Management of Advanced Heart Failure Mechanical Circulatory Assist & Cardiac Transplantation

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1. Epidemiology of Heart Failure
2. Indications and Types of Ventricular Assist Devices (VAD)
3. Candidate Selection for VAD
4. Selection Criteria for Heart Transplant
5. ISHLT Registry Data
Chronic Congestive Heart Failure

The Problem (USA)

- Prevalence:
  - 5,000,000 patients.
  - 550,000 new cases CHF each year.
  - Incidence x 2 in last ten years.
  - 300,000 deaths/year.
  - Most frequent reason for hospitalization in patients > 65 years of age.

- Rehospitalization within 6 months as high as 50%.

AHA/ACC 2005 Heart Failure Guideline Update
By 2010 ~60% of the World’s Heart Disease will be in India!

-Lancet, 2008
Total Years of Life Lost Due to CVD among populations aged 35 to 64

<table>
<thead>
<tr>
<th>Country</th>
<th>2000</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>1.06</td>
<td>1.74</td>
</tr>
<tr>
<td>Russia</td>
<td>3.31</td>
<td>3.21</td>
</tr>
<tr>
<td>India</td>
<td>9.22</td>
<td>17.94</td>
</tr>
<tr>
<td>China</td>
<td>6.67</td>
<td>10.46</td>
</tr>
<tr>
<td>U.S.</td>
<td>1.63</td>
<td>1.97</td>
</tr>
</tbody>
</table>
## Risk Factors for Survival in HF

<table>
<thead>
<tr>
<th>OLD</th>
<th>NEW</th>
</tr>
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<tbody>
<tr>
<td>NYHA Class</td>
<td><em>BUN/Creat/CreatClear.</em></td>
</tr>
<tr>
<td>Ejection Fraction</td>
<td><em>Diuretic Dose &gt;1.5 mg/kg/d</em></td>
</tr>
<tr>
<td>Etiology-ischemic</td>
<td><em>QRS Width &gt;150 msec</em></td>
</tr>
<tr>
<td>LVEDD</td>
<td><em>BNP &gt; 1,000</em></td>
</tr>
<tr>
<td>Hemodynamics</td>
<td><em>Can’t take ACEI/ARB/BB</em></td>
</tr>
<tr>
<td>Peak O2 Consumption</td>
<td><em>Multiple HF Admissions</em></td>
</tr>
<tr>
<td>Norepinephrine level</td>
<td><em>Hematocrit &lt; 34</em></td>
</tr>
<tr>
<td>Serum Sodium</td>
<td></td>
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</table>

More than 3 risk factors warrants referral to Advanced HF Program
Treatment Options for Advanced Heart Failure

1. Medical Management
2. Implantable Cardioverter Defibrillator (ICD) / Biventricular Pacemaker
   - ICD - (MADIT II/SCD-HeFT)
   - BiV Pacemaker/ICD - (MIRACLE/COMPANION)
3. Surgical Management
   - Valve Repair/Replacement; CABG.
4. Mechanical Circulatory Support Devices
   - Ventricular Assist Device (VAD)
5. Cardiac Transplantation
   - Limited by donor shortage
Ventricular Assist Devices (VAD)

• A Mechanical Heart Pump that Provides Circulatory Support to the Failing Ventricle.

• Can Be Used To Support the Right-, Left- or Both Ventricles.
Left Ventricular Assist Device

**Hemodynamic Effect:**

- LVAD increases cardiac output/index.
- Improved cardiac output increases end-organ perfusion.
- Unloads LV thereby decreasing left heart filling pressures.
- LV unloading decreases pulmonary artery pressures leading to a reduction in RV afterload.
- LV unloading also reverses ventricular remodeling, improves chamber geometry, and reduces fibrosis.

- However -
  - Increased venous return to the right ventricle may unmask pre-existing RV dysfunction.

2. Bruckner et al. JHLT 2001; 20: 457
Indications for Ventricular Assist Devices

1. **Bridge to Recovery**
   - Short term support during acute cardiogenic shock or with potentially reversible cases of heart failure.

2. **Bridge to Transplantation**
   - Short to intermediate term support while awaiting transplantation.

3. **Destination Therapy**
   - Long term support as replacement therapy in patients with contraindication to heart transplant.
Bridge to Recovery
Bridge to Recovery

Indications:

1. Cardiogenic Shock following:
   a) Acute Myocardial Infarction
   b) Percutaneous Coronary Intervention
   c) Cardiac Surgery (Post-Cardiotomy)

2. Acute Myocarditis (Viral Cardiomyopathy)
Bridge to Recovery

Short-Term Devices (Days):

1. Intra-Aortic Balloon Pump
2. Ventricular Assist Device
   A. Extracorporeal:
      – Abiomed BiVentricular System (BVS) – Pulsatile pneumatic pump
      – Thoratec PVAD/IVAD – Pulsatile pneumatic pump
      – Biomedicus – Continuous flow, centrifugal pump
      – CentriMag – Continuous flow, magnetically levitated, centrifugal pump
      – Sarns – Centrifugal pump
   B. Percutaneous:
      – Tandem Heart pVAD – Continuous flow, centrifugal pump.
      – <Investigational> Impella Continuous axial flow pump
        » JACC 2008 Nov 4;52(19):1584-8
3. Extra-Corporeal Membrane Oxygenation (ECMO)
Thoratec pVAD

Short Term Devices - Extracorporeal

Pulsatile Pneumatic Pump
CentriMag
Short Term Devices - Extracorporeal

Continuous Flow, Magnetically Levitated, Centrifugal Pump
TandemHeart pVAD

Short Term Devices - Percutaneous

Continuous Flow, Centrifugal Pump
Impella

Short Term Devices - Percutaneous

Continuous Axial Flow Pump
Bridge to Transplant
Bridge to Transplant

**Indications:**

1. Active heart transplant candidate.
2. Inotrope dependent with or without intra-aortic balloon pump (IABP).
3. Cardiac index <2.0 L/min/m²
   or PCWP>20mmHg
Bridge To Transplant

Intermediate Devices (Days to Weeks)
  – Paracorporeal VAD – Thoratec PVAD
  – Implantable VAD - Thoratec IVAD

Long-Term Devices (Months to Years)

Approved
  – Heartmate
    • HeartMate XVE – Pulsatile flow Pump
    • HeartMate II – Continuous Axial flow
  – Novacor LVAS – Pulsatile flow pump
  – Total Artificial Heart – Replaces native ventricle.
    • CardioWest

Investigational
  – Jarvik 2000 – Continuous Axial flow impeller pump
  – Ventrassist – Hydrodynamically suspended centrifugal pump
  – HeartWare – Hydrodynamically/Magnetically suspended centrifugal pump
  – Levacor – Magnetically levitated centrifugal pump
  – DuraHeart - Magnetically levitated centrifugal pump
Jarvik 2000
Long Term Devices - Implantable

Continuous Axial Flow Impeller Pump
Levacor  

Duraheart

Long Term Devices - Implantable

Magnetically Levitated Centrifugal Pump
Destination Therapy
Destination Therapy

**Indications:**

1. NYHA class IV heart failure refractory to maximal medical therapy including inotropes.
2. Depressed LVEF with poor peak oxygen consumption.
3. Contraindication to transplantation.
Destination Therapy

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Investigational

- HeartMate II – Continuous Axial flow
- Novacor LVAS – Pulsatile Flow Pump
- Ventrassist – Hydrodynamically suspended centrifugal pump
Disadvantages to LVAD Therapy

**Complications**

- Infection
- Bleeding
- Thromboembolism
- Pump Failure
- RV Dysfunction
Heart Transplantation

(A) Recipient aorta and pulmonary arteries remain.

(B) Donor (transplanted) heart in place.

Heart is cut so diseased heart can be removed.

Recipient aorta and pulmonary arteries remain.

Sutures used to attach donor heart.
Heart Transplantation

**Indications**
- New York Heart Association Class III-IV heart failure
- Refractory recurrent ventricular arrhythmias
- Refractory recurrent angina not amenable to medical, percutaneous, and/or surgical intervention
- Cardiogenic shock
- Mechanical assistance of a ventilator, intra-aortic balloon pump, ventricular assist device
- Continuous inotropic support/dependence
Relative Contraindications to Cardiac Transplantation

- Obesity (BMI>35)
- Irreversible Pulmonary Hypertension
- Diabetes with End-Organ Damage
- Renal Dysfunction
- Peripheral Vascular Disease
Relative Contraindications to Cardiac Transplantation

- Malignancy
- Active Substance Abuse
- Presence of a Psychiatric Disorder that Would Compromise Adherence to Medical Therapy
- Poor Social Support/Psychosocial Instability
- Severe CNS disease
Whom to Refer for Transplantation

- Age < 70 y/o
- End-Stage Cardiac Disease (NYHA Class III or IV) as a Result of Poor Cardiac Function or Uncontrollable Ventricular Arrhythmias Refractory to Medical Treatment
- Repeated Hospitalizations for Heart Failure
- Strong Social Support
- No Active Drug or Alcohol Abuse
NUMBER OF HEART TRANSPLANTS REPORTED BY YEAR

NOTE: This figure includes only the heart transplants that are reported to the ISHLT Transplant Registry. As such, this should not be construed as evidence that the number of hearts transplanted worldwide has declined in recent years.
AGE DISTRIBUTION
OF HEART RECIPIENTS (1/1982-6/2006)

% of Transplants

Recipient Age

0-9 10-19 20-29 30-39 40-49 50-59 60+

0 5 10 15 20 25 30 35 40

ISHLT

J Heart Lung Transplant 2007;26: 769-781

2007
ADULT HEART TRANSPLANT RECIPIENTS:
Cumulative Incidence of Leading Causes of Death
(Transplants: January 1992 - June 2005)

Cumulative Incidence of Cause-Specific Deaths

- CAV
- Acute Rejection
- Malignancy (non-Lymph/PTLD)
- Primary Failure
- Graft Failure
- CMV
- Infection (non-CMV)

Time (years)

Incidence of Cause-Specific Deaths

J Heart Lung Transplant 2007;26: 769-781

ISHLT

2007
HEART TRANSPLANTATION

Half-life = 10.0 years
Conditional Half-life = 13.0 years

N=70,702

Survival (%)

Years

ISHLT
J Heart Lung Transplant 2007;26: 769-781
Heart Transplant/VAD Team

- Referring Physician
- Local Hospital/First Responders
  - Cardiothoracic Surgeon
  - Transplant/VAD Cardiologist
  - Transplant/VAD Nurse Coordinators
  - Bioengineering Support
  - Medical Support (Nephrology, Pulmonary, Endocrinology, GI, ID...)
- Nutrition, Social Work, Financial Counselor
- Rehab Therapy (Physical, Occupational)
- Pharmacy
Options for Management of Advanced/End Stage HF

**Optimized Drug Rx**

**Surgery**

**BiV Pacemaker/ AICD**

[Branch]

**Advanced Rx**

[Branch]

**LVAD**

[Branch]

**BTT**

[Branch]

**Transplant**

**DT**

**BTR**
New Therapies for Advanced Heart Failure

- Novel Medications
- Pharmacogenetics
- Unique Devices
- Cell Therapy
- Gene Therapy
Gen-1 CorCap

AV Groove Stay Sutures

Anterior Seam
MINIATURE VAD Development - for Adults

Circulite
The Cockroach Heart