free wall not moving, TAPSE very low

• Caveat: hypovolemia/ bleeding & tamponade mimic !!
rv failure: management

- prevention key: go in dry, not vasodilated, with good RV!

- intra-op:
  - iNO 5 ppm, lower tidal volumes, isoproterenol, milrinone/dobutamine, vasopressin to keep MAP > 75, avoid RV flooding with PRBC/FFPs/Platelets.

- post-op:
  - iNO 20 ppm x 24-48 hrs, milrinone/dobutamine, AV pacing.
  - drop VAD speed to “unload” RV into LV, allow septal bounce.
  - open chest, RVAD if needed.
Anticoagulation with VADs

• Historical Heart Mate II:
  – High thrombosis rate, pump was redesigned.
  – Establishing high INR 2.5-3.5 (Expert Opinion).

• Current practice Heart Mate II:
  – No post-op heparin or start very low after 48 hrs (PTT 40-50”).
  – Start warfarin and ASA when chest tube drain minimally or out.
  – Goal INR 1.5 – 2.5 (HeartWare may be higher).
  – OK to stop for elective surgeries temporarily (HeartWare ?)

GI Bleeding with VADs: Common

- 101 pts at Mayo
- 46 XVE
- 55 HM II
- Higher bleeding with CF VADs

GI Bleeding with VADs

Table 5: von Willebrand Factor Levels (n = 31)

<table>
<thead>
<tr>
<th></th>
<th>During VAD Use</th>
<th>After HT</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased or absent VW multimers</td>
<td>100%</td>
<td>0%</td>
<td>0.001</td>
</tr>
<tr>
<td>VW antigen</td>
<td>203.5 ± 107.1, median 187</td>
<td>309.5 ± 83.0, median 327</td>
<td>0.03</td>
</tr>
<tr>
<td>Ristocetin</td>
<td>102.4 ± 26.6, median 117</td>
<td>144.0 ± 53.7, median 120</td>
<td>0.009</td>
</tr>
</tbody>
</table>


GI Bleeding with VADs

• Mostly AVMs, rare gastric/duodenal ulcers.
• Diagnosis:
  – EGD (low yield if no pre-op history of PUD); colonoscopy (low yield if pre-op normal)
  – Capsule endoscopy
  – Tagged RBCs
  – Selective angiography
• Often no active bleeding, so nothing to treat.
GI Bleeding with VADs: Treatment

- INR goal (~ 1.5), some may need to come off warfarin.
- Eliminate ASA and keep low INR.
- Lower rpm to increase pulsatility and flow to watershed areas (mostly affected by AVMs).
- If low MAPs, decrease anti-hypertensive meds.
- PRBC transfusion if Hb < 8.
- *Octreotide for continuous bleeding (100-200 mg sc q 12 hrs, then 20 mg im depot)*.
- *Misoprostol (200 mcg TID).*
- *Premarin 0.3 mg daily*
Thrombosis with VADs: Rare

- Pretty bad, catastrophic most of the time.
- Stroke, peripheral emboli (leg, arm), pump stoppage.
- Hemolysis (high LDH, low haptoglobin, high plasma free Hb, high bilirubin).
- Increased power, increased flow.
- Loss of the VAD hum on exam, VAD “choking”.
- IR or cath lab to do TPA intra LV.
- Peripheral TPA, Integrilllin, bivalirudin -> bad bleeds….
- May require pump replacement.
Infections with VADs: Common

- 15-20% of pts in trials and registry.
- Percutaneous lead, pocket, systemic.
- High morbidity and mortality.
- Peri-op abx: vancomycin, fluconazole, +/- rifampicin (48 hrs usually), G negative coverage (institution specific).
- Nasal mupirocin pre-op, hexidine scrub pre-op x 2.
- Judicious arterial line, central line, PA catheter use.
- Correct percutaneous lead placement and stabilization.
Infections with VADs: Prevention

Nutrition
Operative technique (meticulous)
Tubes out

Drive line stabilization
Education
Ambulation
Drug therapy
Arrhythmias with VADs: VT

- **Causes:**
  - Underlying substrate: scar (ischemic pts).
  - Cannula position (towards septum or free wall instead of pointing towards mitral valve).
  - Suction events.
  - Electrolyte abnormalities.
  - Inotropic agents.

- **Assessment:**
  - ECG (12 lead: see VT location), telemetry, ICD interrogation, echo.

- **Treatment:**
  - Amiodarone, mexiletine, ICD reprogramming for ATP, ablation?
Hypertension with VADs

• Common; remember we measure MAPs.
• Goal MAPs 70-80 (afterload sensitive pumps).
• High MAPs (> 95-100) -> high stroke rates.
• Treatment:
  – ACE-I/ ARB if Cr and K stable.
  – Beta blocker only if RV function good (carvedilol better BP control).
  – Hydralazine, amlodipine.
  – Diuretics: carefully (VAD needs volume to fill).
Pulmonary HTN with VADs

- Majority of chronic heart failure pts have PH.
- VADs over time decrease LVEDP and PA pressures.
- May need to start sildenafil, especially if marginal RV function needing iNO post-op.
- If pre-VAD PH present, recheck PA pressures by echo after 6 months and if abnormal, consider right heart cath to confirm.
- Do not list unless PVR < 3 and PA pressures near normal.
- May need to continue sildenafil post transplant.
VADs: What Am I Taking Home?

- Reality of current heart failure practice and will increase.
- Not all VADs and pts are the same; management has nuances (“art more than science”).
- Optimizing pump speed allows symptomatic improvement, normalization of PA pressures, LV remodeling.
- Prevent RV failure and infection (nutrition !)
- Tailor anticoagulation to pts not to guidelines.
- Manage VT with meds and ICDs.
- Treat A Fib?
- Optimize BP control.
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