

Considerations in Adult ECMO

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Objectives

1. Understand the concept of ECMO
2. Identify the two types of ECMO
 - Veno-Venous
 - Veno-Arterial
3. Identify the indications and contraindications for ECMO support
4. Discuss the management of ECMO patients

ECMO: What is it?



It's not just for babies anymore...

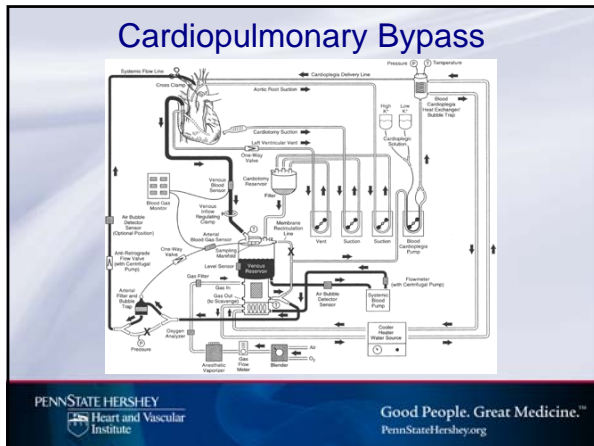


ECMO:

Extracorporeal membrane oxygenation (ECMO) is an extracorporeal (outside of the body) technique of providing cardiac and/or respiratory support to patients whose heart and/or lungs are so severely diseased or damaged that they can no longer serve their function.

So.....it's like being on heart-lung bypass?

NOT EXACTLY.....



Complications of CPB

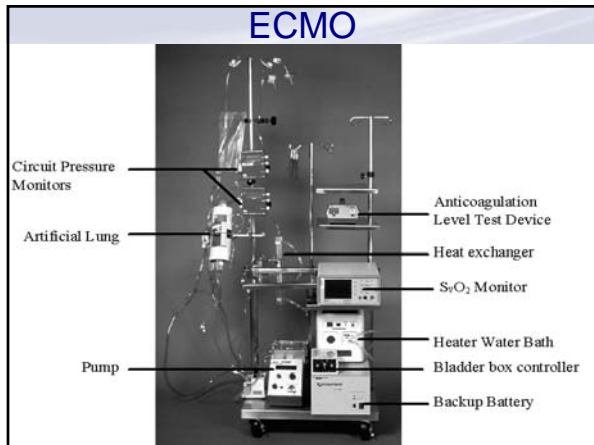
A. Mechanical
The foreign surfaces of the bypass circuit (interact with the blood)
Shear stresses include the pump, cardiotomy suction, and cannulae
Microemboli can form as particles from the oxygenator, platelet aggregate, or fibrin aggregates

B. Humoral
Factor XII (Hageman factor), the alternative complement cascade (C3a), kallikrein, and plasminogen are activated in various degrees
Other factors interrelate and amplify the inflammatory reaction, including the arachidonic acid cascade, interleukins, TNF, and PAF

C. Cellular
Neutrophils play a major role in humoral activation and are sequestered in the lung, releasing cytotoxin and free radicals which increase vasoactivity and vascular permeability
Monocytes and mast cells also participate, although their role is unclear
Lymphocytes have a minor role, if any
Platelets are activated and elaborate GPIB, IIB, and IIIA
Absolute number of platelets is reduced by 40% by the end of bypass, and the number of receptors is also decreased
Endothelial cells are affected by abnormal flow, humoral factors, and local ischemia
A wide variety of substances are expressed by the endothelium, including prostaglandins, thromboxanes, leukotrienes, and interleukins

3. Miscellaneous
Circulatory arrest with profound hypothermia (18-20C) is generally safe up to 45 minutes
Over 60 minutes is associated with increased incidence of neurologic deficit
The period between 45 and 60 minutes is unclear, as histologic injury seems to be greater than functional injury

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- ## Benefits of current ECMO systems
- Simplified circuit
 - Pump, oxygenator
 - Magnetically levitated centrifugal pump
 - Low pressure drop oxygenator
 - Less shear stress
 - Less platelet activation, humoral activation
 - Better biocompatibility
 - Percutaneous insertion
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- ## Indications for ECMO
- 1. Cardiac Failure
 - 2. Respiratory Failure
 - 3. Cardiac and Respiratory Failure
 - 4. High Risk Cath Lab Procedures
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Expected ECMO Outcomes

- Overall – Support of Cardiac and/or Pulmonary systems, allowing time for treatment and recovery from underlying principle diagnosis
 - ECMO DOES NOT TREAT OR CURE THE UNDERLYING PROCESS
- Isolated Respiratory Failure
 - Goal: To improve oxygenation & ventilation and rest the lungs
- Cardiac
 - Goal: To improve blood flow to end organs and rest the heart
- Both respiratory and cardiac failure
 - Goal: combine previous 2 goals

Will You See These Patients? - YES

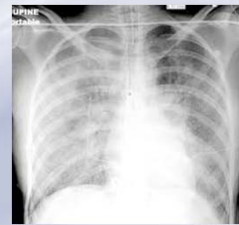
- Emergency Room
- Life Lion – air or ground transport
- Operating Room
- Cath Lab
- All Critical Care Units
- All Nursing Units

- All Nurses, Respiratory Therapists and Healthcare Providers

ECMO: 2 Types

- V-V: Veno-Venous
 - Used for pure respiratory failure without cardiac involvement
 - Approach : Percutaneous
 - May convert to VA
- V-A : Veno-Arterial
 - Used for cardiogenic shock, cardiac and respiratory failure and for high risk intervention
 - Used for primary respiratory failure when V-A cannulation is the only option
 - Approach : Percutaneous or Central

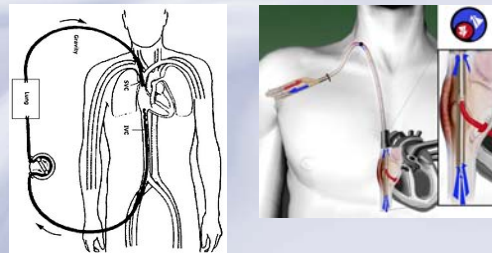
Veno-Venous ECMO



Veno-Venous

- Removal of unoxygenated blood from the venous system, oxygenating the blood and pumping the oxygenated blood back into the venous system without recirculation

VV-ECMO cannulation



VV-ECMO: Indications

- Respiratory Failure (Hypoxia or Hypercapnea)
 - Acute Respiratory Distress Syndrome
 - Pneumonia
 - Influenza
 - Pneumothorax
 - Trauma
 - Pneumonectomy
 - Primary graft failure after lung transplant
 - Pulmonary Embolism

VV-ECMO: Indications

- If the diagnosis 'fits':
 - Likelihood of organ recovery
 - Candidate for lung transplant
- Any reason not to cannulate?

CESAR trial

- ◆ Conventional Ventilation or ECMO for Severe Adult Respiratory Failure
- ◆ Randomized controlled trial to assess the impact of ECMO on survival without severe disability by 6 months in patients with potentially reversible respiratory failure, Murray Score ≥ 3 or uncompensated hypercapnea with pH < 7.20
- ◆ Exclusion – PIP > 30 cmH₂O or FiO₂ > 0.80 for more than 7 days

Murray Score

TABLE 3. ELEMENTS AND VALUES OF THE MURRAY SCORE. AVERAGE OF THE FOUR ELEMENTS IS SCORE

Element	Score				
	0	1	2	3	4
PiO ₂ : FiO ₂	≥ 300	225-299	175-224	100-174	<100
Number of quadrants on chest radiograph with infiltrates	0	1	2	3	4
PEEP (cm H ₂ O)	≤ 5	6-8	9-11	12-14	≥ 15
Compliance (mL/cm H ₂ O)	≥ 80	60-79	40-59	20-39	≤ 19

PEEP, positive end-expiratory pressure.
From Murray JF, Matthay MA, Luce JM, Flick MR. An expanded definition of the adult respiratory distress syndrome. *Am Rev Respir Dis* 1988;138:720-723.

CESAR trial

- ◆ Conducted from 2001-2006
- ◆ Adults were randomized either to VV ECMO at Glenfield Hospital, Leicester, England (90 patients) or continuing conventional care at referral hospitals (90 patients / 68 received ECMO).
- ◆ RR 0.69 (95% CI, 0.05-0.97; $P = 0.03$)
- ◆ Benefit of ECMO seen regardless of age, duration of high-pressure ventilation, primary diagnosis at trial entry, and number of organs failing

Patient Management on VV-ECMO

- VV-ECMO supports, does not cure
- Lung protective ventilation
 - Low FiO₂
 - At least under 0.50, get to 0.30
 - Low airway pressures
 - PIP < 30
 - VT 3 – 4 ml/kg
 - PEEP 5

Patient Management on VV-ECMO

- Use ECMO to control pO₂ and pCO₂
 - Adjust FiO₂ on ECMO to change PO₂
 - Adjust sweep (gas flow) on ECMO to change pCO₂
- Speed – adjusts flow
 - Veno-venous is not a 'pump' – heart is the pump
 - Need enough flow to oxygenate blood and keep blood flowing through the circuit

Patient Management on VV-ECMO

- Wean from ventilator or ECMO?
 - May wean vent first
 - Needs low – moderate ECMO requirements
 - Needs to be able to expand lungs reasonably but ECMO does the work
 - May wean ECMO first
 - Needs continued lung protective ventilation
 - Allow for increased vent requirements off ECMO

Patient Management on VV-ECMO

Avalon catheter

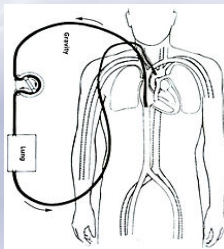
- OOB, even walking
- Must be anticoagulated
- Percutaneous removal



Weaning VV-ECMO

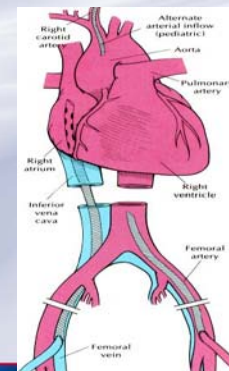
- Extubated or low vent requirements
 - Can take off O₂ completely
- Wean FiO₂ on ECMO to 0.30 or less
 - Can take off O₂ completely
- Low sweep requirements
- Consider status of oxygenator
- Consider overall patient status

Veno-Arterial ECMO



Veno-Arterial

- Removal of unoxygenated blood from the venous system, oxygenates the blood and pumps oxygenated blood back to the arterial system



Veno-Arterial ECMO

- What patient situation indicates the need for Veno-Arterial ECMO support?

Cardiogenic Shock

Clinical Criteria

- Hypotension
 - SBP < 90 for 30 min. or use of pressors to keep SBP > 90
- End Organ Perfusion
 - Cool Extremities or Urine Output < 30ml/hour &
 - HR > 60 beats/min

Hemodynamic Criteria

- Cardiac Index < 2.2 Liters/min/square meter of body surface area
- Pulmonary capillary wedge pressure of at least 15

• <http://www.nejm.org/doi/full/10.1056/NEJM199908283410901#articleTop>

Veno-Arterial: Indications

- Cardiogenic Shock
 - Acute Myocardial Infarction
 - S/P Cardiomy shock
 - Acute on Chronic Heart Failure
 - Fulminant (acute) Myocarditis
 - Post Partum Myocarditis
 - RV Failure after LVAD implant
 - Acute Rejection after Heart Surgery
 - S/P Cardiac Arrest
 - Persistent/Sustained Life Threatening Arrhythmias
 - Drug Overdose
 - Hypothermia
- High Risk Interventions
 - PTCA
- Respiratory Failure
 - When V-V cannulation not possible

Veno-Arterial ECMO

What is our goal?

- Bridge to recovery
- Bridge to LVAD/Bivad/TAH
- Bridge to transplant

Contraindications

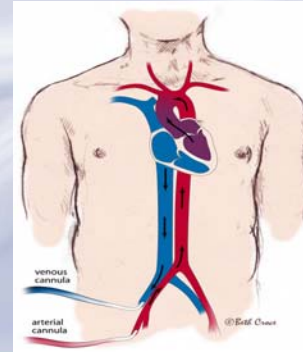
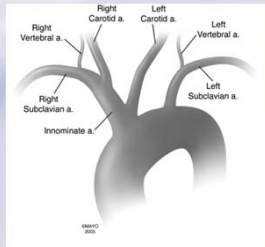
- Absolute: Unrecoverable heart and not a candidate for transplant or LVAD, Prolonged CPR without adequate tissue perfusion.
- Relative: Contraindication for anticoagulation, Advanced age, Obesity, Chronic organ dysfunction (emphysema, cirrhosis, renal failure), Compliance (financial, cognitive, psychiatric, or social limitations)

» <http://elsonet.org/>

Patient Management on V-A ECMO

- Hemodynamics
 - MAP goal 70-90
 - Afterload sensitive (Higher MAP, lower flow)
 - Pressors or Antihypertensives
 - Monitor Pulsatility
 - Desire Aortic Valve ejection
 - May need to add inotropes or beta blockers
 - Monitor CVP
 - Patient specific parameters, absence of chatter
 - Diuretics vs. fluids (per daily I & O goal)
 - Monitor Saturation
 - Patient specific parameters
 - Right Hand or Ear

- Saturation and SaO₂ -measured on right hand/ear because it is furthest from the oxygenated blood from the ECMO circuit
- Gives the 'truest' patient oxygenation level



Patient Management on V-A ECMO

- Goals-
 - Patient specific goal Flow (cardiac output) with ejection
 - Use of the lowest RPM to achieve the desired Flow with ejection (less hemolysis)
 - Titrate FiO₂ for goal saturation (after titrating and minimizing Ventilator)
 - Titrate Sweep (l/min) for goal pCO₂ (35-45)

Patient Management on V-A ECMO

- Ventilator Management
 - Oxygenation
 - ABG with Saturation – Right radial artery
 - Saturation – Right hand/ear lobe
 - Ventilation
 - Minimize Vent FiO₂ first, then ECMO
 - Increasing Flow/RPM increases amount of oxygen in blood
 - Sweep is like minute ventilation, it controls the flow of oxygen to patient
 - Lung Protective Ventilation
 - PAP max of 30
 - TV 3-4 ml/kg
 - Low PEEP
 - Pulmonary Toilet
 - Monitor Tidal Volumes closely

**Ultimate Goal Extubation

Patient Management on V-A ECMO

- Anticoagulation
 - Heparin infusion for PTT goal of 50-60

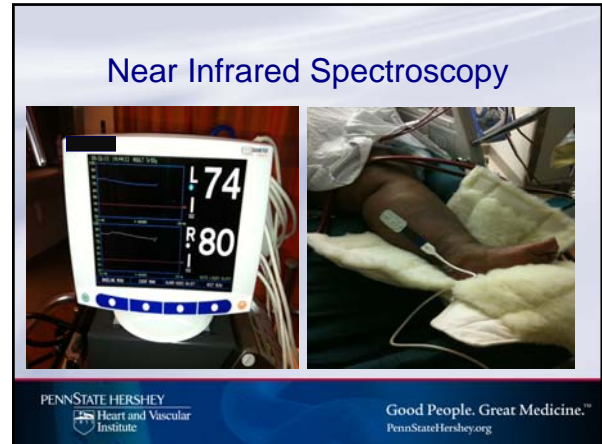
Mechanical Circulatory Support Heparin Protocol: NO HEPARIN BOLUS
Check PTT STAT before starting infusion, 2 hours after starting the infusion and after every change, then every 4 hours.

If PTT < 40 INCREASE infusion rate by 200 units/hr (no bolus)
If PTT 41-49 INCREASE rate by 100 units/hr (no bolus)
If PTT 50-60 NO CHANGE
If PTT 61-70 DECREASE rate by 100 units/hr
If PTT > 70 HOLD INFUSION FOR 1 HOUR then DECREASE rate by 200 units/hr, call Intensivist team

- **Higher PTT goals with weaning**

Patient Management on V-A ECMO

- Assess for Complications
 - "Chatter"
 - RPM adjustment vs. volume
 - Hemolysis
 - Check LDH and Plasma Hemoglobin
 - Heparin infusion
 - Assess oxygenator
 - Bleeding
 - Check Coags, correct if needed
 - Leg Ischemia
 - Clinical assessment
 - Check leg perfusion cannula, assess stopcock & check cannula position by arteriogram
 - Near Infrared Spectroscopy



Weaning from VA-ECMO

- May wean from ventilator first
 - If pure cardiac support
 - Usual vent weaning criteria
 - If cardiac and respiratory support
 - Same criteria as for VV-ECMO patient

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Weaning from VA-ECMO

- Criteria for weaning
 - Hemodynamic stability off ECMO
- Criteria for discontinuing
 - VAD / TAH placement for continued cardiac support
 - Absence of cardiac recovery, multisystem failure, not candidate for support device

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Weaning from VA-ECMO

- Criteria for weaning
 - Hemodynamic stability off ECMO
 - Echocardiogram
 - Clamping of ECMO circuit
 - Monitoring of hemodynamic parameters

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Best practices for ECMO patient management

ECMO PROGRAM

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ECMO Program – Best Practice

- Intensivist led team
 - SCCM, Leapfrog
 - Expert practitioners
 - Consistency
 - 24 / 7 availability
 - Patient selection
 - Outcome based criteria – need more data

References

- <http://www.elsonet.org/>
 - Guidelines for ECMO centers
 - Patient Specific Guidelines
 - General Guidelines for all ECLS cases