DOWN THE RABBIT HOLE OF MECHANICAL CIRCULATORY SUPPORT

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Conflicts of Interest

- I have no conflicts of interest to disclose
WHAT SHOULD I USE???
Learning Objectives

By the end of the session you should be able to:

1. Select appropriate treatment strategies for rapidly progressive heart failure
2. Develop strategies for indolent advanced heart failure
3. Effectively employ the use of temporary mechanical support or the use of durable support in patients with advanced heart failure
### Step 1 – Identify the Patient Profile for MCS

**Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS)**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Time to MCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>“Crashing and burning” – critical cardiogenic shock</td>
<td>Within hours</td>
</tr>
<tr>
<td>2</td>
<td>“Progressive decline” – inotrope dependence with continuing deterioration</td>
<td>Within a few days</td>
</tr>
<tr>
<td>3</td>
<td>“Stable but inotrope-dependent” – describes clinical stability on mild-moderate doses of intravenous inotropes (patients stable on temporary circulatory support without inotropes are within this profile)</td>
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<td>4</td>
<td>“Recurrent advanced heart failure” – “recurrent” rather than “refractory” decompensation</td>
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<td>5</td>
<td>“Exertion intolerant” – describes patients who are comfortable at rest but are intolerant of exercise</td>
<td>Variable</td>
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<td>6</td>
<td>“Exertion limited” – a patient who is able to do some mild activity but fatigue results within a few minutes or any meaningful physical exertion</td>
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<tr>
<td>7</td>
<td>“Advanced NYHA 3” – describes patients who are clinically stable with a reasonable level of comfortable activity, despite history of previous decompensation that is not recent</td>
<td>Not a candidate for MCS</td>
</tr>
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Step 2 – Identify the **Goal** of MCS Treatment

- Bridge to Decision/Bridge (BTD/BTB)
- Bridge to Candidacy (BTC)
- Bridge to Transplantation (BTT)
- Destination Therapy (DT)
- Bridge to Recovery (BTR)
Bridge to Decision/Bridge (BTD/BTB)

- Patients in Cardiogenic Shock with poor hemodynamics and end-organ perfusion
- Contra-indications for long-term MCS or Transplant may exist
  - Neurologic injury following resuscitation?
- Can be considered for **SHORT-TERM (TEMPORARY) MCS**
Short Term MCS Options for Biventricular Failure – ECMO/ECLS

VA-ECMO

Venous

Arterial

Antegrade Sheath
Short Term MCS Options for Biventricular Failure (BiVAD Support)
Short Term MCS Options for LV Failure (Impella or TandemHeart)
Bridge to Candidacy (BTC)

- Patients who are currently ineligible for heart transplantation due to a variety of reasons
  - End-organ function
  - Pulmonary Hypertension
  - Social Issues
- Can be considered for **MCS (usually LVAD)** to allow for the opportunity for anticipated future transplant candidacy
Bridge to Transplantation

• Patients who are at high risk of death while listed for heart transplantation
• Can be considered for **MCS (usually LVAD or BiVAD)** to keep them alive until a donor heart becomes available
Destination Therapy (DT)

- Patients with End-Stage Heart Failure who are ineligible for transplantation
- Can be considered for **MCS (durable LVAD)** as an alternative to transplantation
Bridge to Recovery (BTR)

- Patients who had profound and severe cardiac dysfunction that may be reversible and recover over time
- Can be considered for **MCS (usually LVAD, sometimes ECMO)**
## Current Long-Term MCS Options

<table>
<thead>
<tr>
<th>Device</th>
<th>FDA-Approved Indications</th>
<th>Pump Design and Speed Range</th>
<th>Pump Location</th>
<th>Pump Speed U/min of Flow</th>
<th>Device Illustration</th>
</tr>
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<tbody>
<tr>
<td>HeartMate II</td>
<td>BTT/DT</td>
<td>Biventricular flow</td>
<td>Pre-peritoneal space</td>
<td>Up to 10,500 rpm</td>
<td><img src="image1" alt="Illustration" /></td>
</tr>
<tr>
<td>Thoratec Corp./St. Jude Medical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HeartWare HVAD</td>
<td>BTT/DT</td>
<td>Biventricular flow</td>
<td>Thoracic cavity</td>
<td>Up to 7,000 rpm</td>
<td><img src="image2" alt="Illustration" /></td>
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<tr>
<td>HeartWare International, Inc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HeartMate III</td>
<td>Under investigation</td>
<td></td>
<td>Thoracic cavity</td>
<td>Up to 8,000 rpm</td>
<td><img src="image3" alt="Illustration" /></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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*The PAST*
Indications for Long-Term MCS

- NYHA IIIb/IV and Stage D Heart Failure
- INTERMACS Profile 2-4

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Outcomes of Long-Term MCS - BTT

Multicenter clinical evaluation of the HeartMate vented electric left ventricular assist system in patients awaiting heart transplantation

Figure 2. Probability of survival to transplantation for VE LVAS-treated versus control patients.

Figure 3. Probability of 1-year post-transplantation survival for VE LVAS-treated versus control patients.
Outcomes of Long-Term MCS - BTT

Seventh INTERMACS annual report: 15,000 patients and counting
J Heart Lung Transplant 2015;34:1495–1504

Continuous Flow LVAD/BiVAD Implants: 2008 – 2014, n=12030

BTT: Listed CFLVADs implants 2013-2014, n=1357

Outcome | % at 1 year
---|---
Alive (device in place) | 55%
Transplanted | 31%
Dead | 13%
Recovery | 1%

Proportion of Patients

Months after Implant

Bridge to Transplant Listed and Destination Therapy by Era

% Survival

Months post implant

Event: Death (censored at transplant and recovery)

p < .0001

DT: 2012-2014
N=3243, deaths= 863

BTT Listed: 2012-2014
N=1751, deaths=215

BTT Listed: 2008-2011
N=1528, Deaths= 344

DT: 2008-2011
N=1355, deaths=682
Outcomes of Long-Term MCS - DT

Advanced Heart Failure Treated with Continuous-Flow Left Ventricular Assist Device

Mark S. Slaughter, M.D., Joseph G. Rogers, M.D., Carmelo A. Milano, M.D.,
Stuart D. Russell, M.D., John V. Conte, M.D., David Feldman, M.D., Ph.D.,
Benjamin Sun, M.D., Antoine J. Tatooles, M.D., Reynolds M. Delgado, III, M.D.,
James W. Long, M.D., Ph.D., Thomas C. Wozniak, M.D.,
Waqas Ghumman, M.D., David J. Farrar, Ph.D., and O. Howard Frazier, M.D.,
for the HeartMate II Investigators*


Figure 2. Kaplan-Meier Estimates of Survival from the As-Treated Analysis, According to Treatment Group.
Outcomes of Long-Term MCS - DT

Figure 6. Inference of the survival benefit of current destination therapy with current continuous-flow left ventricular assist device (LVAD) compared with medical management from the REMATCH trial. HMII indicates HeartMate II. (Circ Heart Fail. 2012;5:241-248.)
Limitations of Long-Term MCS – Pre-operative

- **Consideration of Valves**
  - **Aortic Insufficiency (>Mild) will cause recirculation**
    - Needs to be addressed at time of implant
      - Closure (Park’s stitch)
      - Circular patch closure
      - Bioprosthetic Valve Replacement
  - **Mitral Stenosis will impede inflow**
  - **Severe TR is usually corrected…Moderate TR sometimes**
  - **Mechanical Valves usually need to be replaced with Bioprostheses or Closed with a Patch due to risk of thrombosis & embolic events**
  - **ALL Intracardiac shunts (PFO/ASD/VSD) need to be repaired**
Limitations of Long-Term MCS - Preoperative

- **RV Dysfunction**
  - Long-Term RV MCS is challenging because a dedicated implantable RVAD does not currently exist
  - RV failure after a DT VAD is a MAJOR problem
  - Pre-operative predictors of RV Failure post LVAD
    - Right Ventricular Stroke Work Index (RVSWI)
    - Pulmonary Artery Pulsatility index (PAPi)
    - RA:PCWP ratio
Limitations of Long-Term MCS – Post-operative

Continuous Flow LVAD/BiVAD Implants: 2008 – 2014, n=12030

Instantaneous Death Rate (Hazard) for selected causes

- Cause of Death
  - Infection
  - RHF
  - Neurological
  - Device Malfunction
  - MSOF

![Graph showing death rate by cause over time](image-url)
## Limitations of Long-Term MCS – Post-operative

### Table 5: Adverse Event Rates (Events/100 patient months) in the First 12 Months Post-implant by Era for CF LVADs/BIVADs (n = 12,030)

<table>
<thead>
<tr>
<th>Adverse Event</th>
<th>Era 1 (n = 4,744):</th>
<th>Era 2 (n = 7,286):</th>
<th>Era 1 vs Era 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Rate</td>
<td>Events</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleeding</td>
<td>3,932</td>
<td>9.41</td>
<td>4,420</td>
</tr>
<tr>
<td>Cardiac/vascular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right heart failure</td>
<td>238</td>
<td>0.57</td>
<td>276</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>29</td>
<td>0.07</td>
<td>34</td>
</tr>
<tr>
<td>Cardiac arrhythmia</td>
<td>2,007</td>
<td>4.80</td>
<td>2,303</td>
</tr>
<tr>
<td>Pericardial drainage</td>
<td>271</td>
<td>0.65</td>
<td>305</td>
</tr>
<tr>
<td>Hypertension</td>
<td>182</td>
<td>0.44</td>
<td>115</td>
</tr>
<tr>
<td>Arterial non-CNS thrombosis</td>
<td>70</td>
<td>0.17</td>
<td>94</td>
</tr>
<tr>
<td>Venous thrombotic event</td>
<td>304</td>
<td>0.73</td>
<td>286</td>
</tr>
<tr>
<td>Hemolysis</td>
<td>200</td>
<td>0.48</td>
<td>314</td>
</tr>
<tr>
<td>Infection</td>
<td>3,435</td>
<td>8.22</td>
<td>4,132</td>
</tr>
<tr>
<td>Stroke</td>
<td>487</td>
<td>1.17</td>
<td>916</td>
</tr>
<tr>
<td>Renal dysfunction</td>
<td>601</td>
<td>1.44</td>
<td>876</td>
</tr>
<tr>
<td>Hepatic dysfunction</td>
<td>246</td>
<td>0.59</td>
<td>326</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1,104</td>
<td>2.64</td>
<td>1,551</td>
</tr>
<tr>
<td>Wound dehiscence</td>
<td>81</td>
<td>0.19</td>
<td>96</td>
</tr>
<tr>
<td>Psychiatric episode</td>
<td>486</td>
<td>1.16</td>
<td>525</td>
</tr>
<tr>
<td>Total burden</td>
<td>13,673</td>
<td>32.72</td>
<td>16,569</td>
</tr>
</tbody>
</table>

BiVAD, biventricular assist device; CF, continuous flow; CNS, central nervous system; LVAD, left ventricular assist device.
Limitations of Long-Term MCS – Post-operative

Table 6  CF LVAD/BiVAD Implants: 2008 to 2014 (n = 12,030), Levels 1 to 3 (n = 9,781, deaths = 2,596)

<table>
<thead>
<tr>
<th>Primary cause/mode of death</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologic event</td>
<td>466</td>
<td>18.0</td>
</tr>
<tr>
<td>Multisystem organ failure</td>
<td>406</td>
<td>15.6</td>
</tr>
<tr>
<td>Withdrawal of support, specify</td>
<td>271</td>
<td>10.4</td>
</tr>
<tr>
<td>Major infection</td>
<td>228</td>
<td>8.8</td>
</tr>
<tr>
<td>Other, specify</td>
<td>135</td>
<td>5.2</td>
</tr>
<tr>
<td>Respiratory: respiratory failure</td>
<td>124</td>
<td>4.8</td>
</tr>
<tr>
<td>Circulatory: right heart failure</td>
<td>117</td>
<td>4.5</td>
</tr>
<tr>
<td>Circulatory: sudden unexplained death</td>
<td>111</td>
<td>4.3</td>
</tr>
<tr>
<td>Device malfunction</td>
<td>92</td>
<td>3.5</td>
</tr>
<tr>
<td>Circulatory: CHF</td>
<td>85</td>
<td>3.3</td>
</tr>
</tbody>
</table>

BiVAD, biventricular assist device; CF, continuous flow; CHF, congestive heart failure.
Limitations of Long-Term MCS – Post-operative

* Major Event: First occurrence of infection, bleeding, device malfunction, stroke or death

Levels 4-7, n=2189
Events=1620

Level 1: n=1798
Events=1356

Levels 2 & 3: n=7948
Events=5706

P(overall) < .0001
Key Learning Points

1. Identify INTERMACS Patient Profile to guide timing and type of MCS to consider
2. Long-Term MCS is indicated in INTERMACS 2 to 4 patients and NOT Level 1 “Crash and Burn” patients
3. Long-Term MCS improves survival to transplant in BTT
4. Long-Term MCS improves survival in DT eligible patients
5. Bleeding, Stroke and Infection complications limits the efficacy of Long-Term MCS