What is ECMO?

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No disclosures

- Although, I am accepting offers………
So What is ECMO?

- ECMO, ECLS, ECCS, MCS
  - All terms used interchangeably
- ECMO (ExtraCorporeal Membrane Oxygenator)
  - Outside the body oxygenation
- ECLS (ExtraCorporeal Life Support)
  - Outside the body life support
  - ECMO
  - VADs
ECMO
ECMO

- A modified heart-lung bypass technique used to treat *reversible cardiopulmonary failure* that is no longer responsive to maximal conventional therapy.

- More than 50,000 infants, children and adults treated to date.
ECMO vs. Cardio Pulmonary Bypass (CPB)

- **CPB**
  - hypothermia
  - full heart-lung bypass
  - open circuit
  - complete anticoagulation

- **ECMO**
  - normothermia
  - partial, full or no heart-lung bypass
  - closed circuit
  - partial anticoagulation
Cardiopulmonary Bypass

- Cross-Circulation
Dr. John Gibbon
Early Bypass Machines and Lungs

Sheet Oxygenator

Bubble Oxygenator
Bypass Today
History

- **Heart-Lung bypass**
  - 1930s-1950s
- **Adult ECMO**
  - 1970s
- **Neonatal ECMO**
  - Late 1970s-early 1980s
ECMO History

- Adult ECMO came first
- First patient 1971
- NIH trial in late 1970s (HUP was a study center)
  - Trial stopped due to poor survival
- Interest in adult ECMO declined until late 1980s
  - Technology & knowledge improved
Neonatal ECMO

- Dr. Robert Bartlett at U.C. Irvine
- Late 1970s through mid-1980s
- High survival rate (80%) in term babies
- High IVH rate in preterm babies
Neonatal ECMO #1
Esperanza
Criteria for ECMO

- Reversible Disease.
- Failure to respond to maximal conventional therapy
  - HFOV, 100% Oxygen, iNO, Inotropes
- Failure to improve on maximal therapy
- Acute deterioration
Criteria for ECMO

- Oxygenation index > 40  
  \[ OI = \frac{MAP \times FiO2 \times 100}{PaO2} \]

- A(Alveolar)-a(arterial) gradient > 600 > 6 hours
  
  - A-a gradient = \[ \left( 760 - \text{partial pressure of water vapor} \right) \times FiO2 - (1.25 \times PaCO2) - (\text{Post-ductal PaO2}) \]

  - Simplified: 713 - (1.25xPaCO2) - PaO2 assuming at sea level, normothermic and on 100% FiO2.
Contraindications

- Severe intracranial hemorrhage
- Non-reversible coagulopathy
- Prematurity (< 34 weeks)?
- Multi-organ system failure
- More than 5-7 days “hard” ventilation (?)
TIME and Reversibility

![Plot of selected ages](image)

- Survival probability
- Days of mechanical ventilation pre-ECMO
- ELSO Registry
- N=1,243
Trends

Neonatal ECMO

Pediatric ECMO

ELSO Registry, 2010.
Adults

International Summary - January, 2014

Adult Respiratory (18 years and over)

Annual Respiratory Adult Runs

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Nemours. Alfred I. duPont Hospital for Children
ECMO Equipment

Basic Components:
- Roller/Centrifugal Pump
- Oxygenator
- Blender/Gas Source
- Pressure Monitoring
- Servo Regulation
- Heater
The Original ECMO Lung
Today’s Oxygenators

- Quadrox D
- Quadrox iD Pediatric
ECMO Circuit

- Blood is drained from right atrium
- Passes through roller pump or centrifugal head
- Pumped through oxygenator
- Sweep gas flows countercurrent through oxygenator
- Oxygenated blood rewarmed
- Returned to patient via arterial cannula
INDICATIONS FOR TREATMENT
Pulmonary Support

- **Neonatal:**
  - CDH
  - MAS
  - Sepsis

- **Pediatric/Adults:**
  - Pneumonia
  - ARDS
  - Bridge to transplant

Pulmonary Hypertension
Pre-ECMO Pulmonary Management

- High-frequency ventilation/Jet Ventilation
  - Neonates/pediatrics
- Low volume ventilation
- Nitric oxide
- Surfactant replacement
- Permissive hypercapnia
- Prone position
Pulmonary ECMO Management

- **Time:** Lung rest
- **Treat underlying causes**
- **Facilitate recovery**
  - Bronchoscopy, Pulmonary Toilet
  - Surfactant, Nitric Oxide, Sildenafil, Flolan
  - Lung conditioning
  - Steroids
- **Wean from ECMO when patient can be supported on low-moderate vent settings**
Rehabilitation on ECMO – What?
Cardiac Support

- Failure to wean from CPB
- Acute deterioration (cardiac arrest)
- Low cardiac output syndrome
- Pre-op Stabilization
- Bridge to transplant or VAD
Failure to Wean From CPB

- Poor LV function
- Pulmonary
  - Pulmonary hypertension
- Factors
  - Preoperative condition
  - Duration of cardiopulmonary bypass
  - Hemorrhage
Low Output Syndrome

- Predicable fall in cardiac output
- Most cases present 6-12 hours post-operatively
- Causes include:
  - underlying CHD
  - ischemia-reperfusion injury
  - inflammatory mediator release
  - changes in LV loading conditions
Post-op Low Output Syndrome

Wernovsky et al, Circulation 1995
Cardiac Arrest

- Arrhythmia
- Tamponade / mass effect
- Loss of pulmonary blood flow
- Poor coronary artery perfusion
Type of Support

- **Veno-Arterial:**
  - cardiac and pulmonary support
  - cannulation of venous and arterial system

- **Veno-Venous:**
  - No cardiac support
  - Venous cannulation only
  - Improves oxygenation of pulmonary vascular bed (pphn)
VA ECMO Neck Cannulation

- **Arterial cannula**
- **Venous cannula**

© 1991, University of Michigan
VA ECMO Chest Cannulation
VA ECMO Femoral Cannulation
VVDL Avalon Catheter
VV ECMO
Multiple Cannulation Sites
Patient Management

- Multidisciplinary Team Approach
  - Surgeons
  - Physicians
  - Nurses
  - Respiratory Therapists
  - Perfusionists
  - ECMO Specialists
  - Ancillary Staff
  - Therapeutic Services
  - Social Work
Communication

- Communication is key
  - Ultimately, what we do individually or as a team has a direct impact on patient outcomes.
  - Multidisciplinary
  - ECMO Rounds
    - Establish parameters
    - Develop short/long term plans
Care Models

- **Single Caregiver Model**
  - 1 Nurse assuming both roles
  - “Set it and forget it” mentality
  - In-house perfusionist to manage troubleshooting
  - Often times used with centrifugal technology

- **2:1 (ELSO recommendation & Nemours model)**
  - 1 Nurse & 1 ECMO Specialist : patient
  - ECMO Specialist will manage troubleshooting of pump
  - Nurse will assume direct patient care
  - Back-up perfusionist/coordinator available for emergency management.
Anticoagulation

- Heparin bolus administered during cannulation
- Heparin infusion while on ECMO
- Anti Xa, ATIII, PTT and ACT utilized to manage heparin dose
- Activated Clotting time (ACT) monitored hourly initially and then q 2 to 4 hours once Anti Xa stable
- Must always look at full coagulation panel including Platelets, PT, INR, Fibrinogen, Calcium and TEG’s.
Respiratory Assessment

- Auscultation: “I don’t hear a thing?”
- Assessment of secretions
- Daily chest x-ray
- Arterial blood gases q2-6 hours
- Continuous mixed venous, arterial saturation monitoring
Fluid Management

- “Capillary leak syndrome” common in first 48-72 hours
- Massive third spacing necessitates aggressive fluid replacement
- Self limiting process
- Delays pulmonary recovery
- Appears fluid overloaded but intravascularly dry
Serial X-rays during run

Pre-ECMO

Post-cannulation

16 hours into run
Neurologic Assessment

- **Neonates:**
  - Daily head ultrasound, fontanel, pupils
  - EEG if needed
  - CT if needed

- **Pediatric/Adults:**
  - LOC, pupils, GCS
  - EEG, CT if complications suspected
Cardiac Support

- Inotropes weaned once stable
- May be required throughout ECMO course
- Monitor electrolytes and rhythm
- Assess pulse pressure
- Echocardiography on low flow
Medical Complications

- Hemorrhage/Bleeding
  - Surgical site

- Fluid Overload
  - Hemofiltration required

- CNS
  - Seizures, Hemorrhage, infarcts

- Renal Failure
  - Non-pulsatile flow

- Sepsis
Mechanical Complications

- Oxygenator failure
- Tubing rupture
- Air in circuit
- Pump malfunction
Future Applications

- Smaller circuits
- Heparin-bonded circuits/Coated Circuits – reduced need for anticoagulation
- Increased use in resuscitation (ECPR)
- Inter-hospital transport on ECMO
- EXIT to ECMO
Hanuola ECMO Transport Sled
ECLS Transport
Ex Utero Intrapartum Therapy (EXIT)
Thank You!

ECMO Sucks.
(On the venous side)