Device Therapy for Heart Failure

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Learning Objectives

- Overview of Heart failure stages and role of device-based therapies
- Implantable Cardioverter Defibrillator (ICDs) in primary prevention of SCD
- New defibrillation strategies (wearable ICD and subcutaneous ICD)
- Cardiac Resynchronization Therapy (CRT)
Background

- In 2013, the ACC/AHA published an updated Guideline for the Management of Heart Failure
- New terminologies, concepts and recommendations were introduced
- An attempt was made to harmonize the guideline with other guidelines, consensus documents and position papers which are cross-referenced


Terminology

- Guidelines Directed Medical Therapy (GDMT) represents the optimal medical therapy recommended with a class 1 indication
- Heart Failure with reduce Ejection Fraction (HFrEF). LVEF ≤ 40 %
- Heart failure with preserved Ejection Fraction (HFpEF). LVEF ≥ 50 %
  - HFpEF, borderline (LVEF 41-49 %)
  - HFpEF, improved (LVEF >40 %)
- Maintained the concept of “stages”
Classification of HF: Comparison Between ACC/AHA HF Stage and NYHA Functional Class

<table>
<thead>
<tr>
<th>ACC/AHA HF Stage¹</th>
<th>NYHA Functional Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>A At high risk for heart failure but without structural heart disease or symptoms of heart failure (eg, patients with hypertension or coronary artery disease)</td>
<td>None</td>
</tr>
<tr>
<td>B Structural heart disease but without symptoms of heart failure</td>
<td>I Asymptomatic</td>
</tr>
<tr>
<td>C Structural heart disease with prior or current symptoms of heart failure</td>
<td>II Symptomatic with moderate exertion</td>
</tr>
<tr>
<td>D Refractory heart failure requiring specialized interventions</td>
<td>III Symptomatic with minimal exertion</td>
</tr>
<tr>
<td>E End stage</td>
<td>IV Symptomatic at rest</td>
</tr>
</tbody>
</table>


Therapeutic Options for Heart Failure Stages

Heart Failure Device-Based Therapies

- HRpEF (stage C)
  - Investigational devices to improve symptoms

Heart Failure Device-Based Therapies

- HFrEF
  - Stage C
    - Devices to improve survival (ICD)
      - Devices to improve survival and HF symptoms (CRT)
        - Investigational devices
Heart Failure Device-Based Therapies

HRpEF (stage C)

Investigational devices to improve symptoms

HFpEF

Stage C

Devices to improve survival (ICD)

Devices to improve survival and HF symptoms (CRT)

Investigational devices

HFrEF

Stage D

Mechanical Circulatory Support (LVAD)

Device to reduce hospitalization (remote hemodynamic monitoring/CardioMEMS)
Mode of Death in Heart Failure

NYHA Class 2  NYHA Class 3  NYHA Class 4

MERIT-HF Lancet 1999

Beta Blockers’ Effects on total Mortality and Sudden Death in Patients with HF

Heart 2001;85:97–103
Implantable Cardioverter-Defibrillator (ICD) Basics

- Designed to treat a cardiac tachydysrythmia
- Performs cardioversion/defibrillation
  - Ventricular rate exceeds programmed cut-off rate
- ATP (antitachycardia pacing)
  - Overdrive pacing in an attempt to terminate ventricular tachycardias
- All have pacemaker function (combo devices)

Major Components of the ICD system

![Diagram of ICD components]

- Atrial Lead
- RV Lead
- RV Shock Cable
- RV Pacing/Sensor Electrode
- ICD Pulse Generator
Schematic View of the Defibrillation Shock Generated by the ICD

SCD Primary Prevention Trials (ICD Vs. Conventional Therapy)

- MADIT II
- SCD-HeFT
**MADIT-II**

**Objective:**
- Evaluate the effectiveness of ICD therapy ($n = 742$) compared to conventional therapy ($n = 490$) in high-risk post-MI patients
- Post-MI $> 4$ weeks, and
- LVEF $< 30\%$


**MADIT-II Survival Results**

Reduced overall mortality by 31% ($p = 0.007$)

<table>
<thead>
<tr>
<th>Patients at Risk</th>
<th>Years</th>
<th>Defibrillator</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defibrillator</td>
<td>0</td>
<td>742</td>
<td>65 (0.69)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>502 (0.91)</td>
<td>329 (0.90)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>274 (0.94)</td>
<td>170 (0.78)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>110 (0.78)</td>
<td>65 (0.69)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>9 (0.77)</td>
<td>3 (0.69)</td>
</tr>
</tbody>
</table>

SCD-HeFT
Sudden Cardiac Death in Heart Failure Trial

• Determine if amiodarone or ICD will decrease the risk of death from any cause in patients with mild-to-moderate heart failure (Class II and III).
• Maximally treated CHF for ≥ 3 months with a LVEF of ≥ .35

SCD-HeFT Mortality Rate Overall Results

<table>
<thead>
<tr>
<th></th>
<th>Hazard Ratio (97.5% CI)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amiodarone vs. Placebo</td>
<td>1.06 (0.86 - 1.30)</td>
<td>0.53</td>
</tr>
<tr>
<td>ICD vs. Placebo</td>
<td>0.77 (0.62 - 0.96)</td>
<td>0.007</td>
</tr>
</tbody>
</table>

### Who should get an ICD?

- Ischemic CM, LVEF <0.30 (MADIT II)
- Ischemic and nonischemic dilated cardiomyopathy, NYHA class II/III CHF, LVEF < 35%. (SCD-HeFT).

### Who should NOT get an ICD?

- CABG or PCI within the past 3 months-CABG-Patch
- Acute MI within the past 40 days-DINAMIT
- Concomitant disease with less than 1 year likelihood of survival.

**Wearable ICD System**

**ICDs and MRI**

- It is becoming feasible to use MRI for certain ICD and lead models that are MRI compatible if done according to certain protocols.

- Consulting with specialists is necessary before ordering MRIs in patients with ICDs.
**Indications for ICD Deactivation**

- End-of-life care
- Recurrent inappropriate shocks due to lead failure or SVT/AF with rapid ventricular response
- During surgical procedures requiring the use of electrocautery in close proximity to the pulse generator

**Case Presentation**

- A 45 year-old female with history of breast cancer, s/p bilateral mastectomy and chemotherapy (2 years ago). Her cancer is currently in remission with favorable prognosis. She developed Adriaamycin induced cardiomyopathy and despite >9 months of guideline directed medical therapy for heart failure, her LVEF remains 30%. She belongs to NYHA FC II. Her ECG shows NSR, normal intervals, QRS 90 ms, nonspecific T-wave abnormalities. Her L subclavian vein is occluded and she has a history of DVT in the R subclavian vein as a complication of prior Port-a-cath.
- Intravenous ICD implant is recommended?
  A. True
  B. False
Subcutaneous ICD

- 80 joules (delivered)
- 69cc, 145 grams
- Active generator
- 5 year longevity
- Post-shock pacing
- Single lead connection
- Full featured episode storage
- No Brady pacing or ATP

Subcutaneous ICD VS. Transvenous ICD

<table>
<thead>
<tr>
<th>Factors Favor S-ICD</th>
<th>Factors Favor TV-ICD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young and active (less lead failure)</td>
<td>Recurrent monomorphic VT (role of ATP)</td>
</tr>
<tr>
<td>CHD that limits lead placement, valve surgery</td>
<td>Bradycardia requiring pacing</td>
</tr>
<tr>
<td>Indwelling catheters</td>
<td>Indication for CRT</td>
</tr>
<tr>
<td>Immunocompromised</td>
<td>High risk for VT (e.g. sarcoidosis, ARVD).</td>
</tr>
<tr>
<td>Inherited channelopathies (low VT risks).</td>
<td>Preference for remote monitoring</td>
</tr>
</tbody>
</table>
### Cardiac Resynchronization Therapy (CRT)

**LBBB CRT Trial Design**

Patients

<table>
<thead>
<tr>
<th>NYHA</th>
<th>LVEF Inclusion criteria</th>
<th>QRS Inclusion criteria</th>
<th>Primary end point</th>
<th>Results significantly favoring intervention group</th>
</tr>
</thead>
</table>

**Major CRT Trials**

<table>
<thead>
<tr>
<th>Trial</th>
<th>Design</th>
<th>Patients</th>
<th>Mean follow-up</th>
<th>NYHA</th>
<th>LVEF inclusion criteria</th>
<th>QRS inclusion criteria</th>
<th>Primary end point</th>
<th>Results significantly favoring intervention group</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPANION (2004)</td>
<td>CRT-D, CRT-P, ICD</td>
<td>617, 595, 308</td>
<td>15</td>
<td>III, IV</td>
<td>≤35%</td>
<td>≥120 ms</td>
<td>All-cause mortality or hosp</td>
<td>+/+</td>
</tr>
<tr>
<td>CARE-HF (2005)</td>
<td>CRT-P, Med</td>
<td>409, 404</td>
<td>29</td>
<td>III, IV</td>
<td>≤35%</td>
<td>≥120 ms</td>
<td>All-cause mortality or cardiovascular hospitalization</td>
<td>+</td>
</tr>
<tr>
<td>MADIT-CRT (2009)</td>
<td>CRT-D, ICD</td>
<td>1089, 739</td>
<td>29</td>
<td>I, II</td>
<td>≤30%</td>
<td>≥130 ms</td>
<td>All-cause mortality or HF hosp</td>
<td>+</td>
</tr>
</tbody>
</table>
Indications for CRT

<table>
<thead>
<tr>
<th>Class I Indications</th>
<th>NYHA Class I</th>
<th>NYHA Class II</th>
<th>NYHA Class III &amp; Ambulatory Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LVFF ≤ 35%</td>
<td>QRS ≥ 150ms</td>
<td>LVFF ≤ 35%</td>
</tr>
<tr>
<td></td>
<td>QRS ≥ 150ms</td>
<td>LBBB pattern</td>
<td>QRS ≥ 150ms</td>
</tr>
<tr>
<td></td>
<td>LBBB pattern</td>
<td>LVFF ≤ 35%</td>
<td>QRS ≤ 150ms</td>
</tr>
<tr>
<td></td>
<td>Sinus rhythm</td>
<td>QRS 120-149 ms</td>
<td>QRS 120-149 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LBBB pattern</td>
<td>LBBB pattern</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sinus rhythm</td>
<td>Sinus rhythm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class IIa Indications</th>
<th>NYHA Class I</th>
<th>NYHA Class II</th>
<th>NYHA Class III &amp; Ambulatory Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LBBB pattern</td>
<td></td>
<td>LVFF ≤ 35%</td>
</tr>
<tr>
<td></td>
<td>Sinus rhythm</td>
<td></td>
<td>LVFF ≤ 150ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class IIb Indications</th>
<th>NYHA Class I</th>
<th>NYHA Class II</th>
<th>NYHA Class III &amp; Ambulatory Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LVFF ≤ 30%</td>
<td>QRS &gt; 150ms</td>
<td>LVFF ≤ 35%</td>
</tr>
<tr>
<td></td>
<td>QRS &gt; 150ms</td>
<td>LBBB pattern</td>
<td>QRS ≥ 150ms</td>
</tr>
<tr>
<td></td>
<td>LBBB pattern</td>
<td>LVFF ≤ 35%</td>
<td>QRS ≤ 150ms</td>
</tr>
<tr>
<td></td>
<td>Ischemic cardiomyopathy</td>
<td>Sinus rhythm</td>
<td>QRS 120-149 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-LBBB pattern</td>
<td>Non-LBBB pattern</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sinus rhythm</td>
<td>Sinus rhythm</td>
</tr>
</tbody>
</table>
Devices to Reduce Readmissions

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The Ohio State University Wexner Medical Center

Burden of Heart Failure

Heart failure is a big problem …

– HF affects 5.5-7 million Americans

– $31 Billion on HF hospitalizations

– Most frequent cause of rehospitalization in the US

– Importantly, repeat HF admissions lead to worsening mortality!

Heidenriech PA, et al, Circ Heart Fail 2013
Jencks SF, et al, NEJM 2009
Evolution of Acute Heart Failure

- Pressure Changes
- Autonomic Adaptation
- Impedance Changes
- Weight Changes, HF Symptoms

HF Hospitalization


Traditional Methods: Weights & Symptoms

Benefits
- Easy to understand
- Minimal equipment
- Low costs

Drawbacks
- Low compliance rates
- Variability in implementation
- Sensitivity <25%

Moser DK, Am Heart J 2005
van der Wal MH, Eur Heart J 2006
Abraham WT, Congest Heart Fail 2011
Telemedicine Trials to Reduce Readmissions

<table>
<thead>
<tr>
<th>TELE-HF</th>
<th>TIM-HF</th>
<th>BEAT-HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIH sponsored</td>
<td>710 patients</td>
<td>1400+ patients</td>
</tr>
<tr>
<td>1600+ patients</td>
<td>Telemonitoring of weight &amp; symptoms</td>
<td>Electronic telemonitoring</td>
</tr>
<tr>
<td>Frequent phone interactions</td>
<td>Not effective</td>
<td>Not effective</td>
</tr>
<tr>
<td>Not effective</td>
<td>Not effective</td>
<td>Not effective</td>
</tr>
</tbody>
</table>

Bioimpedance

Benefits
- Can be obtained from devices already implanted
- Correlate well to invasive measures

Drawbacks
- Not a primary indication for device implant
- Unlikely to be an option for HFpEF
- Low positive predictive value

Yu CM, *Circ 2005*
Conraads VM, *Eur Heart J 2011*
## Bioimpedance Trials

<table>
<thead>
<tr>
<th>FAST</th>
<th>DOT-HF</th>
<th>OptiLink-HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Good sensitivity</td>
<td>□ No reduction in hospitalizations</td>
<td>□ Recently conducted</td>
</tr>
<tr>
<td>□ Good compliance</td>
<td>□ Increased hospitalizations</td>
<td>□ No hospitalization reduction</td>
</tr>
<tr>
<td>□ Exploratory only</td>
<td>□ Data did not induce clinical actions</td>
<td></td>
</tr>
</tbody>
</table>

## Autonomic Adaptation: Biomarkers

### Benefits
- Both HFpEF & HFrEF
- Repeatable and widely available

### Drawbacks
- Requires phlebotomy (lab visit)
- Costs
- Confounding variables (*e.g.* obesity)
- Unclear what constitutes improvement

Yu CM, *Circ* 2005  
Conraads VM, *Eur Heart J* 2011
### Biomarker Trials for Rehospitalization

<table>
<thead>
<tr>
<th>Trial</th>
<th>Biomarker</th>
<th>Size</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troughton, et al</td>
<td>BNP</td>
<td>69</td>
<td>Positive</td>
</tr>
<tr>
<td>STARS-BNP</td>
<td>BNP</td>
<td>220</td>
<td>Positive</td>
</tr>
<tr>
<td>Berger R, et al</td>
<td>NT-proBNP</td>
<td>278</td>
<td>Positive</td>
</tr>
<tr>
<td>PROTECT</td>
<td>NT-ProBNP</td>
<td>151</td>
<td>Positive</td>
</tr>
<tr>
<td>PRIMA</td>
<td>NT-ProBNP</td>
<td>345</td>
<td>Negative</td>
</tr>
<tr>
<td>BATTLE-SCARRED</td>
<td>NT-proBNP</td>
<td>364</td>
<td>Negative</td>
</tr>
<tr>
<td>TIME-CHF</td>
<td>BNP</td>
<td>499</td>
<td>Negative</td>
</tr>
<tr>
<td>GUIDE-IT</td>
<td>NT-proBNP</td>
<td>1100</td>
<td>Stopped Early (ineffective)</td>
</tr>
</tbody>
</table>

### Hemodynamic Monitoring

**Benefits**
- Both HFpEF & HFrEF (CardioMEMSTM)
- Hemodynamics correlate well to HF events
- Occurs early in the decompensation process
- Known targets (PAD < 18 mmHg)

**Drawbacks**
- Invasive procedure
- Additional device (CardioMEMS)
- Monitoring by staff required

Stevenson LW, *Am J Cardiol* 1990
Stevenson LW, *Circ Heart Fail* 2010
Hemodynamic Monitoring: Sensor Choice

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV Lead</td>
<td>• Good for patients who need devices&lt;br&gt;• Unavailable to patients without device&lt;br&gt;• Worsening battery life</td>
</tr>
<tr>
<td>LA lead</td>
<td>• LA pressure better than PAD?&lt;br&gt;• An additional device implant&lt;br&gt;• Transseptal implant associated with increased complications</td>
</tr>
<tr>
<td>PA Sensor</td>
<td>• No battery&lt;br&gt;• Low implant complication rate&lt;br&gt;• Limited by body habitus&lt;br&gt;• Cost &amp; reimbursement factors</td>
</tr>
</tbody>
</table>

Hemodynamic Monitoring: The Secret Sauce

- Early trials with hemodynamic monitoring did not improve outcomes. Why?
- Successful use of hemodynamics requires treatment to a numeric goal
- This must happen independent of symptoms
  - Physiologic changes will occur before symptoms

Bourge RC, JACC 2008
PA Sensors

- Implanted via right heart cath technique
- Typically placed in branch of left PA
- Provide PA systolic, diastolic, and mean pressures
- PA diastolic pressures typically mirror PCWP/LA pressures

www.wikipedia.org

CHAMPION: CardioMEMS Heart Sensor Allows Monitoring of Pressure to Improve Outcomes in NYHA Class III Heart Failure Patients

- Trial Designed by Steering Committee with active FDA input
- Prospective, multi-center, randomized, controlled single-blind clinical trial
- All subjects followed in their randomized single-blind study assignment until the last patient reached 6 months of follow-up
- 64 US Centers
- PIs: William Abraham, Phil Adamson

550 Pts
w/ CM Implants
All Pts Take Daily Readings

Treatment
270 Pts
Management Based on Hemodynamics + Traditional Info

Control
280 Pts
Management Based on Traditional Info

Primary Endpoint: HF Hospitalizations at 6 Months

Additional Analysis: HF Hospitalizations at All Days (~15 M mean F/U)

Multiple Secondary Endpoints

Hypothesis of the CHAMPION Trial

Change medications based on hemodynamic pressures instead of waiting for signs & symptoms

Heart failure hospitalizations

Protocol Guidelines: PA Pressure Management

Treatment Recommendations for Elevated PA Pressures

- Add or increase diuretic
  - increase/add loop diuretic
  - change loop diuretic
  - add thiazide diuretic
  - IV loop diuretic

- Add or increase vasodilator
  - add or increase nitrate
## Primary Efficacy Endpoint

<table>
<thead>
<tr>
<th></th>
<th>Treatment (n=270)</th>
<th>Control (n=280)</th>
<th>Relative Risk Reduction</th>
<th>p-value(^1)</th>
<th>NNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Efficacy Endpoint: HF Related Hospitalizations (Rate for 6 months)</td>
<td>84 (0.32)</td>
<td>120 (0.44)</td>
<td>28%</td>
<td>0.0002</td>
<td>8</td>
</tr>
<tr>
<td>Supplementary Analysis: HF Related Hospitalizations (Full Duration - Annualized Rate)</td>
<td>158 (0.46)</td>
<td>254 (0.73)</td>
<td>37%</td>
<td>&lt;0.0001</td>
<td>4</td>
</tr>
</tbody>
</table>

\(^1\) p-value from negative binomial regression
NNT = Number Needed to Treat


## PA Monitoring Benefits Are Additive

<table>
<thead>
<tr>
<th>GDMT Class</th>
<th>HF Hospitalization</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hazard Ratio</td>
<td>NNT</td>
</tr>
<tr>
<td>ACEi/ARB</td>
<td>0.59</td>
<td>4</td>
</tr>
<tr>
<td>Beta-blocker</td>
<td>0.66</td>
<td>5</td>
</tr>
<tr>
<td>ACEi/ARB &amp; Beta-blocker</td>
<td>0.57</td>
<td>3</td>
</tr>
</tbody>
</table>

Abraham WT, JACC 2015
### Hemodynamic Monitoring Summary

- Implantable hemodynamic monitors provide direct and actionable measurements of intracardiac and pulmonary artery pressures.
- Management guided by such monitors reduces the risk of heart failure hospitalizations.
- This approach promises to revolutionize the management of heart failure patients.
  - Crisis management ➔ Stability management.

### CardioMEMSTM: Current Status

- Only approved PA pressure monitoring system at present.
- Approved for use in NYHA III HF patients.
- Intended to:
  - Reduced HF hospitalizations
  - Improved QoL
  - No indication to improve survival.
Mechanical Circulatory Support Devices

HF Topography

NYHA I

NYHA II

NYHA III

NYHA IV
NYHA Classification

1 year mortality of NYHA III HF is 10-15%

Scrutenid et al, EHJ 1994
Gheorghiade et al, JACC 2013

NYHA Classification

1 year mortality of NYHA III HF is 10-15%

A HF hospitalization is a strong predictor of mortality (NYHA IIIb-IV)

Scrutenid et al, EHJ 1994
Gheorghiade et al, JACC 2013
NYHA Reproducibility

Inter-observer evaluation
Exact reproducibility: 56%
Within 1 functional class: 93%

NYHA III best correlated with exercise testing
(75% of patients)

Goldman et al, Circ 1981
Franciosa et al, Am J Med 1979
Bennett et al, JHLT 2002
Cardiopulmonary Exercise Testing

- Also known as metabolic stress test, VO2 test

- Peak VO₂ performance <14 ml/kg/min is associated increased risk of death within 24 months in HF patients


No VO₂ testing? Try a 6-minute walk

- Distance ≤ 468 m (1535 ft) predicts higher mortality and hospitalization risk

- 6MWT is a good screening tool

- However, not as strongly correlated as VO₂ data

Wegrzynowska-Teodorczyk K, et al, J Physiotherapy 2013
The High-Risk HF Patient

1 or more of the following:

- HF Sx that fail to respond to medical therapy (persistent NYHA III or worse symptoms)
- Peak VO₂ <14 ml/kg/min
- Intolerance to HF meds (esp new intolerance)
  - Hypotension
  - Renal dysfunction
  - Bradycardia
- Frequent hospitalizations
  - 2 in 3 months
  - 3 in 6 months
  - Need for inotropes during hospital stay

Treatment Options for High-Risk HF Patients

Transplant
- Good long term survival
- Strict selection criteria
- Limited supply of donor hearts
- Complex post-transplant medical regimen

Ventricular Assist Devices
- Improving long term survival (>70% at 2 years)
- Non-limited resource
- Can be bridge-to-transplant (BTT) or destination therapy (DT)
- Requires anti-coagulation
- Complex post-implant medical regimen

Palliative Care/Hospice
- Quality of life > survival
VAD Criteria

- Used as either Bridge to Transplant (BTT) or Destination Therapy (DT)
- EF $\leq$ 25%
- For BTT – must be listed for transplant
- For DT:
  - Failed optimal therapy for 45 of last 60 days
    - Or inotrope dependent (minimum 14 days)
    - Or IABP x 7 days
  - Peak VO$_2$ $\leq$ 14

www.cms.gov

Ventricular Assist Devices
## Summary of VAD Therapy for HF

- Improves survival
- Improves functional status
- Improves quality of life
- Improving technology to reduce complications
- Part of guideline recommendations for treatment of HF

Rogers J, et al, *JACC* 2010  