Mechanical Cardiac Support and Cardiac Transplant: The Role for Echocardiography

David Langholz, M.D., F.A.C.C.
Co-Director Cardiovascular Imaging
Fredrick Meijer Heart and Vascular Institute
Spectrum Health

MCS/Transplant Role for echocardiography

- MCS
  - Device survey and parts
  - Role in patient selection
  - Intraoperative echo
  - Optimization with echo
- Cardiac Transplant
  - Patient selection
  - Post operative surveillance
    - Coronary Artery Vasculopathy
    - Common findings

MCS Definitions, Terminology, Criteria
An Introduction

- Components
- Nomenclature
- Configurations
- Duration of Support
MCS Definitions, Terminology, Criteria
An Introduction

- Components
  - Pump
  - Driveline (power/communication)
  - Peripherals
    - Power source
    - Controller/programmer
    - Carrier/bag

- Picture of HM2, Impella, Tandem

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MCS Definitions, Terminology, Criteria
An Introduction

- Nomenclature
  - VAD type
    - left, right, biventricular, total
  - Duration of support
    - Short term, intermediate, long term
  - Device mechanics
    - Volume displacement vs Continuous Flow
  - Implantation approach
    - Percutaneous vs surgical vs hybrid

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VAD support configurations

- Total Artificial Heart
- Left, Right, Biventricular
- Inflow Cannulation
  - Ventricular
  - Atrial
  - Peripheral vascular
- Outflow Cannulation
  - Aortic ascending or descending
  - Pulmonary artery
  - Peripheral vascular
Duration of Support
A continuum

Percutaneous Extracorporeal Paracorporeal/Implanted
24-96 hrs Weeks months 1-2 years yrs
Impella Tandem IABP
PVAD HVAD
BVS 5000 Centrimag
PVAD IVAD
PVAD
IABP
Heartware

Impella
Echocardiographic evaluation

- Before implantation
  - Large aortic atheroma's
  - Aortic aneurysm's
  - AoV stenosis/AI
  - LVOT obstruction
  - PFO/ASD
  - Evaluate RV_fn
  - Optimize LV filling

- During implantation
  - Verify appropriate position/direction of cannula
  - Optimize LV/RV filling

Tandem Heart
Pre-Operative Evaluation
Importance of Pulmonary hypertension
RV Preservation
Decision regarding RVAD support

Importance of RV function
Using imperfect tools to predict the sometimes unpredictable
Limits fxn of the left sided device
Dysfunction associated with end organ damage
Dysfunction associated with prolonged length of stay

RV function/Dysfunction
- RV transverse diameter (< 3.8 cm)
- RV fractional area change (>40%)
- TAPSE (> 1.5 cm)
- RV systolic strain/strain rate (>16%/1.1m/s)
- RV free wall function
- 3D RV volume/function assessment
MCS
Right Ventricle Pre-op evaluation

- Secondary echocardiographic findings
  - RA dilation (>30 ml/m2)
  - Dilated IVC/hepatic veins
  - PAH
  - Dilation of the pulmonary artery

RV failure after LVAD

<table>
<thead>
<tr>
<th></th>
<th>RV failure</th>
<th>No RVF</th>
<th>P value</th>
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<tbody>
<tr>
<td>TR</td>
<td>1.7</td>
<td>1.4</td>
<td>0.1</td>
</tr>
<tr>
<td>RAP</td>
<td>12.5</td>
<td>11.9</td>
<td>0.6</td>
</tr>
<tr>
<td>PAS &gt; 50 mm Hg</td>
<td>25%</td>
<td>75%</td>
<td>0.03</td>
</tr>
<tr>
<td>Severe RV systolic dysfxn</td>
<td>46%</td>
<td>54%</td>
<td>0.01</td>
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</table>

Echocardiography in Pulmonary Hypertension

- TR in majority of patients
- > 35 mm Hg/ velocity > 2.8 m/s
- RV function and size
- RA size
- Pericardial effusion
ESC Echo criteria (RAP 5 mm Hg)

<table>
<thead>
<tr>
<th>PH Present</th>
<th>Peak TRV</th>
<th>PASP (mm Hg)</th>
<th>Other Signs</th>
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</thead>
<tbody>
<tr>
<td>Unlikely</td>
<td>&lt; 2.8 m/s</td>
<td>&lt; 35</td>
<td>no</td>
</tr>
<tr>
<td>Possible</td>
<td>&lt; 2.8 m/s 2.9 – 3.4 m/s</td>
<td>&lt; 35 35-50</td>
<td>yes no/yes</td>
</tr>
<tr>
<td>Likely</td>
<td>&gt; 3.4 m/s</td>
<td>&gt; 50</td>
<td>No/yes</td>
</tr>
</tbody>
</table>

Echo doppler vs Hemodynamic measurement

- High correlation between TTE/RHC of SPAP (0.57-0.93)
- Good sensitivity (0.79-1.00) and specificity (0.6-0.98)
- BUT…

Pre-Implant Measurement of RV function

- Echo
  - RVEF
  - Tricuspid regurgitation
  - Estimated PAP
  - TAPSE
  - CVP estimate
- Invasive
  - CVP/RA
  - PAP
  - TPG/PVR
  - RVSWI (mPA-mCVP) x SV/BSA
Evaluation of Aortic Insufficiency

- AI may be present in systole and diastole
- Likely to progress over time
- Increases PCW and PA pressure with greater RV afterload
- Moderate or severe AI may warrant intervention pre-op
  - Suture closure
  - Patch closure over mechanical prostheses
  - AVR with bioprosthesis

Intra-operative TEE
Pump speed adjustment

- Keep the LV full while increasing pump speed and de-airing
- Aim for midline septal position
  - Rightward shift suggests too low speed
  - Leftward shift suggests too high speed
- Ideally aortic valve should open every few beats, but this is highly variable
Intra-operative TEE

- Assessment of mitral and tricuspid valves
- Positioning of LV cannula inflow
  - Face toward the MV
  - Changing ventricular geometry

- Assessment of aortic valve and interatrial septum
- Evaluation of right and left ventricles
- Surveillance for air during implant
- Assessment post cardiopulmonary bypass
LVAD Performance
Post-operative

- RV performance
- Suction events
- Pump Speed
- Pulsatility

LVAD Performance
Post-operative

- RV performance
  - Pulmonary artery pressures
  - RV size/function
- Suction events
  - LV collapses around the inflow cannula
  - LV cannula position
  - LV volume

“Sub-Acute” Events

- “Left ventricular” failure
  - Right Heart failure
  - Dehydration
  - Hypertension or Hypotension
  - Arrhythmia
“Sub-Acute” Cardiac Events

- Aortic Regurgitation
- “Left ventricular” failure
- Right Heart failure
- Dehydration
- Hypertension or Hypotension
- Arrhythmia

Planning for Trouble
- Pre-operative
- Post-operative
- Peri-operative

LVAD Echo optimization

Goals
- Want the patient to be hemodynamically unloaded
- Would like to see the aortic valve open
- Watch the septum for RV failure
Echo ramped speed Study

- Patient goals
  - Minimum speed
    - Decrease RPM from set speed in steps of 200
    - AoV opens with each beat
    - LV becomes more dilated
    - MR worsens
    - Symptoms
  - Maximum speed
    - Increase speed from set speed in steps of 200
    - Septal shift
    - Ventricular dysrhythmias
  - Ideal
    - Accommodate normal shift in volume/hemodynamic shifts
    - Usually 400 rpm below maximum speed

LAVD Echo optimization

- Make sure the septum is straight up on the A4C view
- Set the speed 400 rpm before the septal bounce

Echo optimization

- Faster
  - Heart failure symptoms
  - LV still huge/lots of MR
  - High PCWP
- Slower
  - DT pt and the AoV never opens
  - GI bleeding and no source
  - Septum appears shifted to left (and slower doesn’t change hemodynamics)
  - VT
Post-op recurrence of heart failure
Role for Echo

- LV failure
  - Echo guided increase in pump speed
  - Assess for AI
- RV failure
  - Echo guided decreases in pump speed
  - Watch for septal movement and RV free wall function
  - TR
LVAD post implant testing

Indications

- **Routine**
  - 3 mths post implant
  - 6 mths post implant
  - Q 6 mths thereafter

- **Other indications**
  - Low flow
  - Suck down events
  - Hypotension
  - Dizziness

Echo and Cardiac Transplant
Cardiac Transplant Candidacy Issues
- Pulmonary Artery pressures
- Congenital Heart Disease

Cardiac Transplantation Post Tx Echo follow-up
- LV function
- TV regurgitation
- PA pressures

Cardiac transplantation Common echo findings
- LA “enlargement”
- RA “enlargement”
- Suture line “mass”
- Tricuspid regurgitation
Cardiac Transplantation-Rejection
Role of echo

- Cardiac Biopsy- Gold standard
- Cardiac dysfunction seen after widespread damage due to rejection
Cardiac Transplantation
Coronary artery vasculopathy
- Coronary vascular lesions resulting from injury to the artery from immune damage
- Angina often absent
- Cath with IVUS most sensitive tool to detect CAV
- CAV: Non-Invasive diagnosis
  - DSE: Insensitive in detecting mild disease but negative test predicts good prognosis

Summary
- Echocardiography plays a critical role in:
  - Identifying appropriate candidates for MCS and cardiac transplant
  - Peri-operative assessment
  - Routine post discharge surveillance
  - Identifying reasons for changes in clinical status