TEE and VAD Technology
SCA Fellow and Junior Faculty Program

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Disclosures

None
Objectives

• Understand the indications for TEE during VAD insertion.
• Describe the intraoperative TEE examination necessary during VAD implantation.
• Describe the utilization of TEE during the management of VAD malfunction.
• 1969 - Drs. Liotta and DeBakey
• First clinical LVAD in paracorporeal position
• Cardiogenic shock after surgery
• Survived 3 days

http://www.search.com/reference/Artificial_heart
Successful Use of a Paracorporeal Left Ventricular Assist Device in Man

Robert L. Berger, MD; John R. McCormick, MD; Joseph D. Stetz, MD; Michael D. Klein, MD; Thomas J. Ryan, MD; James Carr; Stephen Sweet, MD; William F. Bernhard, MD
Overall Survival

**intermacs**: June 2006 – September 2010
Adult Primary LVADs: n=2506

By Pump Type

- **Continuous Flow Pump**, n=1936, deaths=272
- **Pulsatile Flow Pump**, n=570, deaths=177

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<thead>
<tr>
<th>Month</th>
<th>CFP</th>
<th>PFP</th>
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<tr>
<td>3 mo</td>
<td>91%</td>
<td>83%</td>
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<tr>
<td>6 mo</td>
<td>88%</td>
<td>76%</td>
</tr>
<tr>
<td>12 mo</td>
<td>83%</td>
<td>67%</td>
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<tr>
<td>24 mo</td>
<td>75%</td>
<td>45%</td>
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**Event**: Death (censored at transplant or explant recovery)

**p < .0001**

The Journal of Heart and Lung Transplantation, Vol 30, No 2, 2011
• Brief overview of VADs and Indications
• Indications for TEE performance
• TEE examination
Figure 3  Preperitoneal placement of the HeartMate II pump (below the left rectus muscle and above the posterior rectus sheath).
Basics of VAD therapy - LVAD Circuitry

Thoratec Corporation – HeartMate II & BIVAD
So which ones will we focus on?

The Heart Assist 5 adult VAD is CE approved for use in Europe. A bridge-to-transplant IDE clinical study is currently underway in the US.

http://www.jarvikheart.com/home.asp

IVAD
Thoratec Corporation
Types of VAD therapy

- **Left ventricular devices (LVAD)**
- Right ventricular devices (RVAD)
- Biventricular assist devices (BiVAD)
- Percutaneous devices
- Total artificial hearts (TAH)
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<tbody>
<tr>
<td></td>
<td>No. (%)</td>
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<tr>
<td>LVAD</td>
<td>82 (82)</td>
<td>245 (73)</td>
<td>607 (86)</td>
<td>769 (88)</td>
<td>622 (94)</td>
<td>2,325 (87)</td>
</tr>
<tr>
<td>Bi-VAD</td>
<td>17 (17)</td>
<td>68 (20)</td>
<td>74 (11)</td>
<td>83 (9)</td>
<td>35 (5)</td>
<td>277 (10)</td>
</tr>
<tr>
<td>TAH</td>
<td>1 (1)</td>
<td>22 (7)</td>
<td>22 (3)</td>
<td>22 (3)</td>
<td>11 (2)</td>
<td>78 (3)</td>
</tr>
<tr>
<td>Total</td>
<td>100 (100)</td>
<td>335 (100)</td>
<td>703 (100)</td>
<td>874 (100)</td>
<td>668 (100)</td>
<td>2,680 (100)</td>
</tr>
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Bi-VAD, biventricular assist device; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; TAH, total artificial heart.
WHAT KINDS OF FLOW?
HeartMate II Thoratec Corporation
So what are the indications for use of TEE in VAD insertion?
Indications of TEE for VAD insertion

Practice Guidelines for Perioperative Transesophageal Echocardiography
An Updated Report by the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists Task Force on Transesophageal Echocardiography*

Anesthesiology 2010
Left Ventricular Support by Axial Flow Pump: The Echocardiographic Approach to Device Malfunction

Emanuele Catena, MD, Filippo Milazzo, MD, Emanuela Montorsi, MD, Giuseppe Bruschi, MD, Aldo Cannata, MD, Claudio Russo, MD, Alberto Barosi, MD, Giuseppe Tarelli, MD, Paolo Tartara, MD, Roberto Paimo, MD, and Ettore Vitali, MD, Milan, Italy

(J Am Soc Echocardiogr 2005;18:1422.e7-e13.)

Clinical Utility of Echocardiography in the Management of Implantable Ventricular Assist Devices

Gregory M. Scalia, MBBS, FRACP, Patrick M. McCarthy, MD, Robert M. Savage, MD, FACC, Nicholas G. Smedira, MD, and James D. Thomas, MD, FACC, Cleveland, Ohio

(J Am Soc Echocardiogr 2000;13:754-63.)
But first....a word of caution

THE ECHO IS JUST A MONITOR

Need to understand that the TEE is just a monitor and you have to know what you are looking for and what your differential is BEFORE you start looking.
So, let’s get started....
How to breakdown the examination?

• Pre – Insertion
• Insertion – Canula placement
• Post-Insertion
  – Includes after chest closure
PRE-INSERTION – WHAT ARE WE LOOKING FOR?

- Abnormal Communications
  - ASDs, PFOs, VSDs
- Abnormal Valves
  - TR, AI, PI, MR, MS
- Abnormal Inclusions
  - LV thrombus
- Aorta
- Right Ventricle

Pre-Insertion Abnormal Communications

- Difficult to detect
- Re-check post insertion
  - ! – do this as early asap or while weaning

Pre-Insertion Abnormal Valves

- Abnormal Valves
  - TR, AI, PI, MR, MS

Pre-Insertion

Abnormal Inclusions

• Abnormal Inclusions
  – Thrombus
  – Left ventricular aneurysm
  – Inter-atrial aneurysm

Pre-Insertion
Aorta

• End-to-end anastomosis
• Arthroma ≥ 5 mm
  – Mobile
  – Protruding
• Ascending aortic aneurysm
• Descending aorta
• Role of epiaortic echocardiography?

Pre-Insertion Right Ventricle

• 9-33% may require RVAD (after LVAD implantation)

• Etiology of RV failure
  – Leftward Septal Shift
  – Increased preload

Pre-Insertion
Right Ventricle

• Examination of RV
  – RV inflow-outflow view
  – Longitudinal function
  – RV base to apex motion
  – Free wall motion

• RV dysfunction – multi-factorial (difficult to predict)

• RV Fractional Area change
  – 20-30%
## Pre-Insertion Right Ventricle

**Echo predictors of good RV function after LVAD implant:**

- RV wall hypokinesia
- ++ or +++ TR
- RV-RA pressure drop from 30 to 50 mmHg
- RV-FAC > 20%
- RVOT fs% > 20%
- TAPSE > 10 mm

**Echo predictors of RV failure after LVAD implant:**

- RV wall akinesia
- light or absent
- RVEDD >> LVEDD
- RV-EDD > 85 mm
- RV-EDV > 200 ml
- RV-FAC < 25%
- TAPSE < 10 mm
- RVOT fs < 20%
- RV-RA pressure drop < 30 mmHg

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Fig 5. The figure shows (left) echocardiographic parameters for the preoperative assessment of RV function to distinguish patients needing LV support alone, and (right) patients at risk for severe right ventricular failure requiring RVAD support. RV, right ventricle; RA, right atrium; RVEDD, right ventricular end-diastolic diameter; LVEDD, left ventricular end-diastolic diameter; RVEDV, right ventricular end-diastolic volume.

Pre-Insertion
Right Ventricle

• Right- to-left end-diastolic diameter ratio\(^1\)
• Predictors of RV failure after LVAD\(^2\)
  – CVP/PA > 0.63
  – Need for preoperative ventilator support
  – BUN > 39 mg/dL

PRE-INSERTION – WHAT ARE WE LOOKING FOR?

• Abnormal Communications
  – ASDs, PFOs, VSDs

• Abnormal Valves
  – TR, AI, PI, MR, MS

• Abnormal Inclusions
  – LV thrombus

• Aorta

• Right Ventricle

INSERTION – CANNULAE PLACEMENT

• Correct chamber?
• Correct Position?
• Flow Characterization?
• Obstruction/Regurgitation?
INSERTION – CANNULAE PLACEMENT

Inflow Graft

• Where do they go?
  – What is the correct position?
  – What TEE views can you image them in?
Fig. 2. Live 3D transoesophageal echocardiographic images of a left ventricular VAD cannula

INSERTION – CANNULAE PLACEMENT
INFLOW GRAFT

• What do you look for?
  – PWD
  – CFD

• Abnormal flow patterns?
INSERTION – CANNULAE PLACEMENT
Outflow Graft

• Where do they go?
  – What is the correct position?
  – What TEE views can you image them in?
Fig. 4. Simultaneous biplane transoesophageal echocardiogram with colour Doppler (left) and spectral Doppler (right) image of an LVAD outflow anastomosis onto the ascending aorta.

INSERTION – CANNULAE PLACEMENT
OUTFLOW GRAFT

• What do you look for?
  – PWD
  – CFD

• Abnormal flow patterns?
OUTFLOW GRAFT

Fig. 4. Simultaneous biplane transoesophageal echocardiogram with colour Doppler (left) and spectral Doppler (right) image of an LVAD outflow anastomosis onto the ascending aorta.

POST INSERTION?

• Deairing
• Recheck for PFO
• Septal movement
• RV function
• ALWAYS RE-CHECK POSITION AFTER CHEST CLOSURE

Fig. 10. Air bubbles in the left atrium and left ventricle, after entering around the LA cannula cuff, originating from a pleural tear.
POST-INSERTION
Right heart failure

• We covered this earlier
In Summary.....

- Many types of VADs and their insertion is on the rise.
- VADs are inserted for three main indications: bridge to transplant, bridge to recovery, destination therapy.
- TEE is an invaluable monitor intraoperatively during VAD insertion.
- TEE is only as good as the operator.
In Summary.....

- Pre-insertion examination – look for things that impede flow (MS), cause shunting (PFO/ASD/VSD), shouldn’t be there (arthroma/aneurysm), and re-circulation (AI).

- Pre-insertion examination – Right-sided structures

- Cannulae/Grafts – evaluate position, flow, velocity (CFD& PWD).

- Look for position and PFOs early after insertion and after chest closure

- Don’t forget about the right ventricle!
THANK YOU!