Echo Assessment of Left Ventricular Assist Devices

Federico M Asch MD, FASE, FACC

MedStar Health Research Institute
Washington Hospital Center
Georgetown University
Washington, DC
January, 2018

• I have No conflict of interests to disclose

Acknowledgement: Dr Rachel Marcus
Outline

- Indications for implant
- Available devices
- Role of Echo during implant and Follow-up

Heart Failure

- HF affect over 5M patients in the US
- Around 250,000 suffer advanced HF with suboptimal response despite optimal Medical Therapies
- Heart Transplant is only available to 2,500 patients/year.
LVADs

- Long Term Assist Devices:
  - Heartmate II, III
  - Heartware

- Short term support:
  - Impella,
  - Tandem heart,
  - Centrimag,
  - A-V ECMO (Circulatory and Resp support)

Indications for LVAD

- Bridge to transplant

- Bridge to recovery: Acute myocarditis, Tako Tsubo, Post MI Shock.

- Destination Therapy: Refractory HF, not transplant candidate
Anatomy of an LVAD

Inflow Cannula (LV)
Pump:
   Axial magnetic Rotor (HMII)
   Centrifugal propeller (HVAD)

Outflow Cannula (Aorta)
External Battery connected to pump by a cable (drive line).

Heartmate II
Heartware
smaller, longer battery life, less thrombosis

Figure 2  (A) Drawing of the HVAD, showing the intrapericardial pump location, right parasternal outflow graft position (double white arrow), and outflow graft-to-ascending aorta anastomosis (black arrow). (Courtesy of Heartware, Inc.). (B) X-ray CT scout image showing the anatomic relationship between the left ventricle and the device inlet cannula with its attached intrapericardial pump (single arrow). Although not visible here, the outflow graft would typically be imaged in the right parasternal area (double arrow). The asterisk denotes a cardiac implantable electronic device.
The role of Echo

ASE GUIDELINES & STANDARDS

Echocardiography in the Management of Patients with Left Ventricular Assist Devices: Recommendations from the American Society of Echocardiography

Raymond E. Stainback, MD, FASE, Chair; Jerry D. Blop, MD, FASE, Co-Chair; Deborah A. Agler, RCT, RDMS, FASE; Emma J. Reko, MD, PhD, Merri Bremer, AN, RDMS, EdD, FASE; Judy Hung, MD, FASE; James N. Kirkpatrick, MD, FASE; Joseph G. Rogers, MD, and Nishant R. Shah, MD, MSc, Houston, Texas; Cleveland, Ohio; Louisville, Kentucky; Rochester, Minnesota; Boston, Massachusetts; Philadelphia, Pennsylvania; and Durham, North Carolina

(J Am Soc Echocardiogr 2015;28:893–923.)
Selecting the right candidate – Red Flags

Table 1 Preimplantation TTE/TEE “red-flag” findings

<table>
<thead>
<tr>
<th>Left Ventricle and Interventricular Septum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small LV size, particularly with increased LV trabeculation</td>
</tr>
<tr>
<td>LV thrombus</td>
</tr>
<tr>
<td>LV apical aneurysm</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Right Ventricle</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV dilatation</td>
</tr>
<tr>
<td>RV systolic dysfunction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Atria, Interventricular Septum, and Inferior Vena Cava</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left atrial appendage thrombus</td>
</tr>
<tr>
<td>PFO or atrial septal defect</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Valvular Abnormalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any prosthetic valve (especially mechanical AV or MV)</td>
</tr>
<tr>
<td>&gt; mild AR</td>
</tr>
<tr>
<td>≤ moderate MS</td>
</tr>
<tr>
<td>≥ moderate TR or &gt; mild TS</td>
</tr>
<tr>
<td>&gt; mild PS ≤ moderate PR</td>
</tr>
</tbody>
</table>

LVAD Troubleshooting:
Problems and LVAD optimization

Eco and LVAD:
Key items to evaluate and report

• LV size and function
• Position of the IV septum and cannulas
• Ao Valve opening and AI severity.
• RV size and function
• Always report the RPM at time of exam. (HM II 8500-10000, HVAD 2400-3200)
• Evidence of thrombus
• Compare with prior echoes side-to-side
Parasternal views

- LV and RV size
- Aortic Valve
- Cannulas: Orientation and flow.
Importance of Ao Valve Opening

- Prevents healing and chronic closure
- Prevents thrombosis
- In the event of LVAD dysfunction, allows LV ejection.

Cannulas

- Inflow: in off-axis PLAX and Apical views
- Outflow: Long axis of the ascending aorta frequently at the level of the right PA.
LVAD-induced VT
LVAD Tamponade
Apical Views

- IV septum position
- Cannula orientation and relationship with LV walls.
- Main limitation is artifact from device.
PW to evaluate Doppler velocities

HVAD – Color Doppler artifact
Aortic Regurgitation

• Continuous (D + S)

• Grading severity is challenging

• If $\geq$ Moderate, affects LVAD performance
Echo Red Flags: When to suspect LVAD thrombosis

Signs of LVAD Dysfunction:

- Right-shift of the IVS and LV enlargement
- Ao Valve opening with every beat (9-10/10 beats)
- Blunted flow through both cannulas (PW/CW Doppler)
- RAMP studies (lack of LV dimensions change with increase in pump support/RPM)

A standard Echo report in LVAD pts

- LV and RV function and dimensions (LVIdD)
- Septal position (right, midline, left)
- Inflow cannula position/orientation and relationship to walls
- Aortic valve opening (x/10 beats)
- AI severity
- Direct comparison to prior echoes.
- Device and RPM settings
Non Durable Mechanical Circulatory Support (ND MCS)

• Impella

• Tandem Heart

• ECMO

ND-MCS: Characteristics

<table>
<thead>
<tr>
<th>Device</th>
<th>Deployment &lt;1 h</th>
<th>Percutaneous</th>
<th>Surgical Access</th>
<th>Ambulatory Support (wk)</th>
<th>Bedside Deployment</th>
<th>Oxygenation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IABP</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No/yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Impella CP</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No/Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Impella 5.0 (axillary)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Impella RP (investigational)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TandemHeart LVAD</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>TandemHeart RVAD</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Centrimag LVAD (surgical)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>VA-ECMO</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
V-A ECMO

Standard Approach

Alternate approach

V-V ECMO

Standard approach

Alternate approach
Impella

Heart Failure Clinics, Volume 11, Issue 2, 2015, 215 - 230

Impella

Heart Failure Clinics, Volume 11, Issue 2, 2015, 215 - 230
Impella

- **Inlet:** 3 - 4 cm below Ao Valve
- Should not touch septum or ant MV leaflet
- **Outlet:** 1.5 - 2 cm above sinuses of Valsalva.

Summary

- Echo is critical in LVAD evaluation
- Determine candidacy and co-morbidities that should be addressed in the OR
- Determine LVAD function and Dysfunction
- Device optimization
- LV recovery?
Which of the following findings is critical to report to the surgeon at the time of LVAD implant?

• A- Aortic Regurgitation Severity
• B- LV Dysfunction
• C- TR severity
• D- A and C are correct
• E- All are correct
Which of the following findings is critical to report to the surgeon at the time of LVAD implant?

- A- Aortic Regurgitation Severity
- B- LV Dysfunction
- C- TR severity
- D- A and C are correct
- E- All are correct

Which of the following findings Suggest LVAD Dysfunction?

- A- Severe AR
- B- Significant LVIdD changes in RAMP study
- C- Flat LVIdD changes in RAMP study
- D- A and C are correct
Which of the following findings Suggest LVAD Dysfunction?

• A- Severe AR
• B- Significant LVIdD changes in RAMP study
• C- Flat LVIdD changes in RAMP study
• D- A and C are correct