Mechanical Circulatory Support (MCS) in 2017: What is New and Different?

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Disclosures

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  - Co-Founder
- CR Bard
  - Consultant
- Medlaunch Solutions
  - Co-Founder

Objectives

- CASE REVIEW
- Identify indications for Left-sided Ventricular Assist Device Therapy
  - Available devices
- Discuss mechanism and function of Ventricular Assist Device
- Review current LVAD data and Updates
- Review indications for Extracorporeal Membrane Oxygenation and Right-sided Support (Tandem Heart)
- Bryan Health VAD Program Update
Case Review

- 69 year old divorced female
- PMH: ICM, Chronic HFrEF with at least 10 hospitalizations in one year for HF and SOB - some requiring intubation, COPD, CAD with stents and bypass, PVD, decreased social support
- Presents to local ER, requires intubation again; transferred to Bryan East for further management
- VAD team consulted again (work up was already completed - just trying to decide the risks of surgery and waiting on RUL nodule biopsy)
- Inotrope Dependent with Milrinone, NYHA 4, Failed OMM, pVO2 12.1, EF 15%

VAD Multidisciplinary Team discussed her case thoroughly, as well as discussion took place with UNMC and University of Colorado teams
- Both sites stated they would not do her implant due to her high stroke risk and decreased social support
- Issues our center identified prior to implant: Social Support, INTERMACS class 2, Unclear cannulation sites due to significant PVD, Calcific Aorta, Stroke rate higher
- Gave 50% mortality risk first 30 days; 25-40% stroke risk

Implanted January 2016 (total hospital stay: 38 days)
- Required Temporary RVAD support for RV Failure - Removed on Day 3
- Gained nearly 55#s of fluid weight (and most was in her upper torso and face)
  - Reason for Tracheotomy (and J tube) for Airway Protection above all else
- Inotropes for 11 days
- Discharged to Long Term Acute Care Unit day 21 for trach management and de-cannulation efforts, strengthening (there for 27 days)
- Needed a brief IR visit for a PICC line removal as it was stuck
- Underwent intensive rehab at Bryan West Rehabilitation (there for 13 days)
Heart Failure is **EXPENSIVE!!**

- Currently:
  - "Heart failure costs the nation an estimated $32 billion each year. This total includes the cost of health care services, medications to treat heart failure, and missed days of work" (CDC, 2015).
  - The PROJECTION?
    - "By 2030, >8 million people in the United States (1 in every 33) will have HF. Between 2012 and 2030, real (2010$) total direct medical costs of HF are projected to increase from $21 billion to $53 billion. Total costs, including indirect costs for HF, are estimated to increase from $31 billion in 2012 to $70 billion in 2030" (Heidenreich et al, 2013).

Who should be referred? (Sooner Always Better)...

- NYHA Class IIIB or IV with more than one of the following:
  - Unable to walk < 1 block without dyspnea
  - LVEF <35%
  - 1 Heart Failure admission in the past 6 months
  - Intolerance to ACEI/ARB/Beta Blockers
  - Furosemide dose >1.5 mg/kg/day
  - CRT non-responder Worsening renal function with diuresis
  - Na <136, BUN > 40, Cr >1.5
  - Inotrope dependent

*Of Note: Transplant Guidelines and Criteria changing*

Spring 2018: REFER SOONER as they will wait longer.
True LVAD Indications (Destination Therapy)

- NYHA Class 4 symptoms ("3B" depending on insurance type)
- Ejection Fraction <25%
- Failed Optimal Medical Management for Heart Failure (BB, ACE/ARB, Diuretics, Aldactone, BIV AICDs) for 45 of the last 60 days
  - ie: Any recurrent hospitalizations? Worsening Kidney Function?
- Inotrope Dependency
- Functional Limitation with a peak MVO2 <14 ml/kg/min
- Intolerance to one or more of the traditional HF medication treatments
- Balloon Pump Support

**INTERMACS helps in determining outcomes...**

<table>
<thead>
<tr>
<th>INTERMACS</th>
<th>DESCRIPTION</th>
<th>NYHA CLASS</th>
<th>TIME TO MCS THERAPY</th>
<th>AHA/ACC STAGING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crash and Burning patient</td>
<td>IV Within HOURS</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Progressive Decline on Inotropic Support</td>
<td>IV Within a few DAYS</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Stable but on Inotrope Support</td>
<td>IV Within a few WEEKS</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Recurrent advanced Heart Failure; resting symptoms at home on oral therapy</td>
<td>Ambulatory IV* Within in WEEKS to MONTHS</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Exertion Intolerance</td>
<td>Ambulatory IV*</td>
<td>Variable</td>
<td>D</td>
</tr>
<tr>
<td>6</td>
<td>Exertion Limited or Walking Wounded</td>
<td>Ambulatory IV*</td>
<td>Variable</td>
<td>C-D</td>
</tr>
<tr>
<td>7</td>
<td>Advanced HF III IIIB</td>
<td>IV</td>
<td>Variable</td>
<td>C-D</td>
</tr>
</tbody>
</table>

Early referral are key in how the patient will do after surgery... Our Goal is INTERMACS 3, 4, or 5

Class 3B Heart Failure Symptoms Vs Class 4: Does it Really Make a Difference? ABSOLUTELY!!

<table>
<thead>
<tr>
<th>NEW YORK HEART ASSOCIATION (NYHA) CLASSES</th>
<th>NYHA class I</th>
<th>NYHA class II</th>
<th>NYHA class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>NYHA class I</td>
<td>No limitation on physical activity</td>
<td>No exertional symptoms</td>
<td>No limitations on physical activity</td>
</tr>
<tr>
<td>NYHA class II</td>
<td>Slight limitation on physical activity</td>
<td>No exertional symptoms</td>
<td>No limitations on physical activity</td>
</tr>
<tr>
<td>NYHA class III</td>
<td>Marked limitation on physical activity</td>
<td>No exertional symptoms</td>
<td>No limitations on physical activity</td>
</tr>
<tr>
<td>NYHA class IV</td>
<td>Marked limitation on physical activity</td>
<td>Some exertional symptoms</td>
<td>No limitations on physical activity</td>
</tr>
<tr>
<td>NYHA class V</td>
<td>Marked limitation on physical activity</td>
<td>Severe exertional symptoms</td>
<td>No limitations on physical activity</td>
</tr>
</tbody>
</table>

- NYHA class 3A: Severe limitation on physical activity
- NYHA class 3B: Extreme limitation on physical activity
- NYHA class 3C: Unable to carry on any physical activity
- NYHA class 4: Symptomatic systolic heart failure
Heart Failure Treatments based on NYHA Class

- **HeartMate II (HM2):** Continuous Flow
  - Implant in the most patients in the world
  - Only device fully FDA approved with both BTT and DT indications
- **HeartMate 3 (HM3):** Magnetically Levitated Flow adding Artificial Pulse
  - Smaller and appearing to be more reliable
  - Under Investigation (MOMENTUM 3 trial)
- **HeartWare (HVAD):** Centrifugal Flow
  - Smaller device
  - FDA Approved for BTT indication; Awaiting FDA final approval for DT indication
  - Higher stroke rate in patients with inadequately managed blood pressure

Common Devices Available:

- **HeartMate II (HM2):** Continuous Flow
  - Only FDA-approved LVAD device for Destination Therapy Patients

Mechanism of HeartMate II: Continuous Flow
Mechanism of HeartMate 3: Fully Mag Lev

Still under investigation through MOMENTUM 3 study—Expecting FDA approval for Bridge to Transplant indication soon

Initial 6-month data demonstrated a ZERO reoperation rate in this device for pump thrombosis or malfunction, and <1% reoperation rate for bleeding (compared to 2.3%) [14]

Main Flow

Inlet Recirculation

Shroud Recirculation

HeartMate 3

* Rotary pumps have determined that a pulse is not needed for survival
* Augmenting pulsatility that is generally diminished in rotary pump patients may have benefit for some patients or in certain circumstances
* May address adverse events such as aortic insufficiency, bleeding, and thrombogenesis
* The HeartMate III centrifugal blood pump is capable of very sharp speed changes
* “Artificial pulse” feature initiated and has so far in pre-clinical studies proved to contribute negligible hemolysis and require low incremental power consumption

HeartWare (HVAD):

Centrifugal Flow

For small-framed patients
  • Can place by thoracotomy approach if needed
  • No pump pocket
  • More driveline exit site options (right, left, even cranial for swimmers)
  • ENDURANCE Supplement: Trial data presented, awaiting FDA approval

Mechanism of HeartWare (HVAD): Centrifugal Flow

3. Courtesy of St. Jude Medical

3. Courtesy of HeartWare, Inc
Surgical Pictures of HM2: INTERMACS 1 to 4

INTERMACS 3: 62 yr old
Up AR, CAD, Malt
Increased after 2 days

INTERMACS 4: 73 yr old
Discharged home in 10 days

VAD “Need to Knows”...

- Tend to only fix the Aortic Valve if stenosis or regurgitation present
- Will likely fix patent foramen ovale if present
- Generally don’t touch the Mitral Valve regurgitation as this will improve with therapy
- WATCH INR’s closely with general goal range of 2-3 (but prefer 2-2.5)
- VAD Coordinators generally monitor this
- May not feel a pulse or get an automatic cuff blood pressure (Doppler pressure needed)
- Major side effects always to watch for:
  - Bleeding (GI Bleeds, Epistaxis, Brain Bleeds)
  - Clotting (Strokes, Clots in the pump)
  - Infection (most specifically at the driveline site)
  - *Watch for Depression*
  - NO COMPRESSIONS unless direct order received

Previous Studies Reviewed...

1. **REMATCH** (HeartMate XVE versus Medical Therapy)\(^{(2001)}\)
   - 1 year survival: Device group 52% versus Medical Therapy group 25%
   - 2 year survival: Device group 23% versus Medical Therapy group 8%
   - 48% reduction in death in Device Group

2. **HeartMate II Destination Therapy Pivotal Trial** (2005)
   - Randomized to HeartMate XVE versus HeartMate II
   - Goal was to determine safety of HeartMate II as destination therapy in advanced HF
   - Survival 68% and 58% (1 year and 2 year respectively...)
   - 80% of patients were restored to Class I or II NYHA symptoms
   - Doubled six minute walks lengths
Initial REMATCH trial comparison: Medical Management versus HeartMate XVE\(^8\)

- **Survival**
  - 1 yr: Medical management = 80%, LVAD = 85%
  - 2 yr: Medical management = 80%, LVAD = 90%

- **Median survival**
  - Medical management: 150 days
  - LVAD: 408 days

Major clinical studies have shown HeartMate II to provide high survival rates of long-term support for both BTT and DT patients. Survival rates are up to 7 times greater than previously reported outcomes with medical therapy alone.\(^7,8\)

Survival Results continually improving

Actuarial Trial Vs REMATCH results together
OVER 25,000 PATIENTS HAVE BEEN IMPLANTED WITH THE HeartMate II LVAD

More than 9,000 patients receiving ongoing support*

*Based on clinical trial and device tracking data as of February 28, 2017. Zinc report #SJM-HM-1016-0032(1).

1. HeartMate II Studies (now focuses on Adverse Event Prevention)
   • ROADMAP Trial (Estep et al, 2015)10, 11
     - Earlier implants (Ambulatory Class IV) demonstrates improved QOL, 6MW and depression scores (suggesting earlier referrals are BETTER)
   • PREVENT II Trial (Maltas et al, 2017)12
     - Looked at early Pump Thrombosis risk when following PREVENT guidelines (early heparin bridging, Pump speeds >9000 rpm, implant techniques)
     - 2.9% in first 3 months and 4.2% at 6 months

2. HeartMate3 Studies
   • MOMENTUM 3 Clinical Trial (Mehra et al, 2017)15
     - 6 month data shows reoperation much less in HM3 group vs HM2 (0.7% vs 7.7%)
     - **NO pump thrombosis in first 6 months in HM3 group vs HM2 (0% vs 10.1%)**
   • Hemocompatibility-Related Outcomes in MOMENTUM 3 Trial (Uriel et al, 2017)16
     - 69% were free from hemocompatibility related adverse events (compared to 55% free in HM2 population)
     - Fewer Non-disabling strokes in HM3 sample versus HM2 sample (score of 6 to 24 respectively)

Updated Studies (Not Common…) Updated Studies (Not Common…) Updated Studies (Not Common…) Updated Studies (Not Common…)

3. HVAD Studies
   • ENDURANCE Destination Therapy Trial (Pagani et al, 2012)19
     - Primary endpoint was free of disabling stroke 2 years post implant
     - 55% versus 57.4% reaching primary end point (HVAD versus Other LVAD)—NON-inferiority
     - HVAD improvements made (entering the inflow cannula—increased to 57.5% achieving primary endpoints)
     - 28.7% stroke rate in HVAD arm over two years, compared to 12.1% HM2 over two years
   • HVAD LATERAL Study (ongoing but not recruiting)20
     - Looking at options to implant HVAD in different way besides sternotomy (via thoracotomy)
   • ENDURANCE II Supplemental Trial (2013 to present; enrollment completed and awaiting FDA approval)21
     - Developed Blood Pressure Protocol for HVAD population only and re-studied for endpoints
     - 34.7% “Neurologic injury” (ie TIA) compared to 12.1% HM2
     - Overall HVAD stroke rate 16.9% (14.6% HM2)—However Less than initial study of 28.7% in HVAD population22
• Risk Assessment and Comparative Effectiveness Of Left Ventricular Assist Device and Medical Management in Ambulatory Heart Failure Patients
• Observational NON-randomized study looking at effectiveness of HeartMate II LVAD versus Optimal Medical Management (OMM) in AMBULATORY NYHA Class 3B/4 Heart Failure (not inotrope dependent)
• Higher depression scores and lower Quality of Life scores in LVAD group at baseline
• RESULTS:
  • 80% survival at one year in LVAD group compared to 64% in OMM group (BEST data we have yet!)
  • Significant improvement in 6 minute walk distance (39% vs 21%)
  • Significant improvement in NYHA Class to I or II (77% vs 29%) (HUGE)
  • Significant improvement in HF QOL and Depression scales (55% vs 23%; and 44% vs 16% respectively)

ROADMAP Trial (as a recap) (Estep et al, 2015)

• Indications According to the ACC:
  • Cardiogenic Shock (with or WITHOUT Myocardial Infarction)
  • Fulminant Myocarditis
  • Pulmonary Hypertension and Right Heart Failure
  • Pulmonary Embolus with Hemodynamic Instability
  • Cardiac Arrest (assisted CPR)
  • Medication Overdose
  • Non-ischemic Cardiomyopathy including sepsis induced cardiomyopathy
  • Bridge to Decision for transplant and/or VAD therapy
  • Cardiac Support post Cardiac Surgery

Extracorporeal Membranous Oxygenation (ECMO)

• Indications According to the ACC:
  • Cardiogenic Shock (with or WITHOUT Myocardial Infarction)
  • Pulmonary Hypertension and Right Heart Failure
  • Pulmonary Embolus with Hemodynamic Instability
  • Cardiac Arrest (assisted CPR)
  • Medication Overdose
  • Non-ischemic Cardiomyopathy including sepsis induced cardiomyopathy
  • Bridge to Decision for transplant and/or VAD therapy
  • Cardiac Support post Cardiac Surgery

http://www.sccm.org/Communications/Critical Connections/Archives/Pages/ECMO---Indications-and-Outcomes.aspx
Risks for ECMO

- Thrombosis (1-22%)
- Bleeding and Coagulopathy, including hemolysis (5-79%)
- Limb ischemia (13-25%)
- Infection (17-49%)
- Neurologic Events (10-33%)

- Death Rates for Adults range from 33-92% based on severity of illness when being placed on ECMO

Tandem Heart (Right and/or Left Sided Support)

- Pump designed for Right, Left or BIVAD external and temporary support
- Oftentimes used as a device for RV failure post VAD implantation or RV/LV recovery post extensive MI
- Can be used as Bridge to Decision for Transplant +/- VAD therapy
- Has unique dual lumen catheter capabilities

Bryan Heart VAD (or MCS) Team (as a recap...)

- Dr. Richard Thompson, Cardiothoracic Surgeon and Surgical Director
- Dr. Mathue Baker, Heart Failure Cardiologist and Medical Director
- Sarah Schroeder, ACNP-BC, MSN RN, MCS Nurse Practitioner and Program Coordinator
- Dr. John Steuter, Heart Failure Cardiologist
- Dr. Ryan Shelstad, Cardiothoracic Surgeon
- Andrew Lundstrom, BSN RN, MCS Coordinator
Bryan Health VAD Program and Outcomes

• Joint Commission Certified in Destination Therapy implants
• First Destination Therapy implant September 2012 (56 year old Male)
  • Developed Driveline Infection, VAD bought time with his cancer history and went to Transplant November 2014
• Have implanted 37 patients (27 males, 10 females) + following 2 UNMC patients that transferred care to our team
  • 2012: 1
  • 2013: 3
  • 2014: 5
  • 2015: 10
  • 2016: 9
  • 2017: 9 (thus far)
• 30 day Survival: 86.5%

Mean Length of Stay: 20.66 days (goal is 21 days) and Median Length of Stay: 17 days (shortest 2 days, longest 57 days)

Number of Driveline Complications: 1 (changed technique and dressing style) - still remains at ZERO

Number of Patients Currently on Therapy: 21 (includes two inherited from UNMC)

Length of devices: Longest on device 1507 days (a few months past 4 years)

Bryan Heart Failure Quality of Life Measurements:
  • Average Pre Measurement: 54%
  • Average 3 month Measurement: 73.6%
  • Average 6 month Measurement: 78.5% (4 patients haven’t reached 6 months yet)

References

5. Park, SJ et al. (2012). Outcomes in advanced heart failure patients with left ventricular assist device for destination therapy. Retrieved August 13th, 2015, from http://circheartfailure.ahajournals.org/content/5/2/241.long