Mechanical Circulatory Support
“Approach to the Patient in Shock”
ECMO vs VAD

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I have no financial interests in any VAD company.

Have received research funding, speaking honoraria and/or consulting fees from:

Thoratec  
Seville Medical  
HeartWare Inc  

CorMatrix Cardiovascular  
Medtronic
Bridge to Recovery

- short term support for the acutely decompensated ventricle
  - acute myocardial infarction
  - acute viral myocarditis
  - post-cardiotomy shock

Goal:

- unload the heart to allow for rest and recovery
Probability of Death Based on Postoperative Inotropic Support Following Open Heart Surgery

Hahnemann University Hospital

Low dose: 1-4 mcg/min of epinephrine or 1 - 4 mcg/kg/min dobutamine or dopamine, or 0.1 - 0.24 mcg/kg/min of milrinone.
Moderate dose: 5-9 mcg/min of epinephrine or 5 - 9 mcg/kg/min dobutamine or dopamine, or 0.25 - 0.49 mcg/kg/min of milrinone.
High dose: ≥ 10 mcg/min of epinephrine or ≥10 mcg/kg/min dobutamine or dopamine, or ≥ .5 mcg/kg/min of milrinone.
Probability of Death Based on Postoperative Inotropic Support Following Open Heart Surgery

- If you leave the OR with an IABP and a combination of:
  
  0.1 µg/kg/min Epinephrine
  0.1 µg/kg/min Norepinephrine
  0.5 µg/kg/min Milrinone
  4 Units/hr Vasopressin

Probability of perioperative death > 30%
Probability of Death Based on Postoperative Inotropic Support Following Open Heart Surgery

- Poor prognostic factors:

  - Oliguria
  - MvO2 < 60%
  - SBP < 90 mmHg
  - CVP > 20 mmHg
  - HR > 110
What about the de novo patient in acute cardiogenic shock? (Acute MI, Fulminant Myocarditis, etc)

- Poor prognostic factors:

  Oliguria
  SBP < 90 mmHg
  Elevated JVP
  HR > 110
  Young age!

Do NOT give β-blocker!!
Emergent Support

In cases of acute decompensated heart failure:

- Establish circulatory support as quickly as possible
- Provide adequate support (>2L/min/m$^2$)
- Minimize complications associated with implant

Immediate Goals of Therapy:

- Preserve end-organ function (liver, kidneys)
- Establish neurologic prognosis
Emergent Support

Practical Considerations

- consider presentation: post-cardiotomy vs de novo
- isolated LV failure vs biventricular failure
- severity of pulmonary edema
Emergent Support

Post-Cardiototomy Shock:

- consider VAD when IABP in place and high dose inotropes required

- better outcomes if VAD inserted prior to returning to ICU vs returning to OR after end-organ failure

- 3 inotropes, oliguria, persistent LCO, poor MVO2

- with chest open, utilize the benefit of central cannulation
Emergent Support

When to consider BiVAD vs LVAD alone:

- pre-existing pulmonary hypertension
- poor RV protection (small RCA, retrograde cardioplegia)
- pre-existing hepato-renal insufficiency
- malignant arrhythmias
Emergent Support

De Novo Presentation:

Favouring LVAD alone:
- acute STEMI
- mechanical complication of MI (VSD, MR)

BiVAD preferred when:
- biventricular failure secondary to myocarditis
- presents with oliguria, hepatic congestion
- malignant arrhythmias
Emergent Support

Traditional Forms of Support:

ECMO - percutaneous approach via femoral vessels
- labour intensive
- hemolysis
- need for oxygenator
- continuous flow
## Emergent Support

<table>
<thead>
<tr>
<th></th>
<th>VA-ECMO</th>
<th>VAD</th>
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<tbody>
<tr>
<td>Ease of insertion</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Degree of support</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Ambulate</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Duration of support</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Cost</td>
<td>++</td>
<td>++</td>
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Common Issues

- Need for prolonged (>5 days) support
- Complications in critically ill patients
  - leg ischemia
  - transfusion requirements
  - anticoagulation needs
- Ease of implant in complex cases
ECMO or Short-Term LVADs

- high risk, acutely ill patients
- survival unlikely without mechanical support
- “emergent” implantation
- survival to explant/transplant ~ 25-50%
- survival to hospital discharge ~ 20-30%
Centrimag

Uni/Biventricular Support
Ease of implantation
Cheap!
Medium term support
CentriMag® 2nd Generation System

Pump  Motor  Console / Monitor
Clinical Experiences From Voluntary Registry

- 40% Post Cardiot
- 16% Post Tx
- 9% Congenital
- 9% Post Partum
- 13% ARDS
- 9% RV Post LVAD
- 9% Dil Cardiomyopathy
- 9% Myocarditis
- 9% AMI
Primary Console Control Panel
Left Heart Cannulation

LA  Ao

To CentriMag Pump & Console
Bilateral Support

To CentriMag Pumps & Consoles
Peripheral vs Central Cannulation

- **Central**
  - Most common in OR for post cardiotomy failure requiring oxygenation
  - Via open sternum
  - Usually the right atrium and aorta are cannulated
  - Can insert large cannulae
  - Possibly higher flows
Peripheral vs Central Cannulation

- **Peripheral**
  - Usually for non-surgical patients, either massive MI, ARDS,
  - Usually groin and/or neck vessel cannulation
  - Cannulae selection dependent upon vessel size
  - Flows may be limited
  - May be percutaneous or via ‘cut-down’
## Sample Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
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<tbody>
<tr>
<td><strong>Pump Speed</strong></td>
<td>3000 - 4000 RPM’s</td>
<td>If speed is greater than 4500, assess cannulation and patient condition</td>
</tr>
<tr>
<td><strong>Pump Flows</strong></td>
<td>4 – 5 LPM</td>
<td>Can be 6 – 7 LPM depending on pt. size</td>
</tr>
<tr>
<td><strong>RAP / LAP</strong></td>
<td>10 – 15 mmHg</td>
<td>Aim to reduce workload of ventricles</td>
</tr>
<tr>
<td><strong>CVP</strong></td>
<td>8 – 12 mmHg</td>
<td>Need adequate volume in RA to supply pump</td>
</tr>
<tr>
<td><strong>Target ACT</strong></td>
<td>160 - 180 seconds</td>
<td>May increase depending on type of support and patient condition</td>
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Anticoagulation Guidelines* (with CPB)

- Achieve optimal CentriMag flow then reverse heparin
- May hold off on Heparin in the immediate post op phase
- Start heparin infusion when CT < 50 ml/hr for 2-3 hours
- Target ACT 160 – 180 (for VAD)
- Target PTT 1.5-1.8 times normal (50 – 60 sec)
- *Anticoagulation needs vary per patient
Ventricular Assist Devices

42 y.o. man with DCM and a history of VT

- Presented to Hamilton in VT storm
- Failed attempted ablation, complicated by cardiogenic shock
- Intubated, ventilated and transferred to TGH for further management
Ventricular Assist Devices

42 y.o. man with DCM and a history of VT

Surgical Considerations:

- Acute presentation with malignant arrhythmias
- End-organ function preserved (ie – will tolerate sternotomy)
- Uncertain neurologic status (ie – short term device as bridge to decision)
Ventricular Assist Devices
Ventricular Assist Devices

Extubated day 2 after Centrimag BiVAD

- Ambulatory on POD #3
- Maintained in fast VT x96 hrs until donor heart found
- Successfully transplanted
Ventricular Assist Devices
Other forms of MCS

- TGH Experience
  - Abiomed BVS (n=34)
  - Abiomed AB5000 (n=12)
  - Thoratec PVAD (n=6)

CLINICAL STUDIES

Mechanical circulatory support with the ABIOMED BVS 5000: The Toronto General Hospital experience

Vidyadhar Lad MD, Abdelsalam Elhenawy MD, Steve Harwood CCP, Jane MacIver RN, Mitesh V Badiwala MD, Mark Vallelonga CCP, Terrence M Yau MDCM, Robert J Cusimano MD, Diego H Delgado MD MSc, Heather J Ross MD, Vivek Rao MD PhD
- Retrospective review from 2001-2006
- \( N = 30 \) devices

- Survival to device explant/transplant (55%)
- Survival to hospital discharge (28%)
The CentriMag ventricular assist device in acute heart failure refractory to medical management

Berhane Worku, MD, Sang-Woo Pak, MD, Danielle van Patten, BA, Brian Housman, BA, Nir Uriel, MD, Paolo Colombo, MD, Ulrich Jorde, MD, Hiroo Takayama, MD, and Yoshifumi Naka, MD, PhD

From the Divisions of Cardiothoracic Surgery and Cardiology, Columbia University Medical Center, New York, New York, USA.

- Retrospective study from 2007-2009
- 63 patients with RVAD/LVAD/BiVAD

- 89% survival to explant/transplant
- 74% survival to hospital discharge
UHN Total ECLS Cases (n=148)

- Weaned
- Transplant
- Death
UHN Total ECLS Cases (n=148)

- Range of support 1- 95 days (single pump)
  - Successful lung transplant at 95 days

- Median duration of support varies by indication
  - Post-cardiotomy (~5 days)
  - Acute circulatory collapse (7-10 days)
  - ARDS (21 days)
Resource Management for ECLS

Category 3:
- Recent support, bleeding, unstable
- Perfusionist at bedside

Category 2:
- Stable hemodynamically
- Perfusionist in house

Category 1:
- Stable after prolonged support
- Perfusionist at home, on call
Recent TGH Cardiac Experience

- 27 CentriMag implants in 2012-2014
- 17 patients weaned to device explant/transplant (63%)
- 14 required ECMO at some point
- 15 patients survived to hospital discharge (56%)
Summary of TGH Experience

- There is a trend towards the use of central cannulation with paracorporeal support (+/- Oxygenator) for post-cardiotomy shock

- There is a trend towards early establishment of peripheral ECMO in patients who present with circulatory collapse

- The results of paracorporeal support (+/- ECMO), even with support durations >14d are improving
In 2015:

- short-medium term devices are available which are user friendly and cost-effective

- can provide MCS +/- ECLS with acceptable morbidity and mortality

- can provide support duration >30 days