ECMO Circuit

- ECMO vs CPB
  - Minimize cellular blood trauma
  - Minimize bleeding complications
    - Reducing anticoagulation needs
- Elimination of blood-air interface
- Avoid sheer stresses

- Closed system
- No reservoir
ECMO Circuit

- Blood pump
- Oxygenator
Blood Pump

- Roller type
  - Cheap
  - Durable
  - Control inlet suction
    - Siphon pressure
    - Electronic
  - Larger circuits
    - Floor
    - Tubing spallation
  - Potential for circuit rupture
    - Requires trained bedside personnel
Blood Pump

- **Centrifugal design**
  - Smaller circuit
  - Less risk of circuit rupture
    - Finite positive pressure
  - Thrombus and heat generation resolved
    - Magnetic levitation
  - Regulate inlet suction
Oxygenator

- Silicone
  - Medtronic
  - High resistance
    - Activate blood cells
  - Time consuming to prime
- Polypropylene hollow fibers
  - Standard for CPB
  - Capillary tubes with micropores
  - Leak plasma 24-48 hours
- Polymethyl Pentene
  - Capillary tubes
  - Outer skin prevents plasma leak
  - US Quadrox D (Maquet)
  - Canada/Europe Medos and Novalung
Michigan’s ECMO Circuit

- Adults only
- Better bladder
  - Measure inlet pressure without accessing negative pressure
- CentriMag Pump
  - Console
  - Backup console
  - Backup motor
  - No hand crank
- Measure peak circuit pressure
- Quadrox D oxygenator
Modes of ECMO Support

Veno-venous support (VV)

Veno-arterial support (VA)
ECMO for Shock

• **Indication:**
  – CPR
  – Failure to wean
  – Conventional measures are failing

• **Etiology**
  – Acute myocardial infarction
    • 6% MI with cardiogenic shock
    • 60% mortality
  – Myocarditis
  – Chronic cardiomyopathy
  – Post cardiotomy
    • 80% mortality on 3 inotropes
  – Pulmonary Embolus
  – Septic shock
Emergency Circulatory Support

Exit Strategy

- **Bridge to recovery**
  - Acute MI
  - Myocarditis
  - Post cardiotomy
- **Bridge to transplant**
  - Chronic heart failure
  - Acute MI, cannot be revascularized
- **Bridge to Implantable Circulatory Support**
  - LVAD

- **Exclusion:**
  - Chronic organ dysfunction
  - Advanced age
  - Social contraindications
Emergency Circulatory Support

- Percutaneous ventricular assistance
  - Tandem Heart
  - Impella
- Paracorporeal ventricular assistance
  - Abiomed
  - CentriMag
- ECMO
TandemHeart pVAD

- Percutaneous LVAD
- Transeptal left atrial drainage
- Femoral artery infusion
- Centrifugal pump
Impella

- Peripheral LVAD
- Continuous axial flow
- Across aortic valve
- 2.5 L/min
- Percutaneous 12 Fr

- 5.0 Surgical 22 Fr
  - Femoral
  - Ascending aorta
Abiomed BVS / AB-5000 VAD

- Pneumatic pulsatile pump
- Self regulating
- Extracorporeal
- Paracorporeal

<table>
<thead>
<tr>
<th>Device</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>BVS 5000</td>
<td>5 days</td>
</tr>
<tr>
<td>AB5000</td>
<td>20 days</td>
</tr>
<tr>
<td>Longest AB5000 Patient</td>
<td>312 days</td>
</tr>
<tr>
<td>Lab Testing</td>
<td>&gt; 365 days</td>
</tr>
</tbody>
</table>
Levitronix CentriMag

- Magnetically levitated centrifugal pump
VA ECMO for Shock
(Modified Partial Cardiopulmonary Bypass)

- Advantages
  - Minimally invasive
  - Bedside application
  - Biventricular support
  - Pulmonary support

- Disadvantages
  - Labor intensive
  - Immobilized patient
  - Non pulsatile flow
  - Left ventricular distension
    - Limits recovery
    - Pulmonary hemorrhage
  - Aortic thrombus
  - Cerebral Hypoxia
When to choose ECMO

- Non-post cardiotomy severe biventricular failure
  - Refractory malignant arrhythmias
  - Cardiopulmonary arrest
- Cardiac failure with pulmonary edema
- Septic shock with circulatory collapse
Cannulation

- **Thoracic**
  - Postcardiotomy
  - Typical CPB cannulae

- **Percutaneous femoral/jugular**
  - Arterial: Typical adult 15-17 Fr. Female, 17-19 Fr. Male
  - Leg ischemia avoided with “reperfusion” cannula
    - 10 Fr. Antegrade down SFA
    - 8 Fr. Retrograde up posterior tibial
  - Venous: 23-28 Fr.

- **Open cervical or femoral**
  - Carotid ligation 5-10% watershed infarction
ECMO Management

• Continuous Heparin infusion
  – ACT 210-230 or PTT 40-50
  – Adjust based on bleeding risk
• Platelets > 100K
  – Ongoing platelet consumption
  – More conservative if no signs of bleeding
• Arterial saturation >90%
  – As measured in right arm
• MAP ~65
ECMO Management

• Daily neurological assessment
  – Diprivan or Dex for sedation
• Diuresis/ hemofiltration
• Daily plasma free hemoglobin
  – Significant hemolysis should prompt search for cause
• Q8 hour circuit assessment for clot
• +HIT-change anticoagulation to argatroban
  – Titrate for similar ACT
Left Ventricular Distension

- ECMO is partial bypass
  - Residual RV output and bronchial flow
- LV must eject to avoid pulmonary hemorrhage

- Maintain aortic pulsatility
- Follow pulmonary artery pressures
- Liberal use of echo
  - LV size
  - Aortic valve opening
- Strategies to facilitate LV ejection
  - IABP
  - Inotropes (dobutamine, milrinone)
  - Minimize vasoconstriction (Norepinephrine, Vasopressin)
  - Reduce flow rate
    - Balance SV02 with LV ejection
Left Ventricular Distension

- Venting
- Transthoracic LV vent
  - postcardiotomy
- Percutaneous atrial septostomy
- TandemHeart drain
  - Best placed via right femoral vein
- Impella as LV vent
Aortic Root Thrombus

- VA ECMO via femoral artery
- Minimal LV ejection
- Stasis in aortic root
- Thrombus
- Prevention:
  - Maintain ventricular ejection
    - IABP
    - Inotropes
  - Anticoagulation

- Rarely seen with VADs
  - Turbulence from proximal location of aortic outflow
Cerebral Hypoxia

- VA ECMO
- Femoral cannulation
- Left ventricular ejection
Cerebral Hypoxia

- VA ECMO
- Femoral cannulation
- Respiratory failure
- Left ventricular ejection
- Hypoxic perfusion of coronary and cerebral circulation
Cerebral Hypoxia

– Diagnosis with right radial saturations
– Consider
  • Ventilator adjustments
    – Avoid VILI
  • Better venous drainage
    – Less LV ejection
  • V-AV support
    – Partial VA ECMO/Partial VV ECMO
Evidence

• Retrospective single institution reviews
• ELSO registry
  – Extracorporeal Life Support Organization
• No prospective trials
25 patients
7 required percutaneous LV venting
4 weaned from ECMO (2 survived)
8 bridged to VAD (6 transplanted (75%))
1 bridged directly to transplant
9 survived to hospital discharge (36%)
Renal and hepatic function not predictive
Urine output duration of ECMO
Application of “Double Bridge Mechanical” Resuscitation for Profound Cardiogenic Shock Leading to Cardiac Transplantation

Frank W. Bowen, MD, Alysia F. Carboni, MSN, Mary Lou O’Hara, MSN, Alberto Pochettino, MD, Bruce R. Rosengard, MD, Rohinton J. Morris, MD, Robert C. Gorman, MD, Joseph H. Gorman III, MD, and Michael A. Acker, MD

Department of Surgery, School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania


• 23 patients
  – 2 post cardiotomy
• 3 recovered
• 9 transition to VAD
  – 7 transplanted (78%)
• 10 survived to hospital discharge (43%)

• Bridge to VAD mean ECMO duration only 13.7 hours
Clinical experience with 202 adults receiving extracorporeal membrane oxygenation for cardiac failure: Survival at five years

Nicholas G. Smedira, MD
Nader Moazami, MD
Camille M. Golding
Patrick M. McCarthy, MD
Carolyn Apperson-Hansen, MStat
Eugene H. Blackstone, MD
Delos M. Cosgrove III, MD

• 202 patients
• 107 (53%) postcardiotomy
• 38% 30 day survival
• Age > 55 predictor
• 42 Bridged to VAD
  – 60% survived to transplant
• Excellent long term survival
Early and late outcomes of 517 consecutive adult patients treated with extracorporeal membrane oxygenation for refractory postcardiotomy cardiogenic shock

Ardawan Julian Rastan, MD, PhD, Andreas Dege, MD, Matthias Mohr, MD, Nicolas Doll, MD, PhD, Volkmar Falk, MD, PhD, Thomas Walther, MD, PhD, and Friedrich Wilhelm Mohr, MD, PhD

(J Thorac Cardiovasc Surg 2010;139:302-311)

- 517 postcardiotomy patients
- 61% central cannulation
- Most received IABP
- 24.8% survival to discharge
- Advanced age, Euroscore, Lactate levels predictors
University of Michigan
Device Utilization 1997-2009

Total n=282

- Abiomed n=61
- ECLS n=192
- TandemHeart n=29

# of patients

Year

Device Use by Indication

- Respiratory failure/sepsis: ECLS
- Pulmonary Embolism: ECLS
- Lung transplant: ECLS
- Heart transplant: ECLS
- Post cardiotomy: ECLS, Abiomed, TandemHeart
- Decompensated Chronic Cardiomyopathy: ECLS, Abiomed
- Myocarditis: ECLS, Abiomed
- Acute MI: ECLS, Abiomed, TandemHeart

# of patients

0 20 40 60 80 100
Survival by Diagnostic Indication

- Post-Lung Transplantation
- Respiratory Failure / Sepsis
- Post-Cardiotomy
- Decompensated Chronic Cardiomyopathy
- Pulmonary Embolism
- Myocarditis
- Acute Myocardial Infarction
- Post-Heart Transplantation

0% 20% 40% 60% 80%
Long-term survival

Overall Survival After Temporary Support

N=282 patients
Survival conditional upon hospital discharge

- 86% at 0 months
- 75% at 12 months
- 52% at 24 months

N=117
Conclusions

• ECMO allows resuscitation of patients in shock
• Complications unique to ECMO should be anticipated and avoided
• 25-40% survival rates
• Long term survival excellent