Ventricular Assist Devices

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Background, Indications for VADs

Mechanical circulatory support has become an acceptable therapy for end stage heart failure (HF) in maximally medically treated patients who are good surgical candidates. Most patients who are implanted with a left ventricular assist devices (LVAD) are on the heart transplant list but the trajectory of their HF is so steep that the transplant team worries that they may die before suitable donors are identified. The LVAD is used to as a bridge to transplant. Scientific Registry of Transplant Recipients (SRTR) annual report reveals that 27% of patients listed for heart transplant wait longer than one year.¹ Transplantation is limited by the reliance on organ donation in order to treat HF patients. Therefore, strategies such as implantation of LVADs become cornerstone in managing HF patients on the transplant list due to the limited donor pool.

Another indication for VAD implantation is the treatment of heart failure in patients who are not transplantable, referred to as destination therapy (DT). The Randomized Evaluation of a Mechanical Assistance for the Treatment of Congestive Heart failure or REMATCH trial was designed to determine if VADs can be used to treat HF in patients who are not transplant candidates.² The study demonstrated that HF patients implanted with LVADs live longer with an improved quality of life as compared to maximally medically treated patients. This new indication allows more patients access to this life saving technology.
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Referral Criteria

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Improvements in the technology

LVAD pumps have evolved over the past 20 years. The original, first generation, pumps were designed to mimic pulsatile flow. The pumps were large and had internal components with bearings and valves to provide for pulsatile, uni-directional blood flow. These components would wear out causing pump failure in 1 – 2 years. The size of the pump also limited the patients that could be implanted; a small body habitus was a contraindication to the first generation LVAD.

The second generation pumps have impellers that provide axial blood flow. The pumps are more robust resulting in longer support times. The devices are smaller so people with smaller body habitus, such as children and small framed adults, are candidates for this technology. Axial pumps move blood in a continuous fashion resulting in non-pulsatile flow so patients do not have pulses or blood pressures. Continuous flow physiology is a challenge for hospital staff and EMS providers requiring extra training and awareness in order to provide safe, appropriate care. The Heart Mate II [Thoratec, Inc. Pleasanton, California] pump was FDA approved for Bridge-to-transplant in April, 2008 and for Destination Therapy on January 20, 2010.
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Implantation and Components

Implantation of LVADs requires open heart surgery: sternotomy and cardiopulmonary bypass. The native heart remains in place and the LVAD is piggybacked onto the left ventricle. The surgeon cores out a hole in the apex of the ventricle and attaches the LVAD inflow conduit with a sewing ring. A pre-peritoneal pocket is created for the pump itself in the upper left quadrant of the abdominal cavity. The outflow graft is anastomosed into the ascending aorta. A drive line connects the pump with the external components (controller and power source) via a percutaneous stoma usually in the upper right quadrant of the abdomen. The staff, patients, patients’ support network (family, friends, coworkers), and EMS providers interface with the controller and power source to ensure proper operation of the pump.

*Pictures used with permission from Thoratec Inc. Pleasanton, California*
Case Presentation

History of Presenting Illness:
2/17/09:

62-year-old male presented with a history of a non-ischemic dilated cardiomyopathy with an ejection fraction of 20%. Previously, he was able to walk about 1 mile on medical therapy. Over the course of the previous 2 weeks, he had acute deterioration with DOE and reduced energy level. ICD interrogation revealed atrial fibrillation since 02/05/2009.
He was cardioverted, but did not have early resolution of symptoms. The Heart Failure team was called to evaluate patient for heart replacement therapy (LVAD and/or transplant).

Medical History:
Heart Failure diagnosed in 2003
History of smoking ½ ppd from age 20 to 57. quit 2005
Non insulin dependent diabetes mellitus
ICD placement for Low EF on 01 /05/09

Social History:
Korean decent, speaks English
Married, wife also speaks English
Anesthesiologist
Lives locally
2 adult children

Medications at the time of referral:
amiodarone 400 mg po every 8 hours
carvediolol 6.25 mg po twice daily
digoxin 0.125 mg po daily
enoxaparin 65 mg subcutaneously every 12 hours
furosemide 20 mg IV daily
ramipril 5 mg po daily

Laboratory data
WBC 10.3 \times 10^3
Hemoglobin 11.6 g/dL
Platelets 208 \times 10^3
Sodium 132 mEq/L
BUN 37 mg/dL
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Creatinine 1.7 mg/dL
Total Bilirubin 1.2 mg/dL
INR 1.4
BNP 2062

Echocardiogram: Ejection Fraction less than 15%

Time Line:
2/17/09:
Right Heart Catheterization (RHC):
Cardiac Index: 1.3 liters/minute per meter squared
Pulmonary Artery pressures: 80/36 mmHg (53),
Pulmonary Vascular Resistance> 5 Wood Units
Pulmonary Capillary Wedge Pressure of 40 mmHg.

IV milrinone was initiated.

Milrinone is a commonly used inotropic agent in advanced heart failure therapy when patients are already on beta blockers. The rationale for this selection is that dobutamine works by up regulating the adrenergic receptors directly competing with beta blockers. Milrinone not only does not compete with beta blockers but patients do not tachyphylaxis on this medication. Patients can be discharged on milrinone if they have a ICD due to the arrhythmogenic side effect. Once on milrinone, cardiopulmonary stress tests are no longer valid or necessary as these patients are too sick for exercise evaluation.

2/26/09:
Pt was to be discharged home but deteriorated, with a decrease in serum sodium to 127 mEq/L
RHC was repeated and showed: CO/CI: 3.2 liters/min /1.8 liters/minute per meter squared, with normalized PAP of: 37/14 mmHg (25)

↑ milrinone  0.75 mcg/kg/min IV

02/27/09:
Listed for heart transplant

02/28/09
Discharged on milrinone 0.75 mcg/kg/min IV (maximum dose) via PICC line to achieve consistent CI > 2.0 and PVR < 2.5

Followed weekly in outpatient transplant clinic
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4/8/09:
Presented to transplant team with 1 to 2 days of dyspnea, inability to sleep, and chills profound rigors and a temperature to 100 °F.
Lactate was elevated to 10 meq/L
He was also noted to be in atrial fibrillation. He was admitted for initiation of anti-arrhythmic therapy, TEE, cardioversion; however, overnight he converted to normal sinus rhythm
Transferred to the cardiac care unit in cardiogenic vs. septic shock

Labs:
creatinine from 1 mg/dL on admission to 1.4 mg/dL in 24 hours
sodium dropped from 142 mEq/L to 131 mEq/L.

All cultures remained negative but patient appeared clinically to be in shock

04/08/2009:
RA pressure of 15 mmHg,
pulmonary capillary wedge pressure 29 mmHg,
right pulmonary arterial pressure 66/33, mean 45,
cardiac output 3.13 liters/minute,
cardiac index 1.85 liters/minute per meter squared.
PVR = 5 WU. Not transplantable with PVR > 4.
Recommended LVAD implant as patient had failed maximum medical therapy and deteriorated such that he was not transplantable without mechanical left ventricular off loading.

4/10/09
Heart Mate II VAD (HMII) [Thoratec, Inc. Pleasanton, California]
Immediately postoperatively: intensive care unit with the
milrinone 0.75 mcg/kg/min and
inhaled nitric oxide at 20 parts/million.
Extubated on day two; sildenafil was started
Patient was able to be transferred to a step down telemetry unit by his sixth postoperative day.
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04/24/2009
Patient was discharged home

DISCHARGE MEDICATIONS: Medications include
- amiodarone 400 mg twice daily   arrhythmia suppression
- warfarin as directed   Second generation pumps require anticoagulation
- sildenafil 20 mg 3 times a day   Pulmonary Hypertension
- pantoprazole 40 mg daily   post operative stomach protection
- metoclopramide 10 mg 3 times a day   postoperative constipation
- sitagliptin 100 mg daily   NIDDM
- aspirin 81 mg daily   anti-platelet for the VAD
- lisinopril 5 mg 2 times a day   Manage MAP 70 – 90.
- senna 2 tablets at bedtime   postoperative constipation
- oxycodone 5mg/ acetaminophen 325 mg 1 to 2 tablets every 4 hours   Surgical Pain

04/27/2009,
First follow up in VAD clinic then follow weekly.

5/14/09:
Outpatient RHC showed improved PAP, with PVR 2.4 WU.
Did not require readmission while supported on VAD.

09/17/09:
Orthotopic Heart Transplant (OHT) alive and well through May 2010 at the time of posting.
REFERENCES
