Surgical Options for Advanced Heart Failure

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Rabin Medical Center, Beilinson Hospital

Heart Disease and Heart Failure - The Magnitude of the Problem

- Congestive heart failure affects nearly 5 million in the US and its prevalence is growing around the world.
- About 70,000 new patients each year, with severe heart failure, are expected in the USA by the year 2010
- In 1995 the cost of heart disease in the US was >$174B, with ~70% for hospitalization and nursing home care.

American Heart Association. 1998 Heart and Stroke Statistical Supplement. Dallas, TX: AHA, 1997

Epidemiology of Heart Failure in Israel

- 6-10% of adults > 65 yrs of age
- Total number of patient: 86,000 pts
- New cases: 8,600 per year
- Death per year: 6,000 people

Treatment Options
Surgery

- Revascularization
- Valve repair
- Ventricular reconstruction
- Constraint devices
- Heart (allo)transplantation
- Heart xenotransplantation
- Mechanical devices

Myocardial Revascularization

- Seems to be beneficial when more then 25% viability is present
- Metanalysis *(Allman et al. J Am Coll Cardiol 2002;39:1151-8)*
  - 3088 patients
  - LVEF 32±8%
  - Follow-up 25±10 months
  - Annual mortality

	+VIABILITY	-VIABILITY
CABG	3.2%	7.7%
Medical	16%	6.2%

Mitral Valve Repair

- Popularized by Bolling
- Downsizing ring
- RV dysfunction and PHT are not doing well
- 48 patients with severe MR and EF<25%
  - 12 and 24 months survival: 82% and 71%
  - FC: 3.9±0.3 to 2.0±0.6
  - LVEF 17±3% to 26±8%

Bolling et al. J Thorac Cardiovasc Surg 1998;115:381-8.

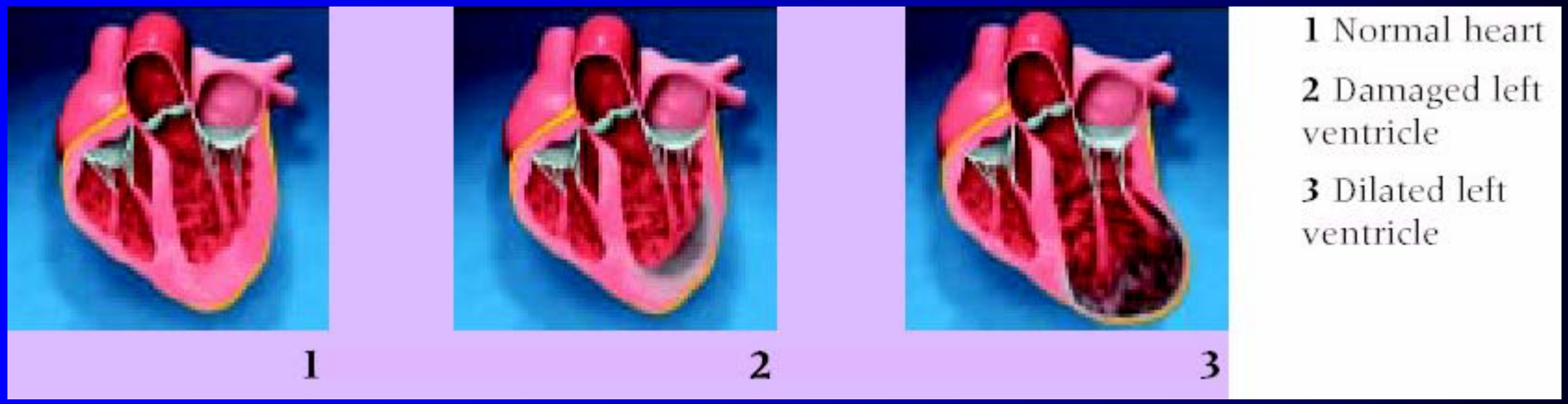
Mitral Valve Repair
No Survival Advantage?

- 419 patients with severe MR
- Death, LV assist device implantation, or transplantation
- Mitral valve annuloplasty (n=126) -> 62 (49%)
- Treated medically (n=293) -> 120 (41%)
- Not significant

Wu AH et al. J Am Coll Cardiol 2005;45:381-7

Ventricular Reconstruction

- Popularized by DOR
- Initially used for LV aneurysm only
- Reshaping the globular dilated heart into a conical one became apparent later



RESTORE Study

- 1,198 patients with postinfarction dilated cardiomyopathy had CABG and LV restoration between 1998 - 2003
- Non contracting segments excluded
- Improved EF and NYHA
- Perioperative mortality – 5.3%
- Overall 5 years survival – 69%
- Freedom from readmissions for CHF – 78%

Athanasuleas et al. JACC 2004; 44: 1439-45

STICH

Surgical Treatment for Ischemic Heart Failure

- Multi center trial
- About 3,000 patients will be enrolled
- MED vs. CABG + MED vs. CABG and LV reconstruction + MED
- LVEF<=35%

Coronary Bypass Surgery with or without Surgical Ventricular Reconstruction

Robert H. Jones, M.D., Eric J. Velazquez, M.D., Robert E. Michler, M.D., George Sopko, M.D., Jae K. Oh, M.D., Christopher M. O'Connor, M.D., James A. Hill, M.D., Lorenzo Menicanti, M.D., Zygmunt Sadowski, M.D., Patrice Desvigne-Nickens, M.D., Jean-Lucien Rouleau, M.D., and Kerry L. Lee, Ph.D., for the STICH Hypothesis 2 Investigators*

ABSTRACT

BACKGROUND

Surgical ventricular reconstruction is a specific procedure designed to reduce left ventricular volume in patients with heart failure caused by coronary artery disease. We conducted a trial to address the question of whether surgical ventricular reconstruction added to coronary-artery bypass grafting (CABG) would decrease the rate of death or hospitalization for cardiac causes, as compared with CABG alone.

METHODS

Between September 2002 and January 2006, a total of 1000 patients with an ejection fraction of 35% or less, coronary artery disease that was amenable to CABG, and dominant anterior left ventricular dysfunction that was amenable to surgical ventricular reconstruction were randomly assigned to undergo either CABG alone (499 patients) or CABG with surgical ventricular reconstruction (501 patients). The primary outcome was a composite of death from any cause and hospitalization for cardiac causes. The median follow-up was 48 months.

RESULTS

Surgical ventricular reconstruction reduced the end-systolic volume index by 19%, as compared with a reduction of 6% with CABG alone. Cardiac symptoms and exercise tolerance improved from baseline to a similar degree in the two study groups. However, no significant difference was observed in the primary outcome, which occurred in 292 patients (59%) who were assigned to undergo CABG alone and in 289 patients (58%) who were assigned to undergo CABG with surgical ventricular reconstruction (hazard ratio for the combined approach, 0.99; 95% confidence interval, 0.84 to 1.17; P=0.90).

CONCLUSIONS

Adding surgical ventricular reconstruction to CABG reduced the left ventricular volume, as compared with CABG alone. However, this anatomical change was not associated with a greater improvement in symptoms or exercise tolerance or with a reduction in the rate of death or hospitalization for cardiac causes. (ClinicalTrials.gov number, NCT00023595.)

From the Duke Clinical Research Institute, Duke University Medical Center, Durham, NC (R.H.J., E.J.V., C.M.O., K.L.L.); the Montefiore Medical Center–Albert Einstein College of Medicine, Bronx, NY (R.E.M.); the National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD (G.S., P.D.-N.); the Mayo Clinic, Rochester, MN (J.K.O.); the University of Florida College of Medicine, Gainesville (J.A.H.); San Donato Hospital, Milan (L.M.); National Institute of Cardiology, Warsaw, Poland (Z.S.); and Institut de Cardiologie de Montréal, University of Montreal, Montreal (J.-L.R.). Address reprint requests to Dr. Jones at P.O. Box 2986, Duke University Medical Center, Durham, NC 27710, or at jones060@mc.duke.edu.

*A complete list of investigators participating in the Hypothesis 2 component of the Surgical Treatment for Ischemic Heart Failure (STICH) trial is provided in the Supplementary Appendix, available with the full text of this article at NEJM.org.

This article (10.1056/NEJMoa0900559) was published at NEJM.org on March 29, 2009.

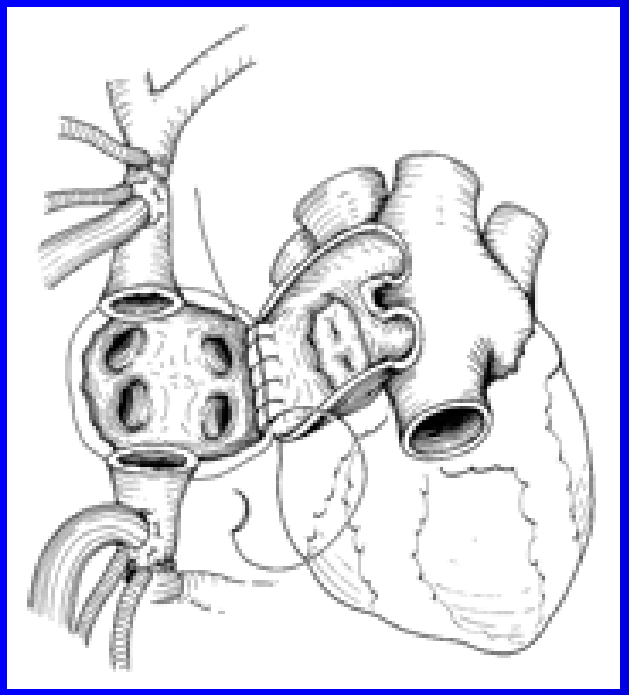
N Engl J Med 2009;360:1705-17.

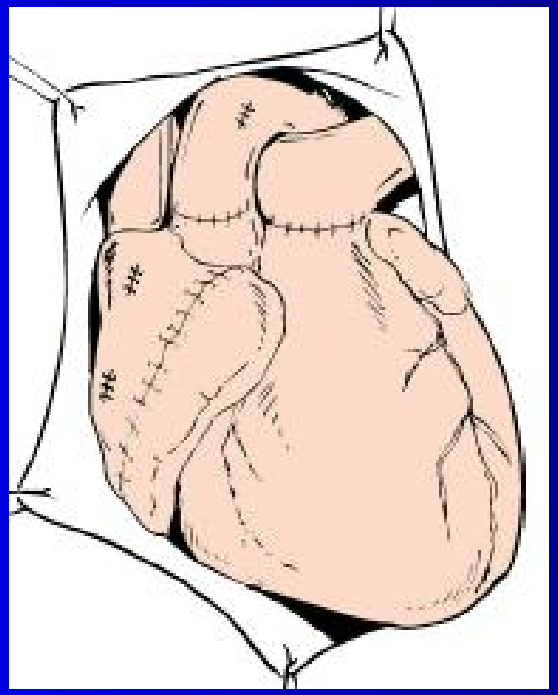
Heart (allo)transplantation

Pros	Cons
• Current gold standard	• **Limited supply** • Requires immunosuppressive medications – Rejection is common – Infection is common

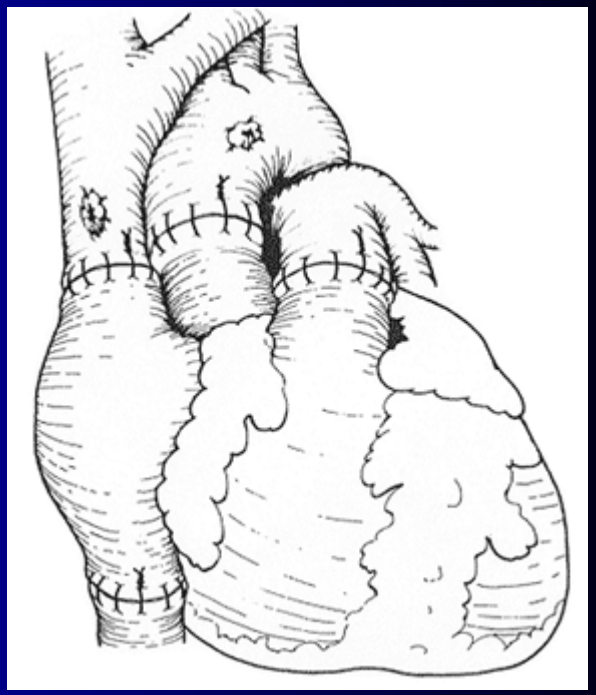
Surgical Technique

Shumway





BiCaval



Less TR
Less Pacemaker

Heart xenotransplantation

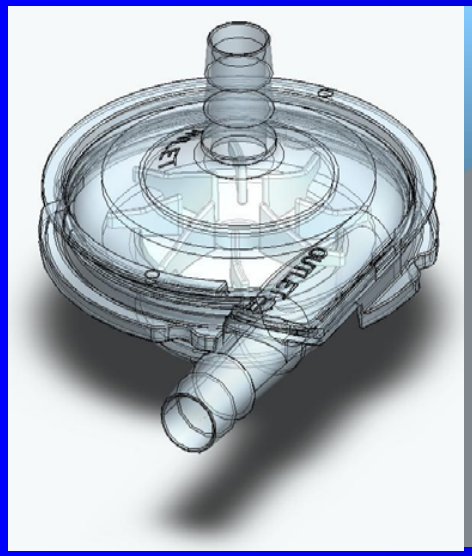
Pros	Cons
• Unlimited supply	• Moral and ethical concerns • Viral infection • Immunosuppressive issues • Not available yet

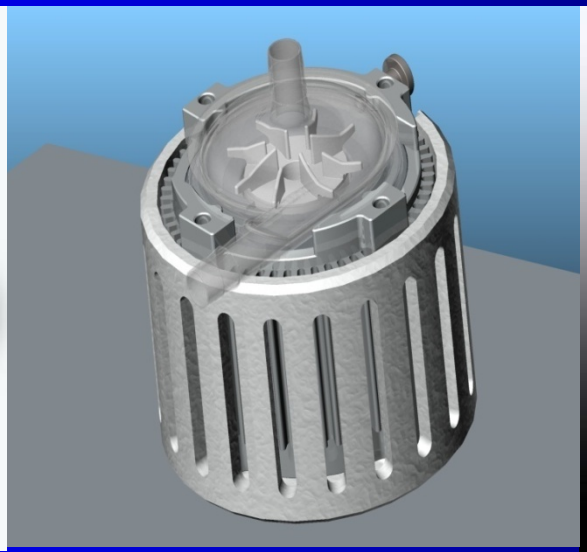
"Xenotransplantation is the future of cardiac transplantation and always will be"
N. Shumway, 1990

Mechanical Assistance availabe

- Short term (Centrifugal pumps)
  - LVAD
  - RVAD
  - BiVAD
  - ECMO
- Long term
  - Pulsatile (Thoratec PVAD, Cardiowest TAH)
  - Axial flow (HeartMate II)
  - Centrifugal (HeartWare)

Levitronix

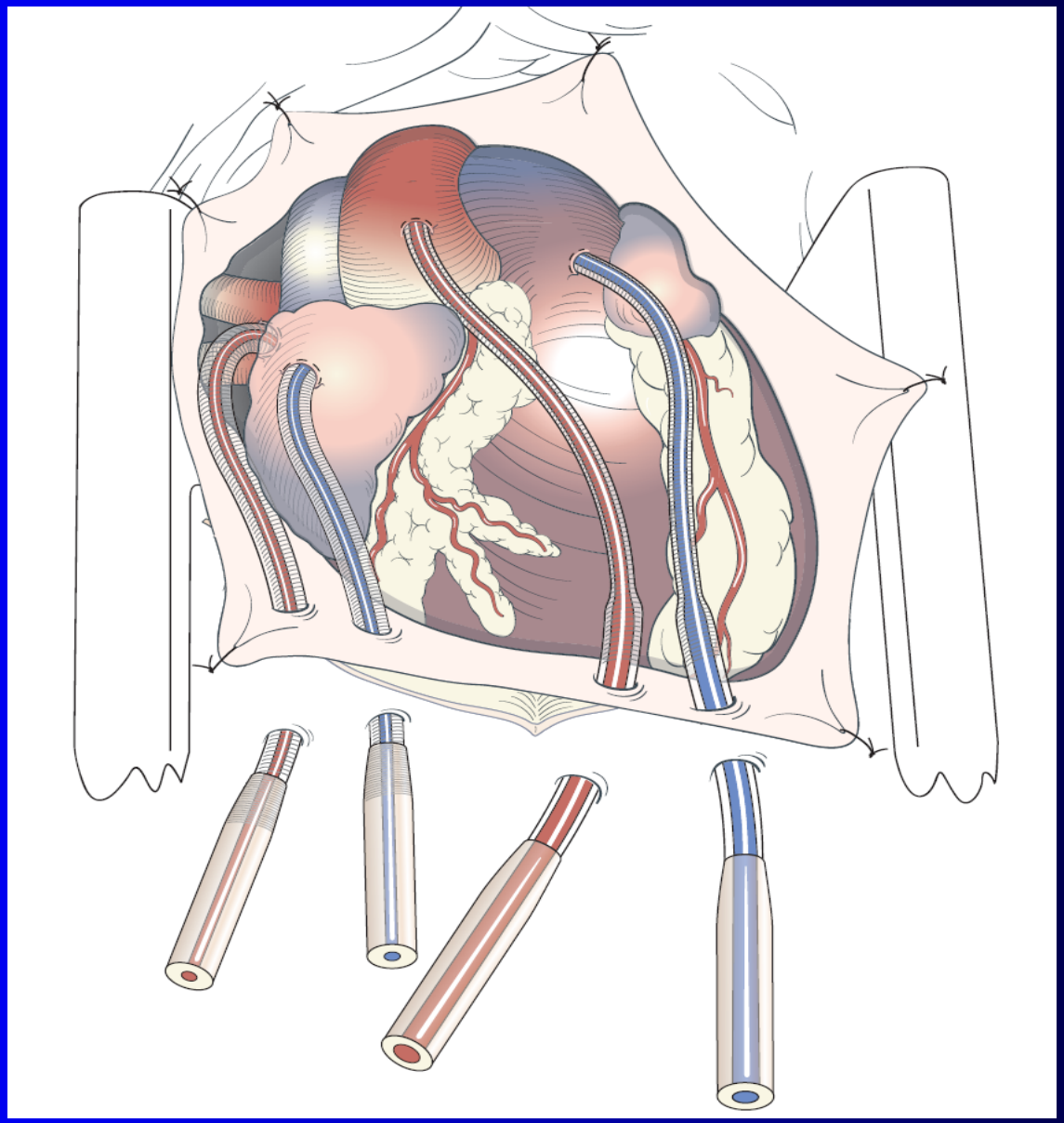




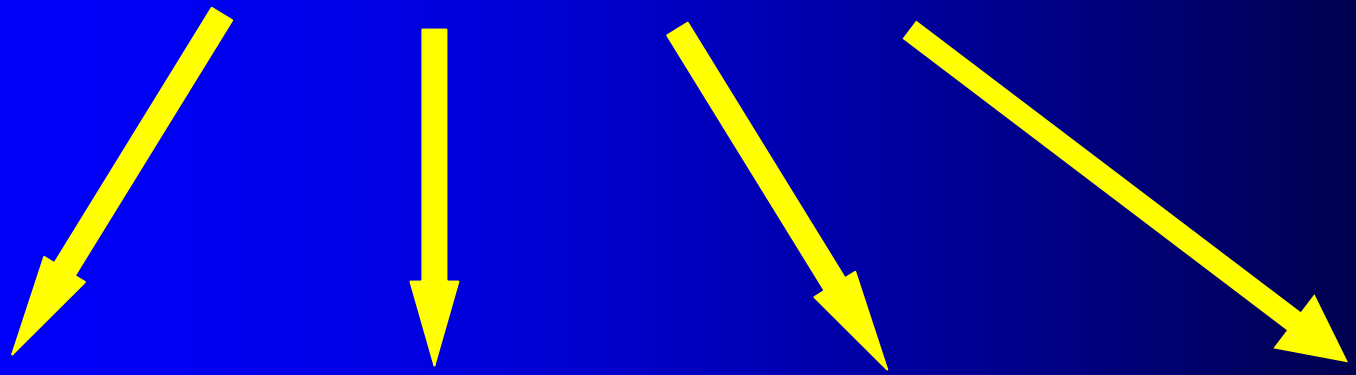
The Levitronix® CentriMag VAS is designed to provide temporary support for patients suffering potentially reversible cardiogenic shock.

FDA approved for up to 30 days of use.

Cannulation



Mechanical Assistance



Bridge to transplant

Bridge to recovery

Long term therapy

Bridge to decision

Univentricular vs. Biventricular Assist Device Support

- Indications for Biventricular Support
  - Signs of Right Heart Failure
  - Intractable Arrhythmias
  - RV/Septal Infarction
  - Elevated PVR
  - Secondary Organ Involvement
  - Prolonged Cardiogenic Shock “Sicker Patients”

Bridge to Transplantation

- Main use of devices today
- Most require LVAD only
- About 10% will require additional RVAD
- About 70% will survive to transplantation
- Survival after transplantation similar to those without a device

Bridge to Recovery

- Currently unpredictable results
- It is yet to be discovered who are the patients that will recover and will not fail shortly after removal of device

Left Ventricular Assist Device and Drug Therapy for the Reversal of Heart Failure

Emma J. Birks, M.R.C.P., Ph.D., Patrick D. Tansley, F.R.C.S., James Hardy, M.B., B.S., B.Sc., Robert S. George, M.R.C.S., B.Sc., Christopher T. Bowles, Ph.D., Margaret Burke, F.R.C.Path., Nicholas R. Banner, F.R.C.P., Asghar Khaghani, F.R.C.S., and Magdi H. Yacoub, F.R.S.

N ENGL J MED 355;18 WWW.NEJM.ORG NOVEMBER 2, 2006

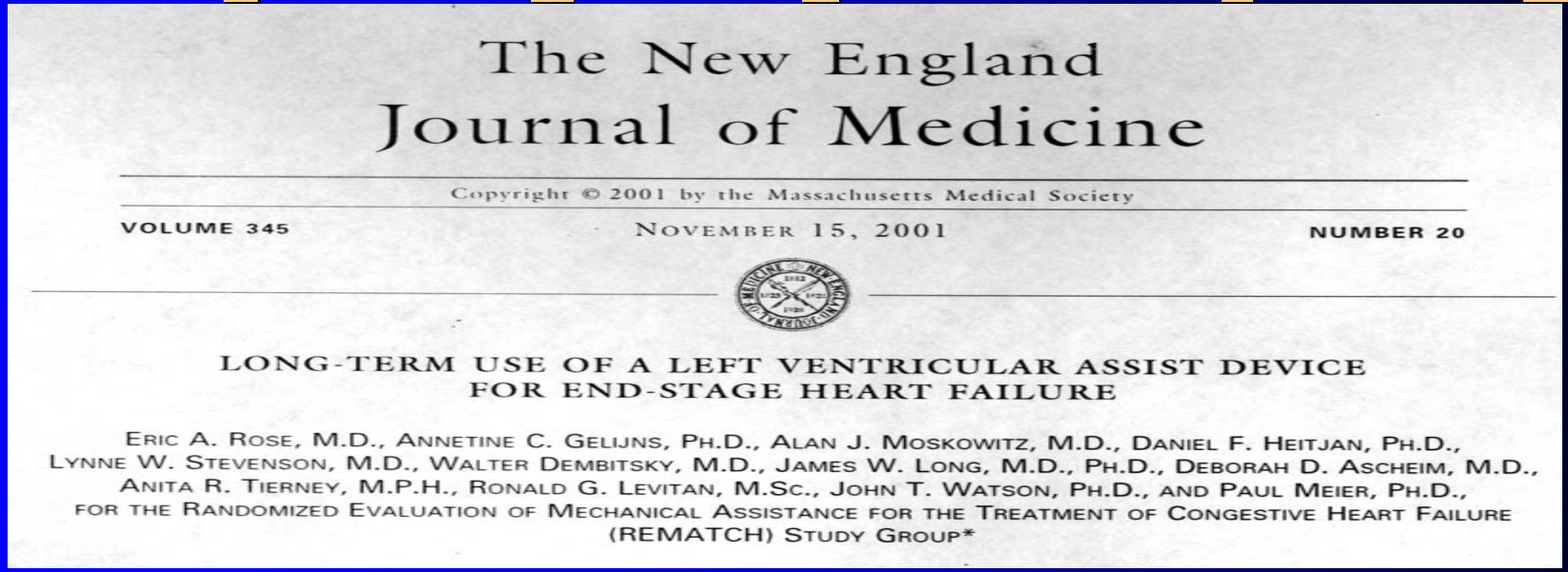
- 15 patients, NICM receiving inotropes
- Extensive HF therapy post LVAD implantation
- 11 patients were explanted after 320±186 days
- 2 died (1 arrhythmia, 1 carcinoma)
- Freedom from HF at 1 and 4 years was 100% and 89%
- Quality of life near normal

Long Term Therapy

- Lack of donors and successful long term support as bridge, opened a new era

REMATCH study

***R**andomized **E**valuation of **M**echanical **A**ssistance for the **T**reatment of **CH**F*



The New England Journal of Medicine

VOLUME 345 · NOVEMBER 15, 2001 · NUMBER 20

LONG-TERM USE OF A LEFT VENTRICULAR ASSIST DEVICE FOR END-STAGE HEART FAILURE

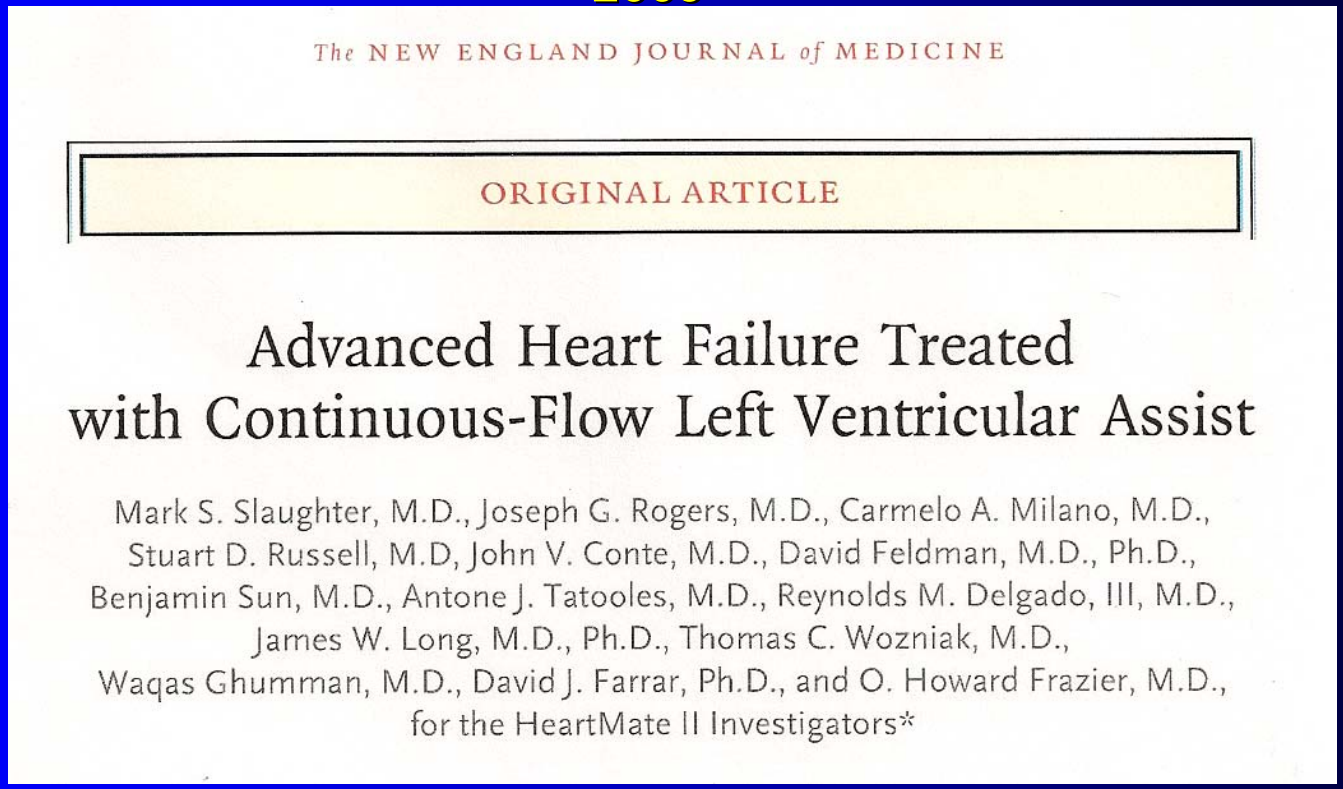
ERIC A. ROSE, M.D., ANNETINE C. GELIJNS, PH.D., ALAN J. MOSKOWITZ, M.D., DANIEL F. HEITJAN, PH.D., LYNNE W. STEVENSON, M.D., WALTER DEMBITSKY, M.D., JAMES W. LONG, M.D., PH.D., DEBORAH D. ASCHEIM, M.D., ANITA R. TIERNEY, M.P.H., RONALD G. LEVITAN, M.SC., JOHN T. WATSON, PH.D., AND PAUL MEIER, PH.D., FOR THE RANDOMIZED EVALUATION OF MECHANICAL ASSISTANCE FOR THE TREATMENT OF CONGESTIVE HEART FAILURE (REMATCH) STUDY GROUP*

- 129 patients (68 – LVAS, 61 – optimal medical)
- Mean age: 66 ± 9 years
- 48% reduction in risk of death
- 1 year survival: 52% vs. 25%
- 2 year survival: 23% vs. 8%
- Improved quality of life at 1 year

Destination Therapy

- Heartmate XVE - an enhanced version of the VE version used in the REMATCH study was approved for destination therapy in non transplanted candidates in 2002 by the FDA.

HeartMate II Destination Trial Nov 2009



The NEW ENGLAND JOURNAL of MEDICINE

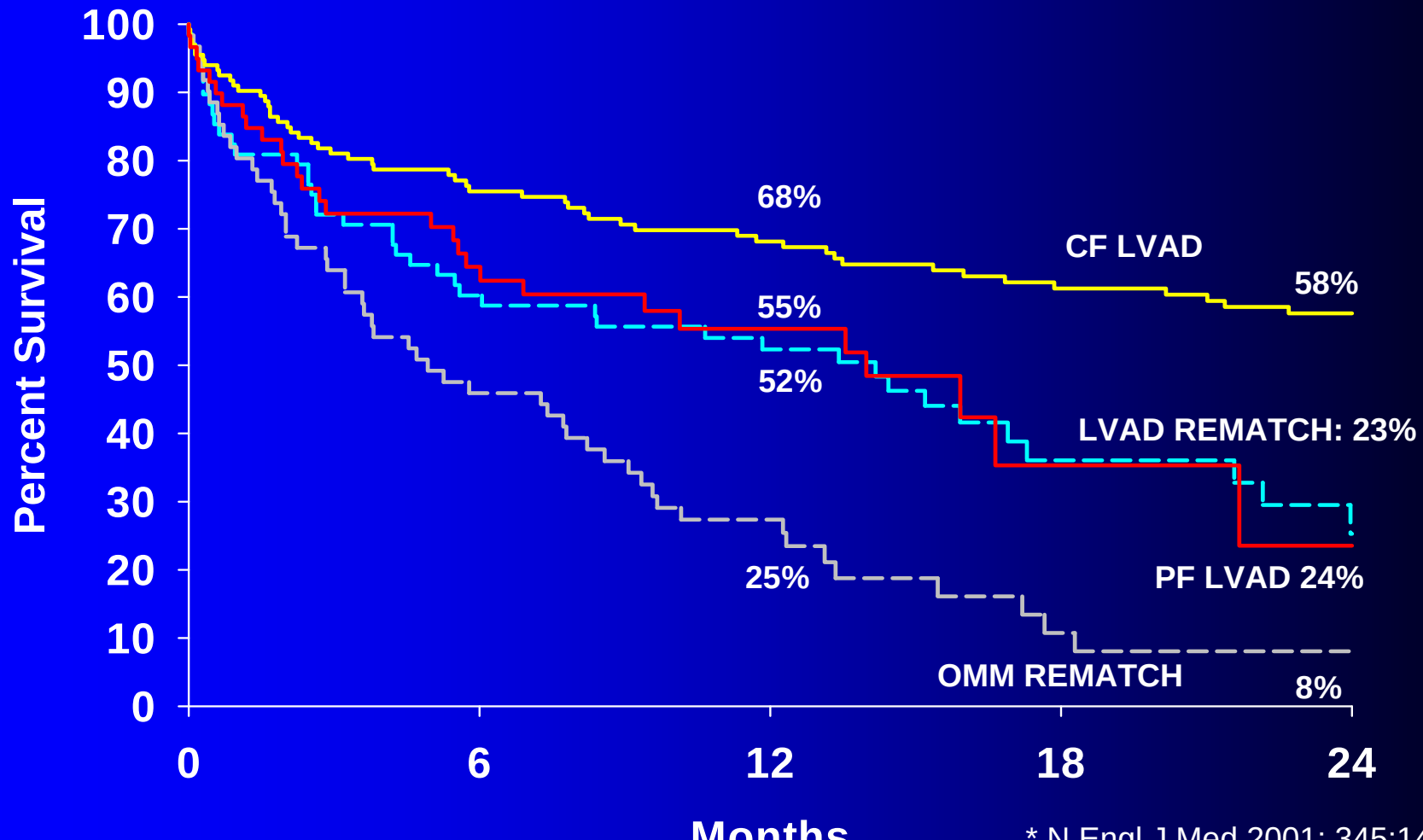
ORIGINAL ARTICLE

Advanced Heart Failure Treated with Continuous-Flow Left Ventricular Assist

Mark S. Slaughter, M.D., Joseph G. Rogers, M.D., Carmelo A. Milano, M.D., Stuart D. Russell, M.D, John V. Conte, M.D., David Feldman, M.D., Ph.D., Benjamin Sun, M.D., Antone J. Tatooles, M.D., Reynolds M. Delgado, III, M.D., James W. Long, M.D., Ph.D., Thomas C. Wozniak, M.D., Waqas Ghumman, M.D., David J. Farrar, Ph.D., and O. Howard Frazier, M.D., for the HeartMate II Investigators*

FDA approval following the study

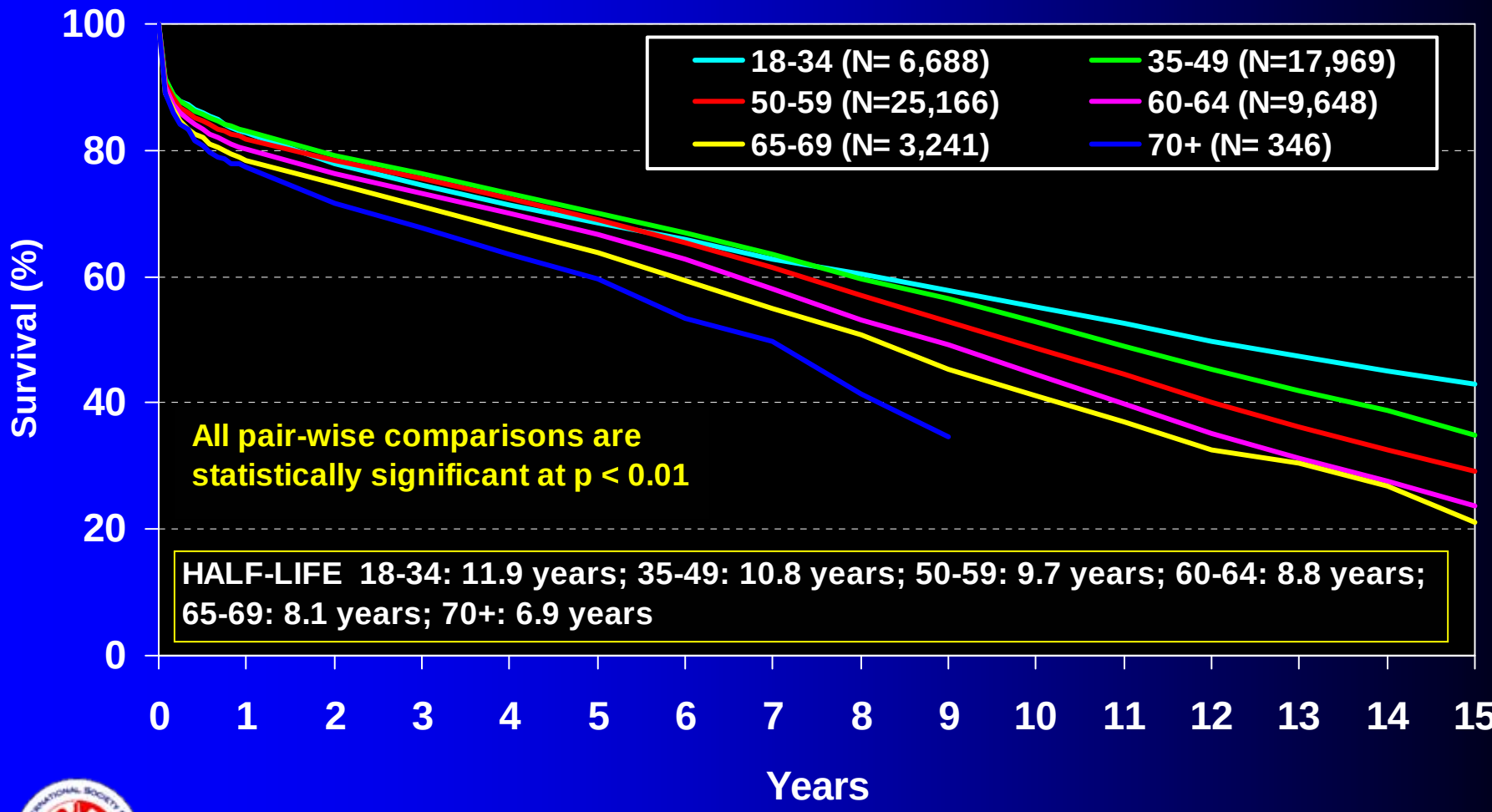
Actuarial Survival vs REMATCH*
HeartMate II Destination Therapy Trial



* N Engl J Med 2001; 345:1435-43

ADULT HEART TRANSPLANTATION

Kaplan-Meier Survival by Age Group (Transplants: 1/1982-6/2005)



ISHLT

2008

J Heart Lung Transplant 2008;27: 937-983

Last updated based on data as of December 2006

Bridge to Decision

- Patients that are non transplantable may turn with time to be good transplant candidate
  - Freedom from malignancy
  - Pulmonary hypertension

Pathophysiology of PHT

- Increased hydrostatic pressure
- Decreased availability of NO
- Hypoxia → vasoconstriction
- Pulmonary vessels remodeling

Clinical Perspective

- Elevated pulmonary vascular resistance unresponsive to pharmacological intervention is a major limitation in heart transplantation.
- PVR >2.5 Wood units in about 30% of all heart transplant candidates
- Non-responsive pulmonary hypertension in 70% of these patients

Chen JM et al. J Thorac Cardiovasc Surg 1997;114:627-634.

Clinical Perspective

- Survival Rate After Orthotopic Heart Transplantation (18 Months)
  - PVR<2.5 Wood 72 %
  - PVR > 5 Wood 38%

Anguita M et al. J Heart Lung Transplant 1992

Left ventricular assist devices decrease fixed pulmonary hypertension in cardiac transplant candidates

Daniel Zimpfer, MD,[a] Philipp Zrunek, MS,[b] Wilfried Roethy, MD,[a] Martin Czerny, MD,[a] Heinz Schima, PhD,[b] Leopold Huber, PhD,[b] Michael Grimm, MD,[a] Angela Rajek, MD,[c] Ernst Wolner, MD, PhD,[a] and Georg Wieselthaler, MD[a]

J Thorac Cardiovasc Surg 2007;133:689-95

- 35 patients who received LVAD for PHT
- PHT decreased in all
- 24 (70%) survived to transplantation

ELSEVIER

European Journal of Cardio-thoracic Surgery 31 (2007) 698–702

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

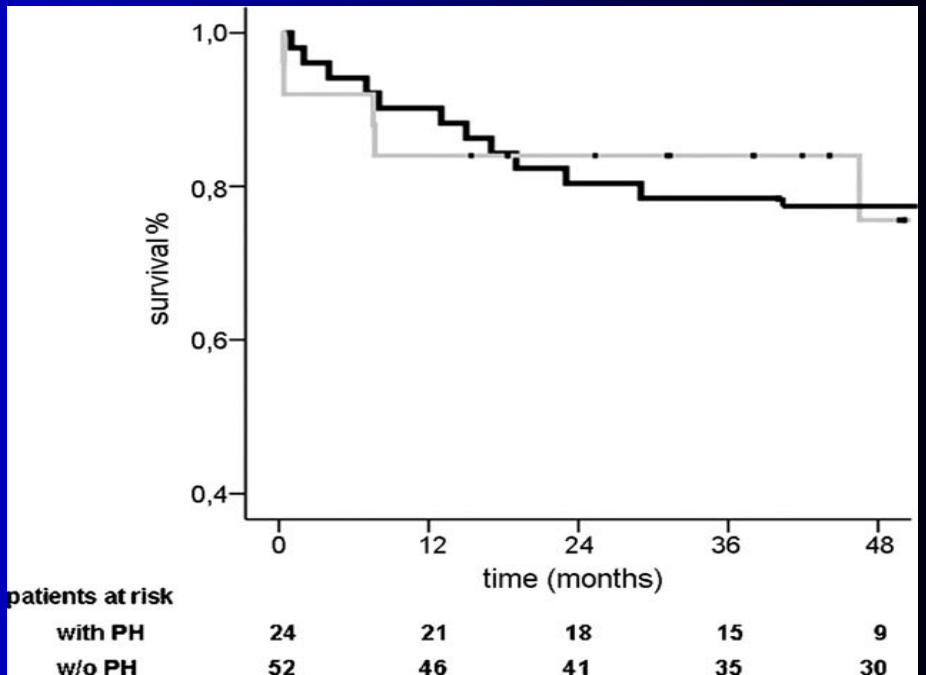
www.elsevier.com/locate/ejcts

Post-transplant survival after lowering fixed pulmonary hypertension using left ventricular assist devices☆

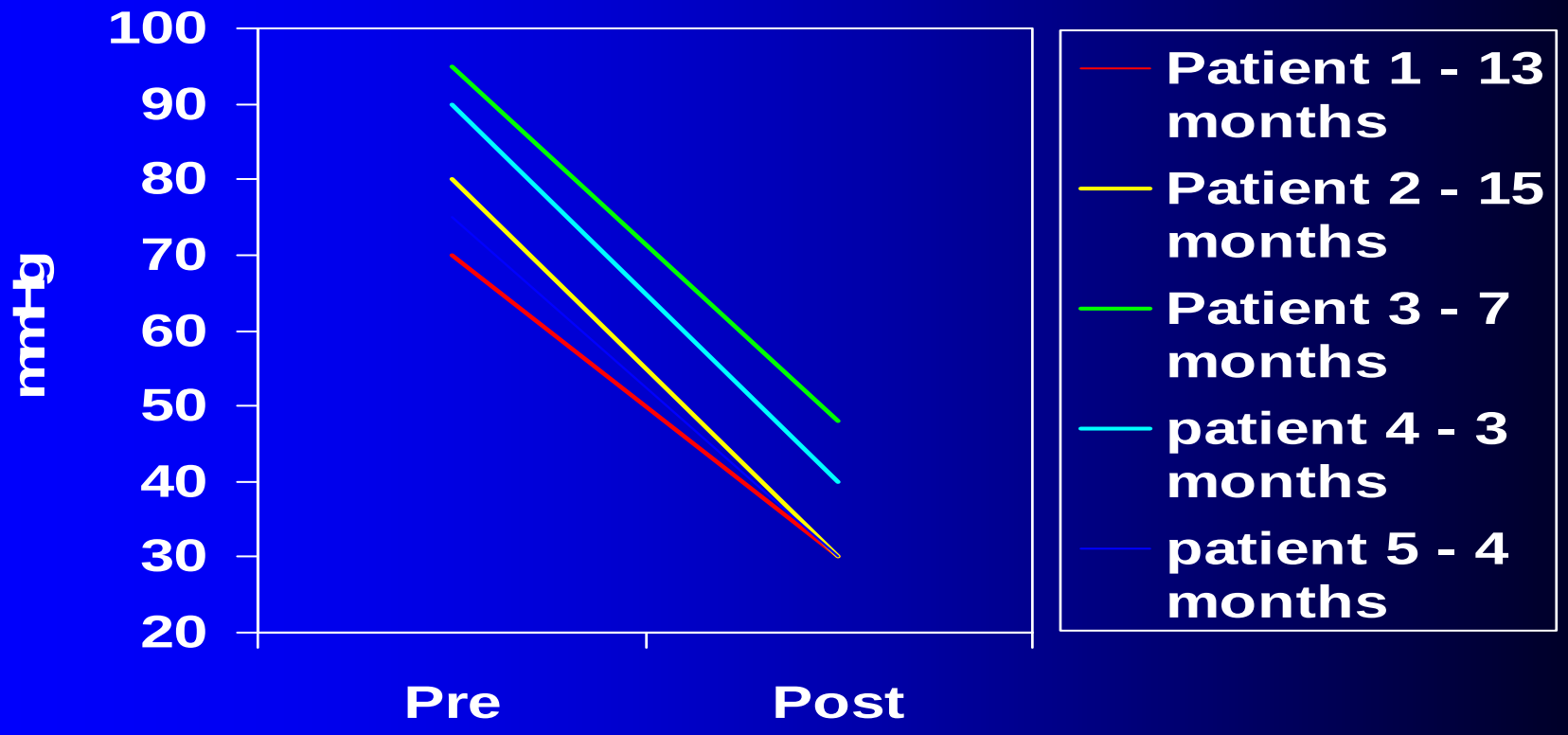
Daniel Zimpfer [a,*], Philipp Zrunek [b], Sigrid Sandner [a], Heinz Schima [b], Michael Grimm [a], Andreas Zuckermann [a], Ernst Wolner [a], Georg Wieselthaler [a]

[a] *Department of Cardiothoracic Surgery, Medical University of Vienna, Wahringer Guertel 18-20, A-1090 Vienna, Austria*
[b] *Department. of Biomedical Engineering, Medical University of Vienna, Ludwig Bolzman Institute for Cardiovascular Research, Austria*

- 24 LVAD for PHT
- 52 matched NO PHT
- Similar survival



Pulmonary Pressure



Devices

Complications

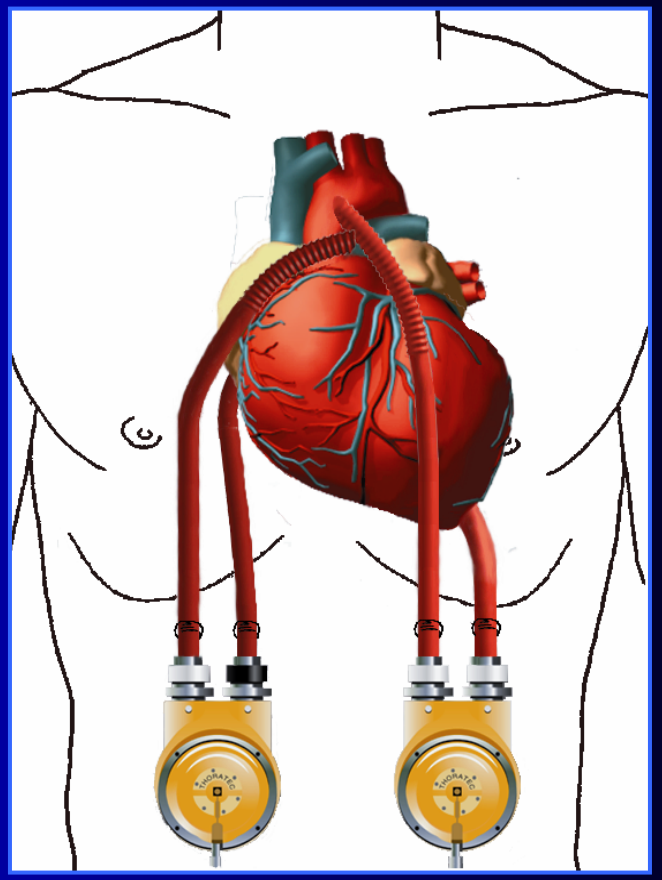
- Infection
- Malfunction
- Thromboembolism

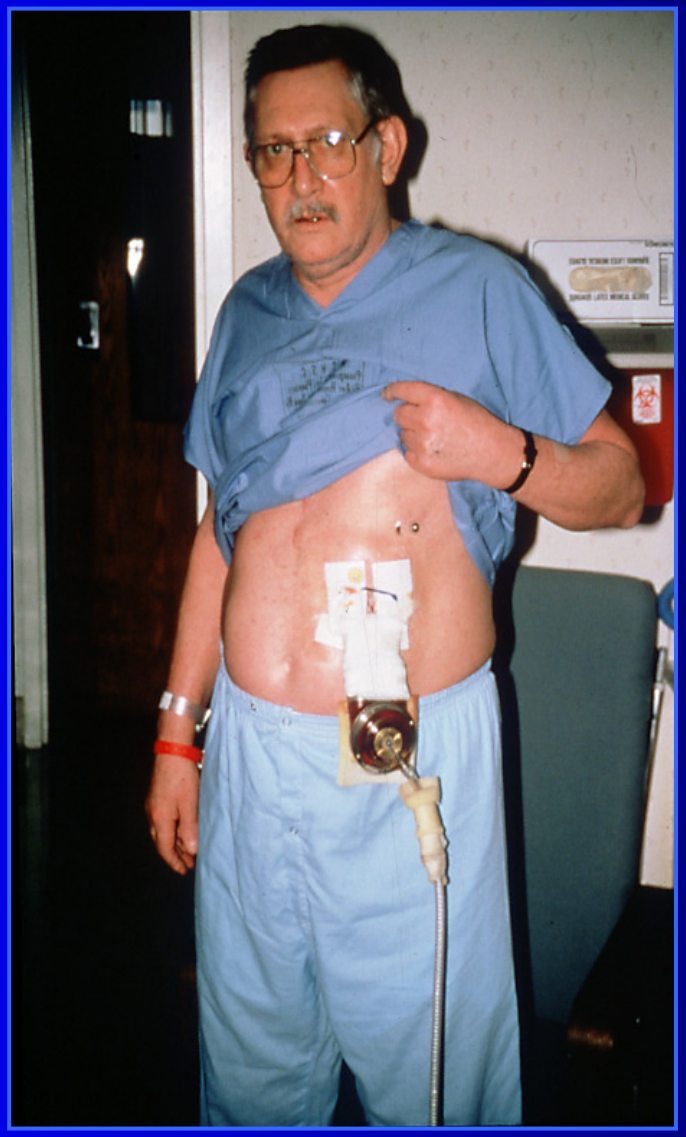
Limitations

- Size
- Durability
- Portability
- Energy source

Thoratec®: *Paracorporeal VAD*

- Pulsatile
- Pneumatic
- Univentricular or Biventricular Support
- Numerous Cannulation Options
- Small and Large Patients (17 Kg - 144 Kg)
- Short to Long-Term Support





Univentricular vs. Biventricular Assist Device Support

- Indications for Biventricular Support
  - Signs of Right Heart Failure
  - Intractable Arrhythmias
  - RV/Septal Infarction
  - Elevated PVR
  - Secondary Organ Involvement
  - Prolonged Cardiogenic Shock “Sicker Patients”

Total Artificial Heart

Total Artificial Heart patient Mr. Potiron *leaves University Hospital of Nantes in France to enjoy life at home thanks to the European portable driver. After 502 days of life with the Artificial Heart, on April 3, 2009, Mr. Potiron received a donor heart transplant and is currently enjoying life at home with his family.*

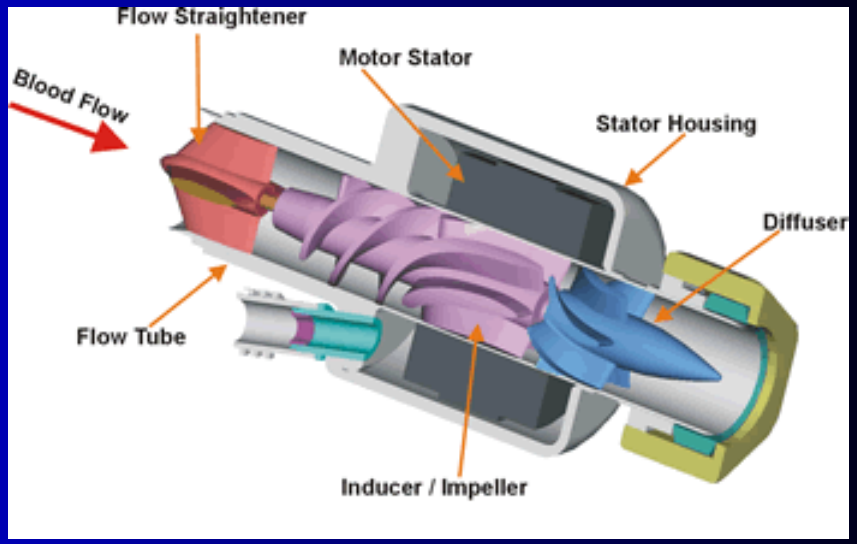
CardioWest

- Pulsatile, pneumatic driven

Fully FDA approved as a bridge to transplantation Since 2004

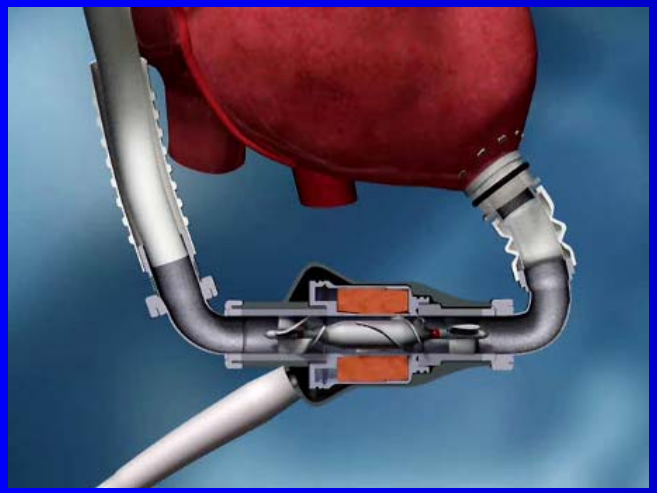
Axial Flow Pumps

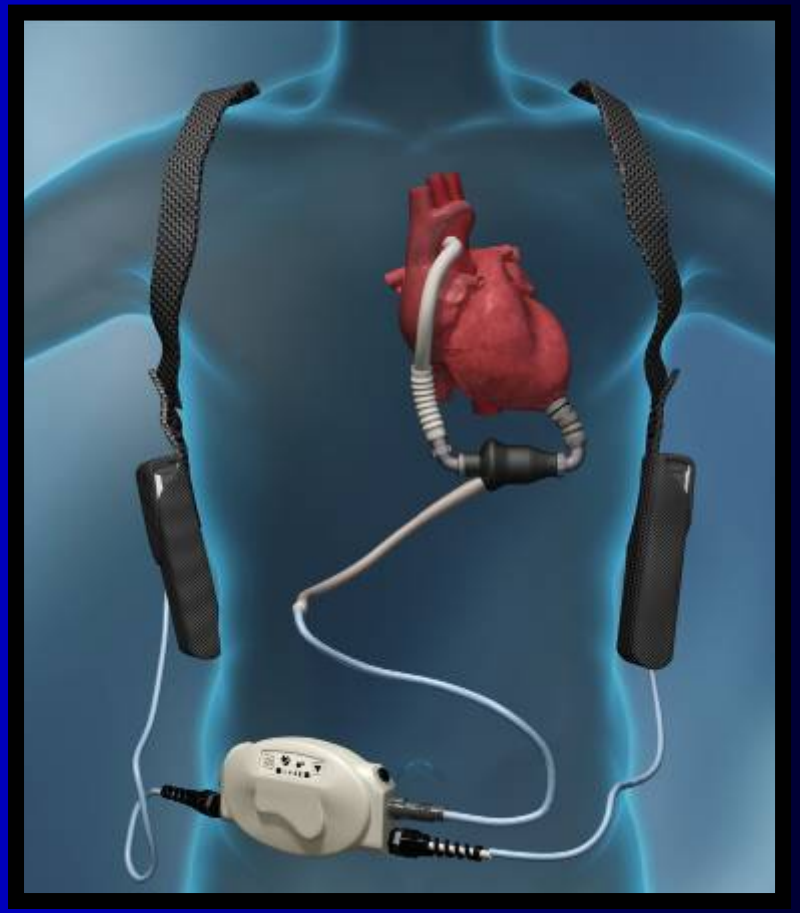
- magnetically suspended
- Small
- Silent
- Valveless
- 7,000-12,000 RPM
- Afterload dependent
- Can deliver up to 10 lit/min



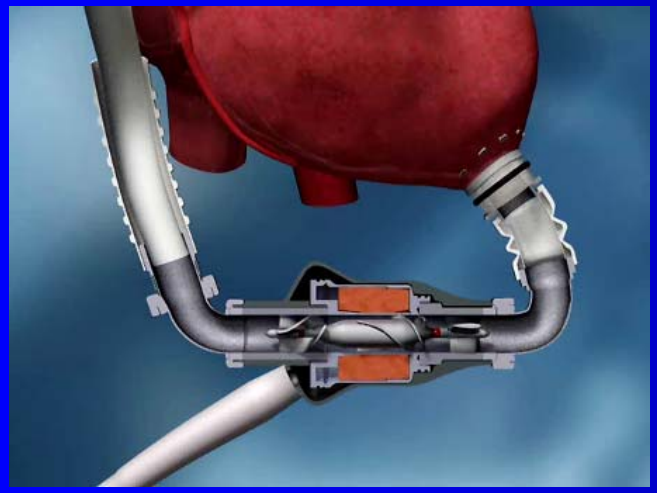
Axial Flow Pumps

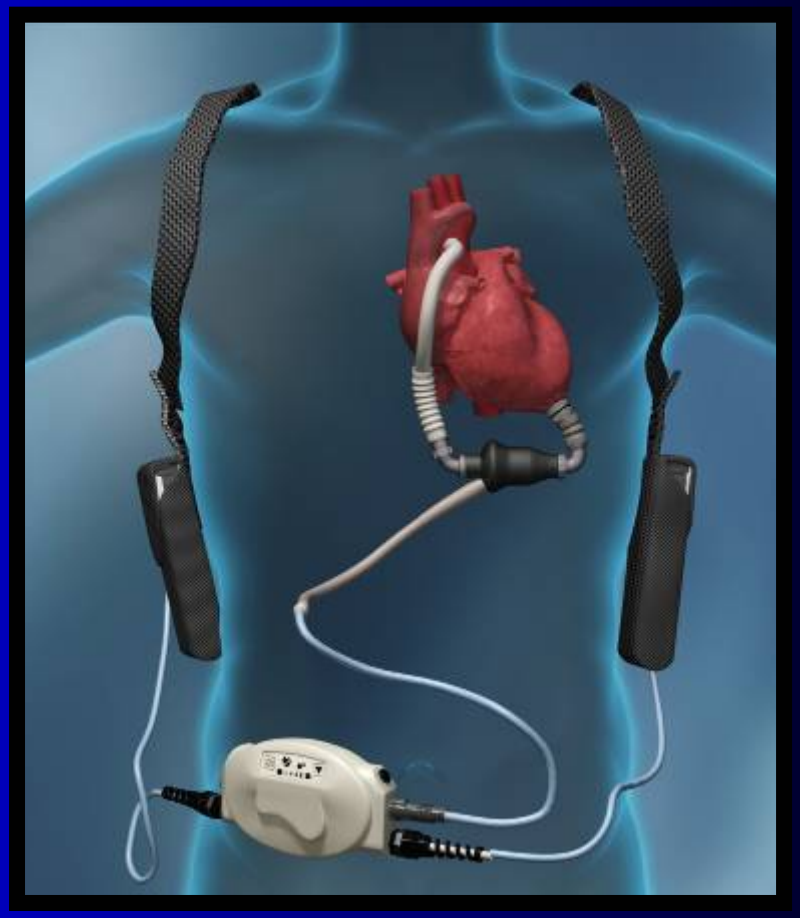
HeartMate II

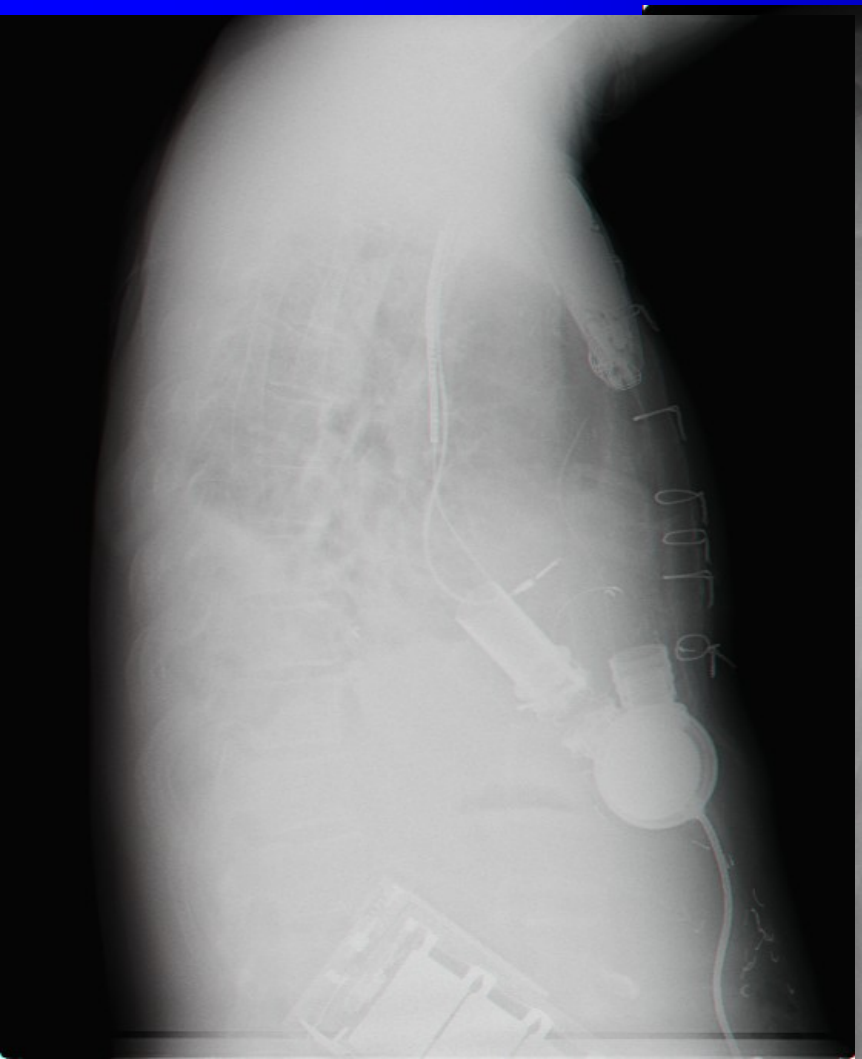


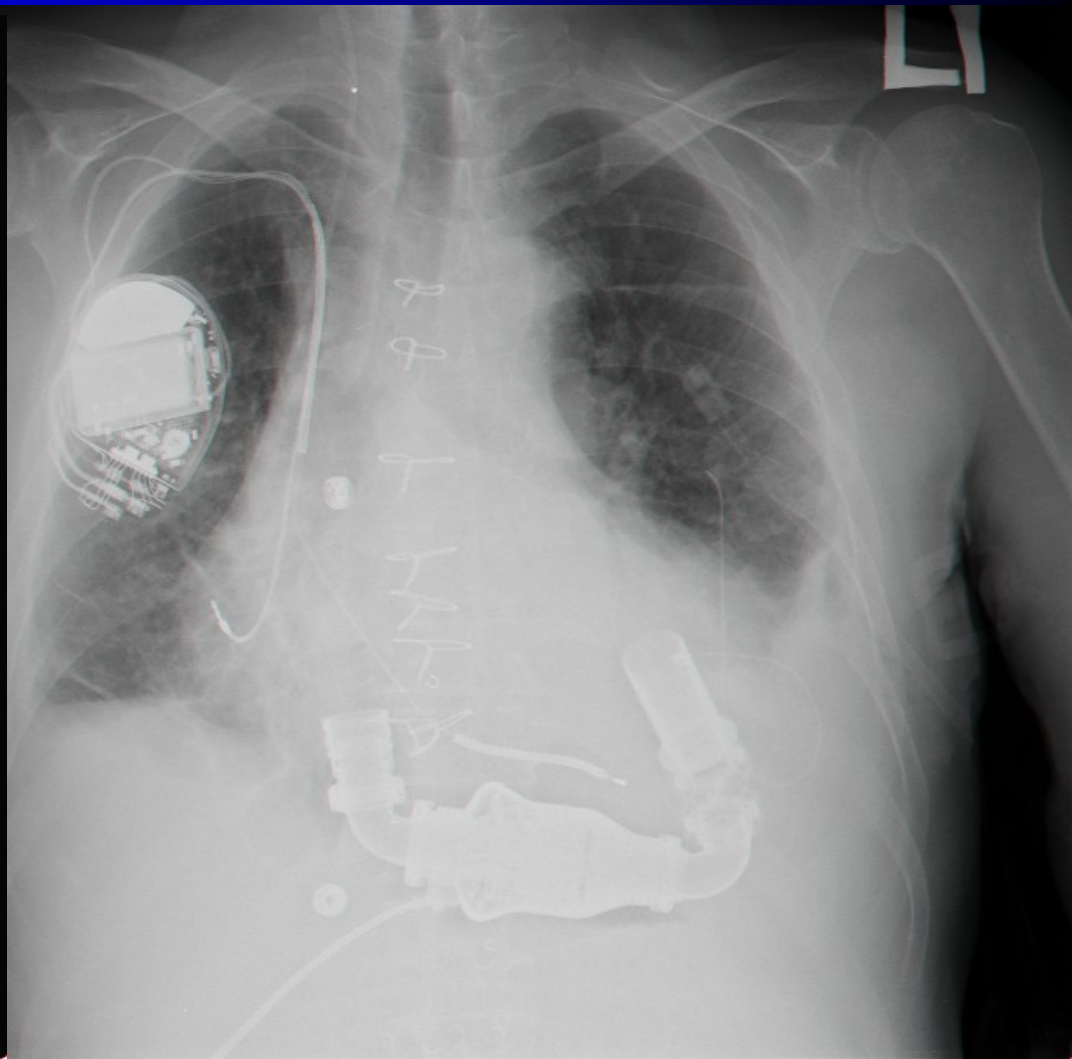


HeartMate II









65 y/o male, ICM, s/p CABG,
Sev PHT, 9/08

70 y/o male, ICM, s/p CABG,
LV+RV dysfunction 8/08

Centrifugal Pumps
HeartWare

- magnetically levitated
- Small
- Silent
- Valveless
- 2,000-3,000 RPM
- Afterload dependent
- Can deliver up to 10 lit/min

Contraindication for VAD

- Sepsis
- Coma
- Anuria
- Multiorgan failure

Consult

- **I’ve known this guy with heart failure EF 10% for years. He’s been doing great. But he acutely decompensated two weeks ago and arrested at home. Went to his local ED and arrested again. They put a balloon pump and shipped him to us.**
- **He arrested twice on the way. The last one was a long one, and he got intubated. His kidneys took a hit and we put him on CVVH for a few days. He looked great, and we got him extubated.**
- **We got him down to only milrinone and he was sitting in a chair, we placed it PICC line in him and we thought we could get him home.**
- **But…**

Consult

- **He arrested again the day before yesterday, got reintubated, and got a balloon pump again. He's back on CVVH (hasn't made urine in two days, but his baseline creatinine is 'only' 2.3). He's on three high dose inotropes with a cardiac index of 1.2. It took us all day yesterday to get it above 1.**
- **I think he's got some shock liver too. His transaminases are going up. His INR is 4.5 but that could be because he has not been eating well and may be vit K deficient.**
- **I think a pneumonia or line sepsis, could have triggered all this recent decompensation. But its hard to tell, his lungs are whited out, and it may just be from fluid.**
- **I think he needs a VAD, don't you?**

"In general, erring on the side of early implantation is advisable because after a certain level of decompensation the patient may not be able to recover in time"

P.M. McCarthy, in The Stanford Manual of Cardiopulmonary Transplantation